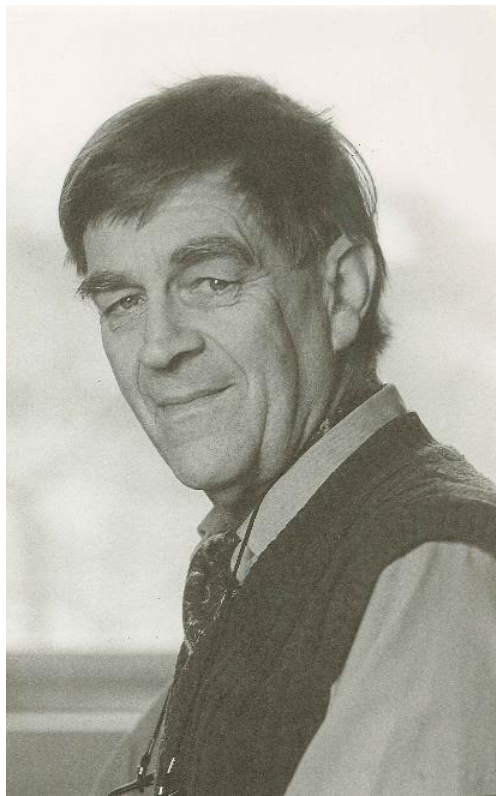


Ground flora dynamics in Wytham Woods, 1974-2018, based on the Dawkins Plots



Dedicated to the memory of H.C.Dawkins 1921-1992

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Summary

This report summarises ground vegetation results from five recordings (1974, 1991, 1999, 2012 and 2018) of 164 permanent 10x10 m plots in Wytham Woods.

- Overall mean ground flora cover per plot across the whole of the Woods went down from about 80% in 1974 to 64% in 1991, before increasing to 78% in 2018.
- Both substantial increases and decreases occurred at the plot level over the 45-year period, but with no overall pattern to these changes across the Woods.
- Canopy cover is the major limiting factor on ground vegetation cover; but tree species effects are important, with light-canopied species such as ash *Fraxinus excelsior* allowing more ground vegetation cover to develop.
- A total of 235 species were found across all recordings, which is not outstandingly rich for the size of the Woods (c.400 ha) but includes a good representation of woodland species typical of lowland woods.
- The flora is dominated by a small number of species notably *Rubus fruticosus*, *Poa trivialis*, *Mercurialis perennis* and *Brachypodium sylvaticum*; the top twelve species contributed 47% of species records across all five recordings.
- The vegetation can be broadly grouped into that of the older woodland of semi-natural origin, the younger plantation stands and the more open rides and glades.
- The species recorded were grouped into woodland specialists (40 species, that tend to be stress tolerators, often high-shade species); the more competitive, woodland generalists (105 species) that tend to be the commonest plants in the woods; and 90 non-woodland species associated with the more open plots which have a greater ruderal element and more species with high light requirements.
- The contribution of non-woodland species is greatest in the Ride and Glade plots; the contribution of woodland specialists increases the longer an area has been wooded while that of non-woodland species declines.
- Species richness per plot showed little variation over the 45 yrs, except for a low value in 2018 (16.7 species per plot in 1974, 17.3 in 1991, 15.5 in 1999, 16.1 in 2012, 13.5 in 2018).
- There was similar pattern to the number of species recorded in total across the full set of plots (182 in 1974, 171 in 1991, 147 in 1999, 158 in 2012, 141 in 2018).
- Plot species richness was negatively correlated with canopy cover over the whole period, but small differences in canopy cover (<25%) had relatively little effect on plot richness.
- Across all recordings, species richness in the more open Ride and Glade areas (mean 24-30 species per plot) was about 1.5-2.0 times the number found in the more closed woodland plots.
- Species richness at the plot level often showed large fluctuations from one recording to the next, with both increases and decreases being common for a plot. In any one plot, only a few species were recorded across all five recordings, with many species turning up only once or twice.
- The similarity (Sorensen's Index) between recordings from the same plot steadily declined with increasing time interval between recordings.
- The similarity between plots from the same recording time (homogeneity) was highest in the 1990s, but then declined again. Homogeneity went both up and down in different parts of the Woods between each recording.

- A major reason for increasing homogeneity was that the 20th century plantation plots became more similar to the older woodland and less like the Ride and Glade plots.
- Trends seen across the Woods in the older stands of semi-natural origin appear to be partly an effect of increased canopy cover – i.e. they were becoming more shady.
- Ellenberg Indicator Values for light (EIV-L) per plot were negatively correlated with canopy cover and there was a general decline in Ellenberg Light Score per plot over the 45-yr period.
- The Competitor element of the flora declined while the Stress-tolerator element went up.
- Soil acidification may have contributed to some floral changes between 1974 and 1991; there were small decreases in Ellenberg Indicator Reaction (pH) scores.
- No thermophilisation of the ground flora was detected in terms of shifts in the mean January or mean July temperatures of the species or plot scores; there was a slight trend towards species associated with higher annual rainfall, but this may be an artefact through the favouring of more shady floras.
- There was no overall change in Ellenberg Indicator Values for Nitrogen. There was an increase for the 20th Century plantation group of plots, but other plots often showed decreases. Some high EIV-N species such as *Alliaria petiolata* are however increasing. There was also a weak negative relationship between an increase in EIV-N and a decline in species richness (but R^2 less than 10%)
- Most species were present in plots with only low cover-abundance, whether measured by frequency in 13 sub-quadrats (0.1 m² each) recorded across the main plot or by overall cover estimated by eye.
- A small number of species dominate the high frequency/high cover values which tend also to be the species with high overall plot occurrences such as *Rubus fruticosus* or *Mercurialis perennis*.
- Changes in within plot cover-abundance tend to be similar to changes in overall frequency of occurrence (no of plots in which a species was present), e.g. declining *Chamerion angustifolium*, increasing *Brachypodium sylvaticum* and *Hedera helix*.
- For a few species the trends were different: bramble *Rubus fruticosus* showed large within-plot declines in cover between 1974 and 1999 but little overall change in number of plots in which it occurred.
- The biggest single change in the vegetation over the 45 years was the decline in cover of bramble and rise in *Brachypodium sylvaticum* between 1974 and 1999, and the reversal of this trend between 1999-2018.
- There was a general trend for species that had been increasing up to 1999 to then decrease in the period from 1999-2018.
- Biomass per plot, estimated using the Phytocalc approach, halved between 1974 and 1991 but has shown a slight upward trend since. The decline (and recovery) in biomass was driven largely by the change in the cover of bramble.
- The major driver of change apart from light appears to be the major increase in deer pressure between 1974 and 1999; subsequent deer management has allowed a partial recovery.
- Changes in the ground flora at Wytham Woods tend to be site-specific although they show some similarities to changes seen across wider parts of the country.
- Further changes in the ground flora are expected as the canopy cover changes in response to Ash Dieback.

1. Introduction

Wytham Woods lie about 8 km north-west of the city of Oxford in southern England (latitude 51° 46' 38.4" north; longitude 1° 20' 23.56" west; elevation c.60-160m). They comprise about 400 ha of mixed, mainly broadleaved woodland with a variety of histories and origins, that were acquired by the University of Oxford in 1942-43 <https://www.wythamwoods.ox.ac.uk/home>. Since then they have been the subject of numerous research projects, in some cases extending over several decades (Savill et al., 2010).

One such long-term study of the vegetation, set up with funding through a NERC grant, was initiated in the early 1970s by Dr Colyear Dawkins of the Department of Forestry (Dawkins and Field, 1978). Dawkins and colleagues marked 164 permanent vegetation plots (each 10x10 m) at alternate intersections of a 100x100 m grid across the Woods. For each plot they collected data on the ground vegetation, tree and shrub layers, and soils. The aim of the project was *'to devise a system for permanent low-fraction sampling of polyspecific woodland, capable of diagnosing and predicting long-term changes in specific composition and growth over large areas'*.

The project was based on the assumption that changes would occur, and that posterity would want to understand their magnitude, history, causes and consequences. However, in designing the system no specific assumptions were made about what particular changes would take place or what would be of most interest over the subsequent decades. Rather a variety of measurements were made that could provide some useful baselines for comparisons more-or-less whatever happened in future (Dawkins and Field, 1978).

This report analyses the changes in the ground flora based on re-recordings of the plots in the subsequent 45 years. Wytham Woods are in some ways a microcosm of lowland broadleaved woods because of their mixture of origins (pre-1800, 19th century, 20th century) and treatments (semi-natural stands and plantations). Changes in the ground flora in different parts of Wytham may be mirrored in many other woods and the results reflect broader biodiversity changes over the last five decades. All woods are however different, so any extrapolations must be made with care.

1.1 Subsequent recording in the Dawkins Plots

The way the plots were established and first recorded between 1973 and 1976 is described in Dawkins and Field (1978). Relevant details are also given in section 3 of this report. Little was then done for about a decade with what will be called hereafter the Dawkins Plots and the data collected from them. In the mid-1980s a partial re-recording was carried out which established that changes were happening in the vegetation (Horsfall and Kirby, 1985), but resources at the time did not permit a full study and these data are not included in this analysis. Four full recordings have subsequently been carried out, referred to as the 1991, 1999, 2012 and 2018 surveys respectively (Table 1) as well as other associated studies.

In 2017 Ash Dieback was confirmed as present in the Woods (Kirby, 2020). Subsequently there has been rapid spread and a large number of trees are showing symptoms. The ground flora results presented here (1974-2018) represent the state of the vegetation prior to the opening out of the canopy that is expected to take place over the next few years. Further records will be made over as part of a broader study of the impacts of Ash Dieback on the Woods.

Table 1. The establishment and recording of the Dawkins plots in Wytham Woods

1973-1976 '1974 recording'	Establishment of the 100 m grid of marker posts and first recording of the 164 plots (Dawkins and Field, 1978).
1984-85	Trial re-recording of about a quarter of the plots (Horsfall and Kirby, 1985). These data have not been included in the analyses*.
1991-92 '1991 recording'	Re-recording of the vegetation in all but one plot (473074) (Kirby et al., 1996, Kirby and Thomas, 2000a). Plots were also established and recorded in Bean Wood (one of the outlying copses) but these data have not been included in the analyses*.
1992 (2008)	Resampling of soils from 50 plots (Farmer, 1994, 1995). Soil from 30 of these plots was analysed again in 2008 (A. Gosler, pers. comm.)
1999-2002 '1999 recording'	Re-recording of the vegetation in all plots (Corney et al. 2008,, Kirby 2004, 2010a,b)
2002-2009	Annual recording of the 14 plots in Marley Wood; not included in this report.*
2011-2012 '2012 recording'	Re-recording of the vegetation in all plots; tree and shrub data reported in Kirby et al. (2014)
2018 '2018 recording'	Re-recording of the vegetation in all plots reported in Kirby et al., (2022)
2019-2022	22 plots with high ash cover are being checked annually for Dieback along with a quarter of the remainder*.
2023/2024	Re-recording of the vegetation in all plots is proposed.

*raw data held by the author.

Since 1992 Wytham Woods have been part of the Environmental Change Network (Morecroft and Taylor, 2010). A baseline survey of the vegetation at all grid points was carried out and then a subset of these (including 20 of the Dawkins Plots) have been used in the coarse and fine grain recording programmes (<http://data.ecn.ac.uk/sites/ecnsites.asp?site=T08>) .

- Coarse-grain sampling (VC). 50 random 2m x 2m grid plots surveyed every nine years. Species presence recorded in each of the 25 40cm x 40cm cells of the plot. Where plots fall in woodland, seedlings, dbh, height and dominance are recorded within a surrounding 10m x 10m plot.
- Fine-grain sampling (VF). At least 2 10m x 10m plots randomly selected within each NVC type surveyed every three years. Species presence recorded in 40cm x 40cm cells.

Table 2. The Dawkins plots used in the ECN recording since 1992.

Plot no	ECN no	Survey type	Plot no	ECN no	Survey type
457 074	15	Coarse	463 082	178	Coarse
453 078	29	Coarse	460 081	181	Coarse
457 082	54	Coarse	458 089	224	Coarse
452 081	56	Coarse	464 075	257	Coarse
456 081	60	Coarse	469 074	268	Coarse
453 086	72	Fine	470 075	322	Coarse
454 089	96	Coarse	475 074	333	Coarse
460 076	122	Coarse	472 073	336	Coarse
463 074	137	Coarse	475 078	344	Coarse
461 084	168	Fine	478 075	361	Coarse

A sub-set of the Dawkins Plots have been used in the 'ForestReplot' programme (<http://www.forestreplot.ugent.be/index.html>) . This brings together a wide range of permanent plot studies across Europe to carry out comparative analyses, supported by new data collection where necessary, along gradients of climate, pollution and management impacts (Verheyen et al., 2017). Examples of work including results from Wytham are given in Bernhardt-Römermann et al. (2015), De Frenne et al. (2013), Depauw et al., 2020, Landuyt et al. (2019), Maes et al. (2019b), Perring et al. (2018), Verheyen et al. (2012).

Dawkins and Field set up similar plot systems to that at Wytham at the Warburg Nature Reserve just north of Henley and at Halton Wood just north of Wendover in the Chilterns. Recording at the Warburg Reserve (1973, 1992, 2009) is described by (Kirby and Thomas, 2000b; Kirby et al., 2016) with further data from 2019 awaiting analysis. No work has ever been done, to my knowledge, with the data from Halton Wood and it is not known if the plots there would still be refindable.

1.2 Storage of data

Electronic copies of the Warburg and Wytham data are being deposited with the Bodleian Library at <https://ora.ox.ac.uk/objects/uuid:948a1302-5023-4216-b5a4-3e815dfe95ed> although not all material is in there yet; the Wytham data are also be held in the Wytham Data Archive.

Paper copies of the original Warburg, Wytham and Halton recordings, and the paper record sheets from the subsequent recordings for Wytham and Warburg are currently held by the author at 29 Chalfont Road, Oxford. Digital images of the most recent recordings for Wytham and the Warburg Reserve are being made and copied to the site managers.

2. Variations in composition and structure of Wytham Woods

2.1 Geology and soils

The Woods lie around and over Wytham Hill (Figure 1), with Oxford Clay on the lower slopes, then a band of Calcareous Grit (sand), with the top of the hill having shallow soils developed from Corallian Rag limestone (Taylor et al., 2010). A summary of the soil data from the plots in 1974 is given in Table 3.

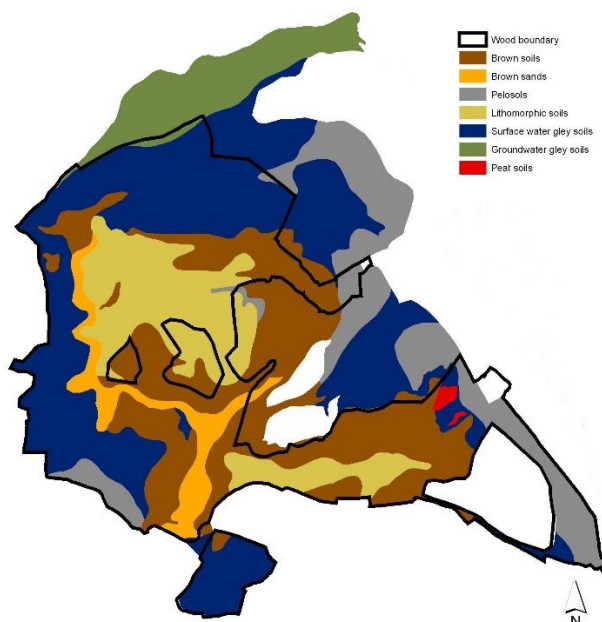


Figure 1. Major soil groups (© National Soils Resources Institute) from Taylor et al. (2010)

Table 3a. Soil characteristics of the plots from 1974 across the three main geological formations

	No of plots	Mean	SE Mean		No of plots	Mean	SE Mean
pH in CaCl				Organic matter %			
clay	62	5.969	0.117	clay	62	9.59	0.343
sand	46	5.585	0.191	sand	46	7.281	0.343
rag	55	6.853	0.117	rag	55	10.352	0.397
Extractable Potassium mg/l				Extractable Phosphorus mg/l			
clay	62	27.71	1.01	clay	62	1.241	0.208
sand	46	23.35	1.34	sand	46	1.396	0.274
rag	55	28.07	1.34	rag	55	1.774	0.199
Total Nitrogen g/100g				Extractable Calcium mg/l			
clay	62	0.3611	0.0159	clay	62	807	168
sand	46	0.2828	0.0176	sand	46	1141	332
rag	55	0.4718	0.0243	rag	55	5036	754

Table 3b. Distribution of plots of differing origins across the main geological types

	clay	rag	sand	All plots
Pre-1800. Semi-natural origin, mainly neglected coppice with standards	21	3	5	29
Pre-1800. Semi-natural origin, but disturbed by 20 th C plantings and spread of sycamore	20	13	7	40
19 th C. Semi-natural origin, largely high forest structure, often with sycamore	7	6	6	19
19 th C. As above but replanted in 20 th century.	0	1	10	11
19 th C. Mainly mature broadleaved stands, planted on open ground in 19 th C.	4	19	4	27
20 th C. Developed (mainly planted) on open ground in the 20 th century	2	7	6	15
Various, rides and glades	8	7	8	23
All	62	56	46	164



2.2 History and past treatment

The Woods are a mixture of ancient and long-established semi-natural stands, areas of plantations from the 19th and 20th centuries and glades/open grassland and rides. Their history to c.1945 is described by Grayson and Jones (1955). Subsequent developments have been assessed from the diaries of Charles Elton (1943-1965), during the transition from a traditional shooting estate to a research facility; and from those who have worked in the Woods in recent decades (Elton, 1942-1965; Kirby, 2016; Perrins, 2010). This variety of woodland origins and treatment has been simplified into the categories in Table 4 and Figure 2 and their composition is summarised in Tables 5 and 6. The pre-1800 (ancient woodland) stands are more concentrated on the clays; the mature 19th century stands on the Coral Rag, but all types occur across all geologies (Table 3b).

The tree and shrub records for each plot (Dawkins and Field, 1978, Kirby et al., 2014) consist of:

- A list of all woody species in the plot;
- Diameters (breast height) of the four largest trees;
- Canopy cover (>2.5m), split by species, and shrub cover (all species) (0.5-2.5m), estimated across the plot diagonal;
- The basal area of the trees in the plot and its surroundings estimated by relascope sweeps from plot corners (Bitterlich, 1984);
- Regeneration (presence of seedlings or saplings up to 1m tall) was recorded in 13 0.1m² circlelets positioned evenly along the two diagonals of the plot;
- In 2018 a canopy photograph was taken from the centre of the SW-NE diagonal using a mobile phone and Blackeye fisheye lens.

Table 4. Broad categorisation of the types of woodland represented by the plots.

Date became woodland		No of plots	
Pre-1800	Semi-natural origin, mainly neglected coppice with standards	29	
Pre-1800	Semi-natural origin, but disturbed by 20 th C plantings and spread of sycamore	40	

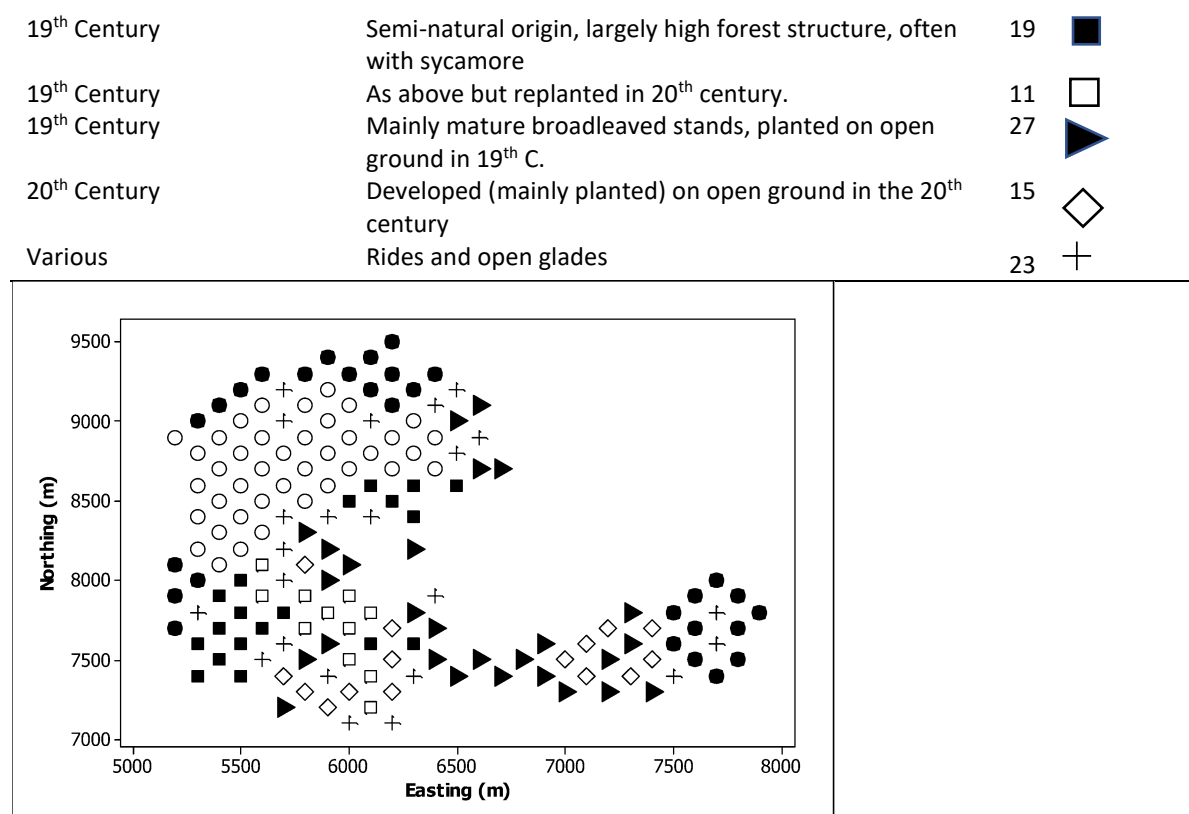


Figure 2. Distribution of plots with different origins and treatments (key to symbols in Table 4).

Table 5. (a) Changes in overall tree and shrub species abundance in Wytham Woods (1974-2012). (Standard errors for means are given in brackets); (b) trends in tallest seedling/sapling height

Year	1974	1991	1999	2012	2018
Mean % canopy cover (>2.5m)*	81 (2.2)	68 (2.5)	77 (2.2)	75 (2.1)	76 (2)
Mean % understorey cover (0.5-2.5m)*	44 (2.7)	25 (1.8)	15 (1.3)	18 (1.7)	18 (2)
Basal area (m ² /ha) all species**	14.6 (0.7)	21.5 (0.9)	31.1 (1.4)	33.9 (1.3)	38.6 (1.3)
Mean diameter (cm) of biggest tree rooted in plot regardless of species but excluding 6-10 plots with no trees at each recording.	25.4 (1.8)	29.2 (2.0)	33.8 (2.0)	36.4 (2.2)	38.3 (2.0)

*estimated across the SW-NE diagonal of the plot. The understorey includes tall bramble thickets

** measured using a relascope and includes trees in the surrounding area to the plot.

(b) Frequency of different seedlings/sapling heights based on the tallest recorded in the circlets.

	1-10 cm	11-20cm	>20cm	Ht not recorded
1974	20	11	17	19
1991	30	3	1	54
1999	65	21	1	7
2012	51	34	19	11
2108	34	38	52	-

Ash can grow almost anywhere across the Woods and has been spreading, as judged by the records from the Dawkins Plots. It has gone from present in 126 of the 164 plots in 1974 to 143 in 2018.

Mean canopy cover has increased from 18 to 25%, basal area from 2.8 m²/ha to 11.8 m²/ha. Of the four tree species that make up the bulk of the Woods it was the most successful up until 2017.

Table 6. Changes in tree and shrub species abundance in Wytham Woods (1974-2018).

Year	No of occurrences in plots					% Contribution to canopy					Basal area estimates (m ² /ha)				
	1974	1991	1999	2012	2018	1974	1991	1999	2012	2018	1974	1991	1999	2012	2018
Species															
<i>Fraxinus excelsior</i>	126	137	145	151	143	18	19	23	26	25	2.8	5.8	9.4	11.2	11.6
<i>Acer pseudoplatanus</i>	95	81	88	76	83	17	15	17	18	20	3	4.3	5.6	6.6	7
<i>Quercus robur</i>	58	47	46	45	41	12	10	9	7	8	3	4.5	5.5	5.6	5.3
<i>Fagus sylvatica</i>	30	32	29	37	31	10	10	12	11	10	1.6	2.5	4.1	4.1	4.4
<i>Betula</i> spp	32	23	16	16	11	5	3	2	2	2	1.1	0.9	1.4	1	0.9
<i>Ulmus procera.</i>	20	12	7	8	11	2.6	1.1	0.9	0.4	0.5	0.5	0.1	0.4	0.1	0.2
<i>Acer campestre</i>	33	25	22	33	30	3	2	3	2	2	0.6	0.7	0.8	0.8	0.8
<i>Salix</i> spp ¹	23	12	9	9	8	2	1	0.4	0.5	0.8	0.2	0.4	0.4	0.3	0.3
<i>Ilex aquifolium</i>	4	3	6	22	31										
Other broadleaves ²	12	12	9	12	13	4	3	4	4	4	0.6	0.8	1.5	1.8	1.5
Conifers ³	24	20	18	15	8	2	3	3	2	3	1.1	1.4	2.1	2.2	0.6
Shrubs															
<i>Crataegus</i> spp ⁴	102	103	106	101	106	5	3	3	3	3	Not recorded				
<i>Corylus avellana</i>	63	52	52	61	63	7	7	8	10	8					
<i>Prunus spinosa</i>	30	32	32	32	28	3	1	2	1	0.5					
<i>Sambucus nigra</i>	54	40	20	14	13										
<i>Euonymus europaeus</i>	36	7	4	17	11										
<i>Ligustrum vulgare</i>	27	14	2	6	3	3.5	1.2	0.8	0.1						
<i>Cornus sanguinea</i>	26	13	7	6	4										
Other shrubs ⁵	13	2	2	3	4										

1. Mainly *Salix caprea*, but some *S. cinerea*
2. *Aesculus hippocastaneum*, *Carpinus betulus*, *Castanea sativa*, *Malus sylvestris*, *Populus* spp., *Tilia europaea*
3. *Larix* spp., *Picea* spp., *Pinus* spp., *Pseudotsuga menziesii*, *Thuja plicata*, *Tsuga heterophylla*.
4. Mainly *Crataegus monogyna* but small amounts of *C. laevigata*.
5. *Rhamnus catharticus*, *Viburnum lantana*, *Viburnum opulus*

The abundance of ash varies across the Woods, it is relatively low in the ancient semi-natural areas in the north-west and most abundant in the some of the areas allowed to grow up as woodland in

the 19th century. There are a few large veteran ash scattered through the Woods; some may have been managed as pollards on Wytham Common when that was still being grazed in the 18th and early 19th century. An age-diameter curve is being constructed which suggests that most of the ash trees are less than 80 yrs-old, consistent with the comments in the late 1950s of a cohort of ash developing after the Second World War (Kirby, 2020).

Regeneration has been dominated by ash throughout the period but for much of the time few seedlings grew to more than 20cm because of deer browsing. However, from the mid-2000s more were developing into tall saplings, and locally in gaps small clumps of young ash trees 2-4 m high could be found. Unfortunately, these are particularly vulnerable to Ash Dieback and many have since died.

3. The Dawkins Plot ground flora recording methods

3.1 Plot locations and marking procedures

Dawkins and Field with colleagues marked out a 100x100 m grid across the Woods with wooden posts at each intersection; the top section was painted orange to make them easier to see. The grid positions were surveyed in using chains and compass bearings, no easy feat on sometimes steep slopes with bramble up to 2 m or more high in places. Subsequent measurements of the post locations using GPS indicates that some of the posts were up to about 10 m off their nominal position. A few posts were deliberately offset from the grid point because otherwise they would have been in the middle of a ride. In the subsequent decades as posts have rotted and fallen-over they have not always been replaced in precisely the original location.

Dawkins and Field's original intention was for a 20x20 m vegetation plot to be recorded at all the grid intersections, but this proved impractical with the time and resources available. Instead, the central 10x10m plot of the intended 20x20 m plot was recorded and only at every other grid intersection, giving 163 plot plus one extra that was used for training. The plots therefore are 14.1 m offset from the *original* post on a bearing of 45° true (Figure 3) equivalent to about 48.5° magnetic. In a few cases the surveyors seem to have not included the magnetic correction as the angle from post to plot appears to be closer to 45°. In retrospect, having the plot offset from the post proved useful because it reduced trampling on the vegetation as other researchers went to read the post labels to check where they were.

Buried metal markers were put with the posts that had a plot associated with them (not apparently at the alternate, non-plot ones). There are a couple (453078, 477078) where there appears never to have been a metal marker put in although the post is in the right place. For the rest, a metal detector should always be used to check the correct position for measuring out to the plot.

The south-west corner of the plot is 14.1 m in a north-eastly direction from the correct post-position. It is marked, as is the north-east corner, by a buried metal marker (all four corners were marked at the Warburg Reserve). Provided two of the three markers (one at the post and one of the two diagonal corners) can be found then the plot can be re-located and laid out with a high degree of accuracy. Over the years it has sometimes proved impossible to detect the plot markers, usually because of dense vegetation: tall bramble can prevent the metal detector being swept over the ground surface; post and plot positions have sometimes ended up covered by a log pile. Some of the recordings may therefore have been a few metres off the correct locations, but in all cases will have been in essentially the same stand, as confirmed by other features of the plot such as large trees. In

2018 all but a handful of the metal markers were found, so the starting assumption should be that if no marker can be detected you are in the wrong place!

Care does need to be taken that a strong signal from the metal detector is actually from a post marker, even if it is on approximately the right distance and bearing from the post. There are numerous old cartridge cases scattered through the Woods as well as more substantial bits of old metal (for example remnants of small mammal traps). Although it can take a few extra minutes, it is advisable to scrape the earth and vegetation away to expose the top of the plot marker (buried pipe) to be sure you have found the right bit of iron. In a few cases these may now be 25 cm deep, but often there is a shallow depression above them, from the previous scrapings!

Photographs are also available of the posts (from 2015) and of the plots looking from the north-east corner back to the south-west for most plots from 2012 and 2018. These can be useful where the post has fallen, been moved, become buried in the vegetation or converted into a pond.

Appendix 1 sets out notes on finding the correct, i.e. original, post positions and plot markers.

Appendix 12 gives brief descriptive comments from the recordings for each plot.

3.2 Laying out the plot

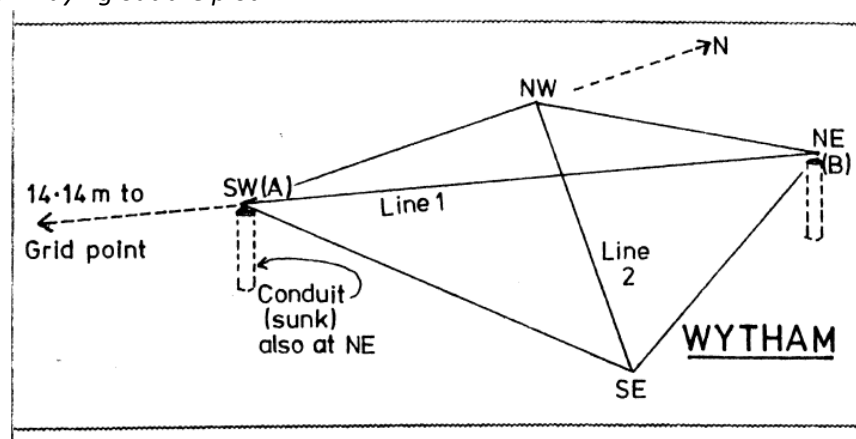


Figure 3. The layout of the plots.

From the diagonal line between the two marked corners (SW and NE) the rest of the plot is laid out using tapes and trigonometry. The precise line of the boundary may vary slightly between surveys such that trees on the edge may have been included in the plot at one re-recording but not at others. In 2018 a rough map was made of all the trees in or on the edge of the plot which should make it easier to decide in future if the sudden appearance/disappearance of an edge tree is real or a recording artefact.

3.3 Recording the ground flora data

Dawkins and Field (1978) describe how the plot was recorded in 1974-1976. This is generally how plots have been recorded subsequently with some minor variations. For the ground flora the key records are:

- A list of all vascular plants present within the plot;
- An estimate of the vegetation cover less than 0.5 m high across diagonal 1 (south-west to north-east); in practice tall herbs such as nettle and bramble might get included in this even if some of their leaves were taller;

- A record of species rooted in 13 circlets (round quadrats of 0.1 m²) distributed across the diagonals; the number of circlets in which a species was present gives an indication of the local frequency of that species, but not all species in the plot might occur in the circlets.
- In 1974 an estimate of cover was made for six species, previously identified as relatively abundant within the Woods (*Chamerion angustifolium*, *Hyacinthoides non-scripta*, *Mercurialis perennis*, *Pteridium aquilinum*, *Rubus fruticosus*, *Urtica dioica*) using the following scale: 0, absent; 1, 1-5% cover; 2, 6-25% cover; 3, 26-50% cover; 4, 51-75% cover; 5, 76-100% cover.
- In the subsequent recordings Domin cover-abundance scores were assigned to all species (0, absent; 1, single plant < 4% cover; 2, a couple of plants < 4% cover; 3, several plants < 4% cover; 4, 5-10% cover; 5, 11-25% cover; 6, 25-33% cover; 7, 34-50% cover; 8, 51-75% cover; 9, 76-90% cover; 10, 91-100% cover. Domin values, albeit subjective estimates, provide useful information on which plant species are likely to be contributing most to the overall biomass of the ground vegetation.

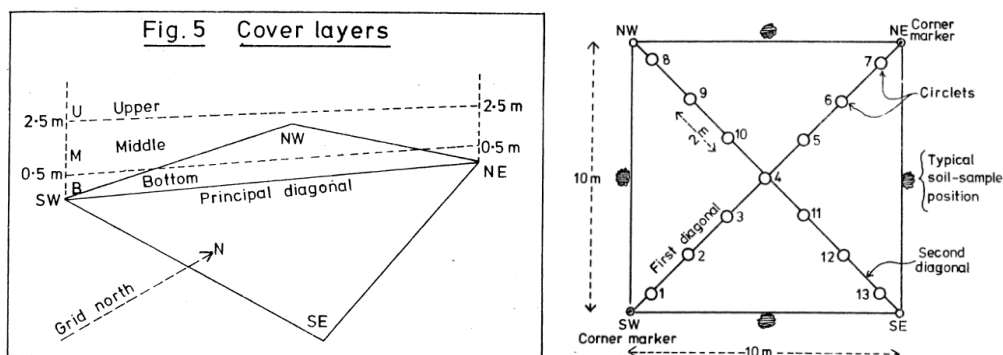


Figure 4. The procedure for estimating the cover of different layers and recording species frequency through subplots (circlets) across the diagonals.

3.4 Sources of potential errors in comparisons across recordings

Ideally all the recording would have been done by the same group of expert botanists in one year and during the best season for detecting the ground flora (Archaux et al., 2006; Kirby et al., 1986; Korb and Fule, 2008; Milberg et al., 2008; Oredsson, 2000). This was not possible in practice.

None of the original surveyors from 1974 were still active in the Woods when the 1991 and subsequent re-recordings were carried out. The current author played a major role in all the recordings since 1991 but did not make all the records (typically one member of the survey team did the circlet recording while the other searched the rest of the plot). Some combining of species records has taken place where it seems likely that there was inconsistency in species identification.

With a fair wind and not too much bramble about 8 plots a day proved to be a reasonable rate of working, meaning the full set requires about 20 working days. In practice the recordings generally had to be fitted in among other commitments—none of the re-recordings have had dedicated funding—so most re-recordings were spread across the whole summer and some vernal species may therefore have been underestimated. Some recordings were spread across more than one year, but as the gaps between the recordings were much greater than within recording periods this is not thought to present a significant problem (Hedl and Chudomelová, 2020).

Appendix 2 lists people involved in the various recordings and the dates plots were recorded.

4. Data exploration and analysis

Basic analyses of the data to pick out the main spatial and temporal patterns in the ground flora across the 45 years. I have looked particularly at where the data helps to support or contradict general issues and ideas that have been raised in respect of woodland ground flora conservation and management over this period. It is by no means an exhaustive exploration of the results! The main findings have now been published as Kirby et al. (2022).

4.1 Overall vegetation cover change

The mean cover per plot of vegetation below 0.5 m (estimated along the SW-NE diagonal) was calculated and related to changes in canopy cover (estimated as >2.5m along the diagonal) and the contribution to the canopy of different tree species.

4.2 Species richness changes

Some studies have shown declines in the richness of the woodland ground flora over the last 30-50 years (Kirby et al. 2005) but this may depend on scale at which richness is assessed. For example fewer species may be detected in any one plot, but within the whole collection of plots richness may not change because all species are still present somewhere. Plots that had open-canopies (generally high species richness) in the first recording may lose species as the canopy reforms and shade increases, but this loss could be offset if other plots that were dense-canopied in the first recording become more open. Species-richness was therefore assessed for the whole set of 164 plots; for subgroups of plots representing different historical origins or treatments (see Figure 2). Species were identified that contributed disproportionately to the records in terms of their frequency of occurrence and abundance across the Woods.

4.3 Changes in the type of species

The species were grouped in different ways to aid interpretation of the various analyses as follows with more detail in Appendices 3 and 4:

- Through classification of species as Woodland specialists, Woodland Generalists and Non-woodland species based on the approach described in Kirby et al. (2012);
- By their Ellenberg Indicator Values (EIV) for Light, Moisture, Reaction (pH) and Nitrogen as modified for British conditions (Ellenberg, 1988; Hill et al., 2004);
- By their Plant Strategy (Competitor, Stress-tolerator, Ruderal types) after Grime et al. (2007);
- By the mean values for their range of January Temperature, July temperature and annual precipitation (Hill et al., 2004).

The Ellenberg values are strictly ordinal values, but are often treated as cardinal numbers, in order to calculate the mean score for the a condition (Light, Nitrogen etc) in a plot or to explore the likely meaning of axes in a multi-variate analysis. This approach has been adopted in this report, but without any weighting according to species cover/abundance (Käfer and Witte, 2004).

4.4 Similarity comparisons between plots within and between recordings

Species richness could stay the same even though the species composition in the plot changes. Therefore, the species lists for each plot were compared for each pair of recordings using Sorensens's Similarity Index:

$S = 2c * 100 / (a + b + 2c)$ where c = species found on both occasions; a and b are the numbers found on only one or the other occasion.

Changes in the species recorded from one time to the next are a mixture of real gains and losses of species and errors in recording (failure to record a species that is really there). If fluctuations in species numbers per plot are primarily driven by which species happen to be recorded out of an otherwise stable species pool (cryptic turnover) then we might expect the similarity between plot records from one time to the next to be independent of the time interval between comparisons. If there is some sort of directional shift in species-composition then the similarity should decrease with increasing time between recordings.

A separate analysis looked at the Similarity Index between plots within the same recording. Each plot was compared to every other plot recorded at that time to give a measure of homogeneity of vegetation across the Woods. If this measure increased over the five recordings it would suggest that the vegetation was becoming more homogenous as was found in the repeats of Ronald Good's surveys in Dorset (Keith et al., 2009).

4.5 *Decorana analysis*

The changing composition of the plots was also explored using Detrended Correspondence Analysis (DECORANA). Initially all records were used. A second analysis was then carried using the 99 plots that corresponded to the Pre-1800 woodland and the stands from the 19th century of semi-natural origin that had largely grouped together on the full analysis (see Table 4).

4.6 *Changes in species cover/abundance*

Most analyses have been based simply on presence/absence of a species in a plot. The majority of the species, in all recordings, occupied less than 10% of any plot (Domin scores 1-4), such that weighting by cover would have little effect.

For selected species that commonly contributed higher levels of cover or which showed distinctive patterns in terms of their occurrence, further analyses were carried out using the Circlet Frequencies and the Domin scores. For 1991, 1999, 2012, 2018 recordings the Domin cover scores were converted to a percentage value based on the midpoint of the range (Table 7).

Table 7. Conversion of 1974 cover scores and Domin values to percentage cover estimates

Domin scores and % range	% cover equivalent	1974 cover score	% cover equivalent
1	1		
2	2	1 1-5%	2.5
3	3		
4 4-10%	7.5	2 6-25%	15
5 11-25%	17.5		
6 26-33%	29	3 26-50%	37.5
7 34-50%	41.5		
8 51-75%	62.5	4 51-75%	62.5
9 76-90%	82.5	5 76-100%	87.5
10 91-100%	95		

In the 1974 recording cover was estimated only for 6 species and only on a five-point scale. For these 6 species the score was converted to percentage cover using the mid-point of the range. For the other species the frequency values from the circlets record from 1991-2018 recordings for all species were regressed on the relevant percentage covers to provide a general relationship between species cover and frequency. This was then used to convert the 1974 circlet values into cover estimate (Appendix 5).

4.7. Estimates of understory biomass

Biomass for individual species were calculated through applying the Phytocalc approach (Bolte et al., 2004; Schulze et al., 2009) to the estimates of species cover derived from the Domin scores (and backcasts for 1974 data). The form of the equation is given below:

$$P = a \cdot PC^b \cdot MS^c$$

P= Above ground biomass (dry matter, 105°, g/m²); PC= Percentage cover (species, species group); MS= Mean shoot length (above ground, cm); a,b,c Empirical parameters obtained by fitting measured data in the original study (Bolte et al., 2004) and assumed to apply to Wytham as well.

Details of how this was applied to the Wytham data, including the parameters used for each species, are given in Appendix 6.

5. Results

5.1 Changes in vegetation cover

Mean cover (all plots) of the ground vegetation declined during the 1990s but increased again during the last two decades (Table 8). Vegetation cover below 0.5m height (estimated along the main diagonal) was little affected by a canopy cover (>2.5m height) of less than 50% but could be increasingly limited thereafter by increasing shade: the patterns were similar over the 45 years (Figure 5).

Table 8. Mean ground flora cover (<0.5 m high) across the SW-NE diagonal

Recording	Mean %	SE
1974	80.35	2.05
1991	64.24	2.41
1999	67.08	2.48
2012	78.56	2.08
2018	76.15	2.04

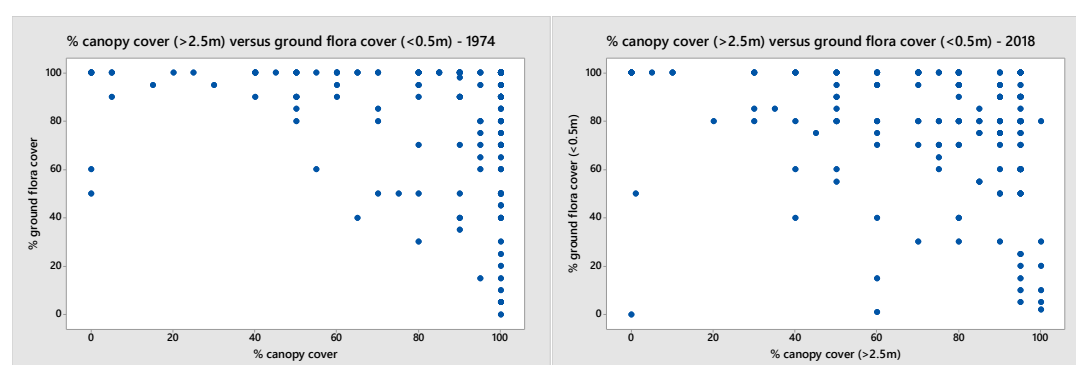


Figure 5 % Ground flora cover versus % canopy cover in 1974 and 2018.

A principal components analysis using the 2018 data confirmed, what is also obvious on the ground: a high canopy cover percentage, particularly of beech and to a lesser extent sycamore is more likely to be associated with a low percentage cover in the middle (0.5-2.5 m) and low (<0.5 m) layers and with low species number in the ground flora. Amongst the main ground flora species the more specialist woodland ones (*Mercurialis perennis*, *Hyacinthoides non-scripta* and *Brachypodium sylvaticum*) are more associated with higher shade (high canopy cover, higher levels of beech and

sycamore) while the taller species (*Rubus fruticosus*, *Pteridium aquilinum*, *Urtica dioica*) are more associated with the lighter conditions (Figure 6). Ash, which has the least dense canopy is more associated with high cover and richness in the ground flora vectors than the other main tree species.

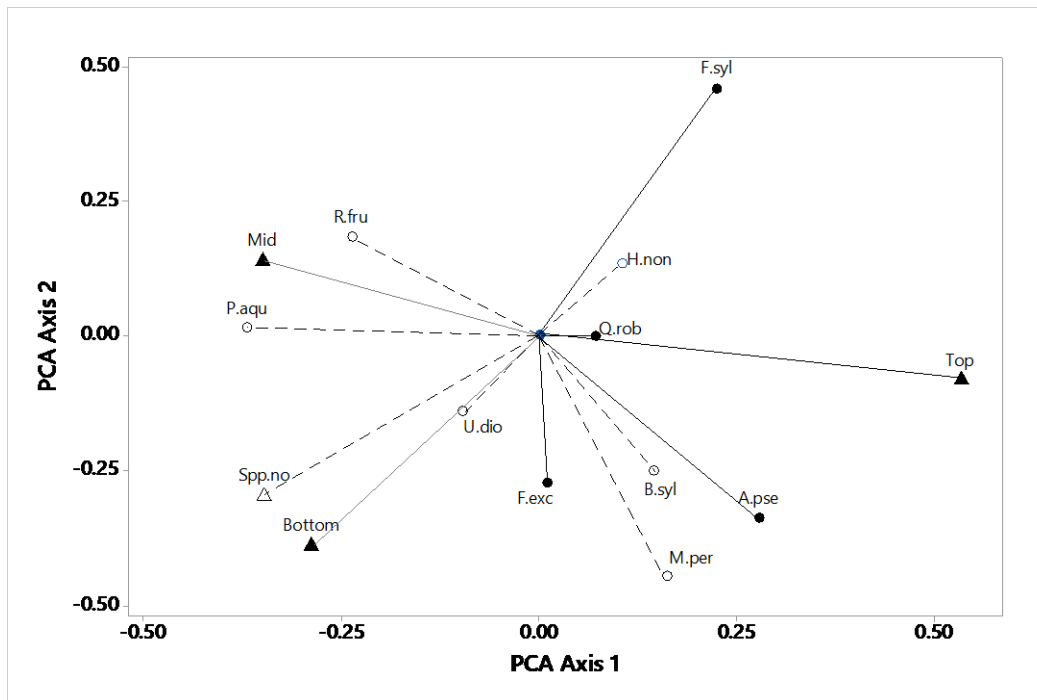


Figure 6. Principal Components Analysis showing correlations between ground flora and cover of the main tree species to the canopy above the plot in 2018.

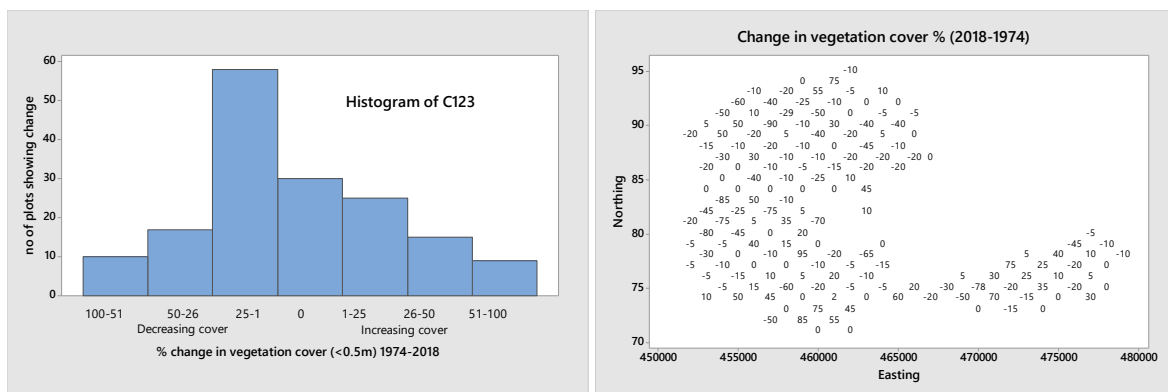


Figure 7. The difference in ground cover (<0.5m height) per plot between 2018 and 1974. (a) number of plots showing large decreases or increases in cover; (b) distribution of cover changes across the Woods.

About 30% of plots (51) showed vegetation cover differences of more than 25% between 1974 and 2018, split more or less evenly between those increasing in cover and those decreasing in cover (Figure 7). While small differences in the cover estimates may simply be recorder effects, these larger differences are likely to represent real changes. There appeared to be no general pattern across the woods, consistent with the response being due primarily to local factors, particularly gap creation or closure around the plot itself.

- Overall mean ground flora cover per plot across the whole of the Woods went down from about 80% in 1974 to 64% in 1991, before increasing to 78% in 2018.
- Both substantial increases and decreases occurred at the plot level over the 45-year period, but with no overall pattern to these changes across the Woods.
- Canopy cover appeared to be the major limiting factor on ground vegetation cover; but tree species effects are important, with light-canopied species such as ash allowing more ground vegetation cover to develop.

5.2 Overview of the flora composition

A list of species and the number of plots in which they were found in each recording (irrespective of cover within the plot) is given in Appendix 7.

The total of 235 ground flora species across all recordings (excluding tree and shrub species) is 38% of the 622 species recorded from the Wytham Estate as a whole (Gibson, 1986). However this total figure includes some species only found outside the woodland boundary, for example on the farmland and riverbanks.

The total found in the plots includes about half the species that are associated with woodland to some degree or other that were used on the standard woodland survey card used by the conservation agencies in 1980s and 1990s for the country as a whole (Kirby et al., 2012). It also compares well with the 277 species found in a survey of 103 woods spread across Britain, with 16 plots per wood, recorded in 1971 and 2001, each plot being twice the size of those at Wytham i.e. 200m² (Kirby et al., 2005); 162 of these species were found in Wytham.

The top twelve species (Table 9) contributed 41% of all records. Some of these species showed little change in occurrence, e.g. *Rubus fruticosus*, some increased particularly between the 1974 and 1991 recordings (*Poa trivialis*, *Brachypodium sylvaticum*, *Deschampsia cespitosa*) while some declined (*Urtica dioica*).

Table 9. The most frequently occurring species across the Woods, 1974-2018

Species	Number of plots in which species occurred					Total
	1974	1991	1999	2012	2018	
<i>Rubus fruticosus</i>	143	128	127	141	142	681
<i>Poa trivialis</i>	111	140	147	127	114	639
<i>Mercurialis perennis</i>	138	132	121	122	121	634
<i>Brachypodium sylvaticum</i>	64	137	142	146	141	630
<i>Urtica dioica</i>	123	129	121	101	98	572
<i>Deschampsia cespitosa</i>	50	101	125	126	116	518
<i>Circaea lutetiana</i>	135	88	81	99	88	491
<i>Glechoma hederacea</i>	100	110	94	69	52	425
<i>Hyacinthoides non-scripta</i>	62	63	79	100	98	402
<i>Geum urbanum</i>	72	63	73	99	83	390
<i>Galium aparine</i>	91	68	48	104	72	383
<i>Pteridium aquilinum</i>	99	78	70	70	63	380

The top twelve in Wytham include three of the five species commonly over-dominant in lowland broadleaved woodland *Mercurialis perennis*, *Rubus fruticosus*, *Urtica dioica*, *Pteridium aquilinum* sometimes referred to as ‘thugs’ (Marrs et al., 2013). They are typical species for National

Vegetation Classification W8 *Fraxinus excelsior*-*Acer campestre*-*Mercurialis perennis* community which is the main type across the Woods (Rodwell, 1991). The other ‘thug’ (*Hedera helix*) is present in Wytham: *Hedera* can tolerate high levels of shade, but is susceptible to grazing where present at low heights.

Woodland generalists made up the biggest group of species and occurrences. The Non-woodland component had twice as many species as the Woodland Specialists, but the contribution of Non-woodland species in terms of occurrences was much less (Table 10). As expected the relative contribution of Woodland specialists was higher in the older woodland (Peterken and Game, 1984), whereas the Non-Woodland species were most abundant in the Rides and Glades. The Non-woodland species component declined over the course of the recordings from 33% of species and 8% of occurrences in 1974 to 27% of species and 4% of occurrences in 2018.

Table 10. Woodland Specialists, Woodland Generalists and Non-woodland species found in different parts of the woodland (based on all five recordings)

Woodland origin and (no of plots)	No of species			No of occurrences		
	Non- woodland	Woodland generalists	Woodland specialists	Non- woodland	Woodland generalists	Woodland specialists
pre 1800, (69)	25	78	32	69	3784	1059
19th C. wood, (84)	36	89	28	113	2971	657
20th C. wood (15)	41	78	22	136	904	130
Rides and glades (23)	74	89	25	481	2240	444
All 164 plots	90	105	40	799	9899	2290

Means were calculated for each plot based on the species Ellenberg Indicator Values and Grime’s Plant Strategy scores etc (Appendix 8). There was little overall change. The losses were concentrated amongst the more light-demanding species, based on EIV-Light numbers with the number of occurrences largely maintained at the shady end of spectrum. There is no obvious pattern for EIV-Nitrogen or EIV-Moisture. There was a weak suggestion of increased acidification in parts of the Woods and that the flora was a little more moisture-demanding towards the later recordings. No thermophilisation of the ground flora was detected in terms of shifts in the mean January or mean July temperatures of the species or plot scores.

- A total of 235 species were found across all recordings, which is not outstandingly rich for the size of the Woods (c.400 ha) but includes a good representation of woodland species typical of lowland woods.
- The flora is dominated by a small number of species notably *Rubus fruticosus*, *Poa trivialis*, *Mercurialis perennis* and *Brachypodium sylvaticum*; the top twelve species contributed 47% of species records across all five recordings.
- The vegetation can be broadly grouped into that of the older woodland of semi-natural origin, the younger plantation stands and the more open rides and glades.
- The species were grouped into woodland specialists (stress tolerators, often high shade species); the more competitive, woodland generalists that tend to be the commonest plants in the woods; and the non-woodland species associated with the more open plots which tend to have a greater ruderal element and high light requirements.
- The contribution of non-woodland species is greatest in the Ride and Glade plots;
- The contribution of woodland specialists increases the longer an area has been wooded while that of non-woodland species declines.

5.3 Species Richness patterns

Although 235 species were found across all recordings the most found at any one time was 182 from the 1974 records, going down to 141 species in 2018 (Table 11). This pattern is repeated in the totals for the different woodland groups (see Table 4).

The numbers found in the closed woodland plots were about half those in the Ride and Glade plots; Peterken and Francis (1999) drew attention to the high proportion of species associated with just a small area of open space in their study of the Lincolnshire limewoods.

The disturbed areas in the older woodland tended to be richer than the semi-natural blocks in the first two recordings (Corney et al., 2008). Various plantations created in the late 1950s and 1960s had only relatively recently closed canopy by 1974.

The number of species in the different woodland blocks thereafter tended to converge. The oldest semi-natural stands showed least overall change. As with the total number of species the mean number per plot in 2018 was the lowest.

Table 11. Mean number of species per plot by woodland origin and treatment (see Table 4).

Woodland type & Origin	No of _plots	1974	1991	1999	2012	2018	Across all times
Pre-1800, semi-natural	29	13.4	15.2	15.0	15.9	13.0	27.6
Pre-1800, disturbed	40	16.3	15.4	13.5	13.3	11.6	26.7
19th C., semi-natural	19	12.9	15.3	14.5	15.9	12.3	29.2
19th C._disturbed	11	15.4	10.1	11.7	12.4	12.5	30.0
19th C, plantations	27	13.9	14.8	12.3	12.5	10.3	26.4
20th C., mostly plantation	15	19	17.9	13.7	15.6	11.8	41.5
Rides and glades	23	27.6	30.5	27.4	28.2	24.0	53.7
All plots	164	16.7	17.3	15.5	16.1	13.5	32.5

The broad geology of the Woods did not have a significant effect on the mean plot richness, nor was there any obvious overall relationship between 1974 species richness and the then levels of soil Nitrogen or soil pH (measured in CaCl_2).

Species richness was negatively correlated with canopy cover, calculated using the data from all five recordings, with little difference in the relationship if calculated for each recording separately (Figure 8). Where plots had shown large increases in canopy cover between 1974 and 2018 their species richness dropped markedly (Figure 9).

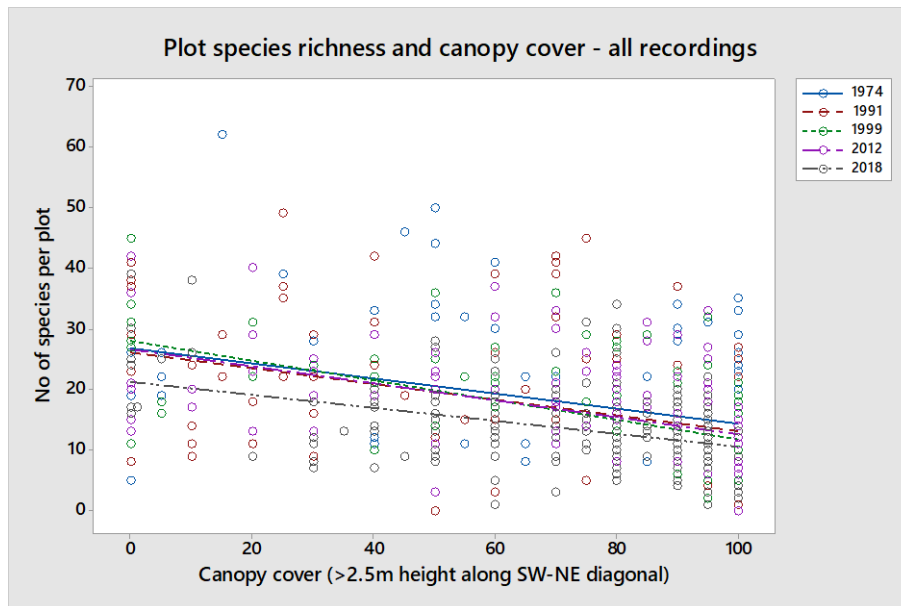


Figure 8. Plot species richness and canopy cover for all recordings.

No of species = $25.3 - 0.13 \times \text{Canopy cover}$. $R^2=19\%$ $p<0.001$. $F=194$, df 1, 817.

The lines show the relationship for each recording when analysed separately.

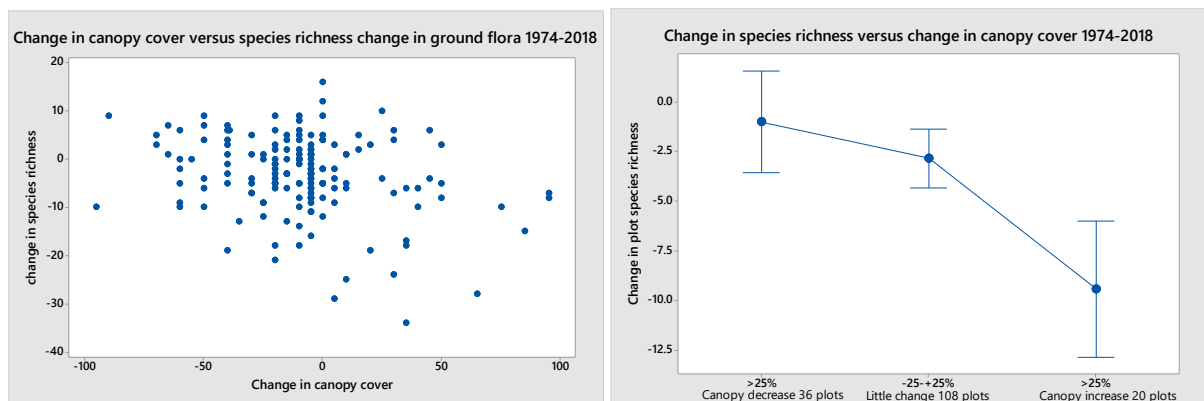


Figure 9. Change in number of species per plot with changing canopy cover (2018-1974) (a) all plots; (b) mean change with standard error bars for plots showing a large decrease in cover (>25%), where little change ($\pm 25\%$), or a large increase in canopy cover (>25%).

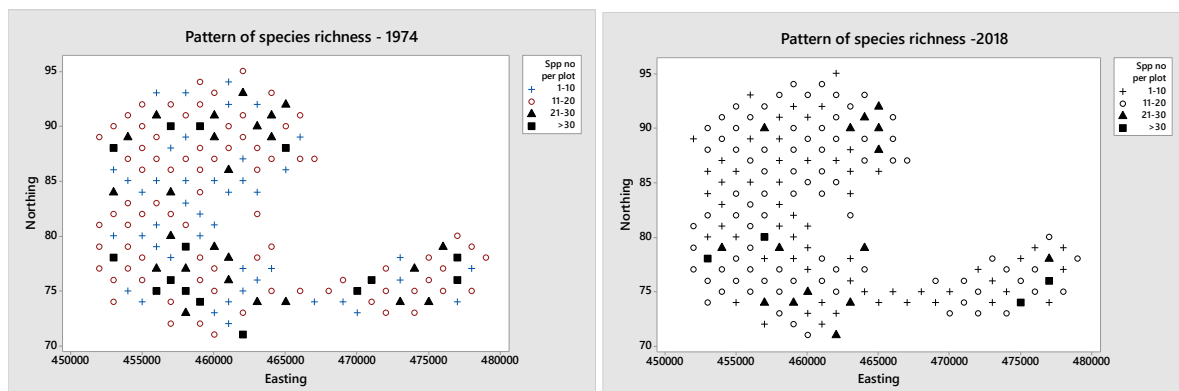
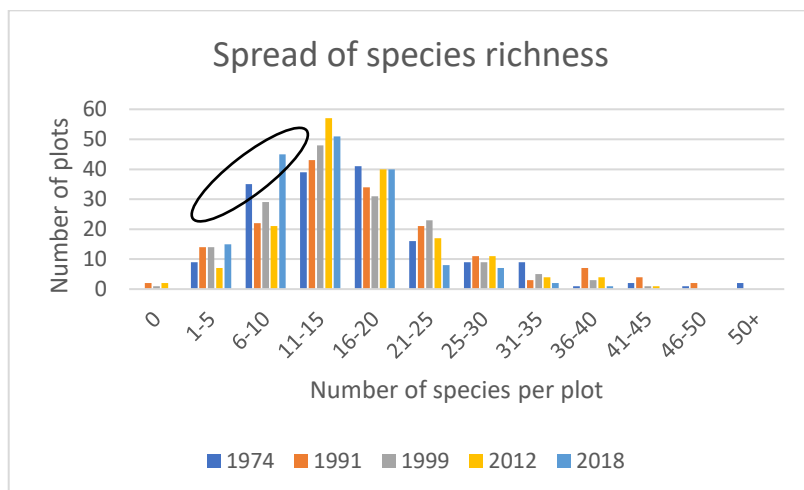


Figure 10. Patterns of plot species richness: 1974, 2018.

Methodological factors could have contributed to lower richness values in 2018: it was during a severe drought and many of the plots were recorded by one person (the author) rather than two. However, the spread of species richness values is similar to previous recordings except for a spike in the 6-10 species class (also seen in the 1974 records) and slightly fewer in the >30 species classes. When recording species-poor plots there is more of a tendency to concentrate on adding to the list, and so I believe the spike in low richness plots is genuine.



- Species richness per plot showed little variation over the 45 yrs, except for a low value in 2018 (16.7 species per plot in 1974, 17.3 in 1991, 15.5 in 1999, 16.1 in 2012, but only 13.5 in 2018).
- There was similar pattern to the number of species recorded in total across the full set of plots (182 in 1974, 171 in 1991, 147 in 1999, 158 in 2012, 141 in 2018).
- Plot species richness was negatively correlated with canopy cover over the whole period, but small differences in canopy cover had relatively little effect on plot richness.
- Across all recordings species richness in the more open Ride and Glade areas (mean 24-30 species per plot) was about 1.5-2.0 times the number found in the more closed woodland plots.

5.4 Species richness stability and turnover

Even after 45 years species-richness in 1974 explained about 27% of the variation in plot richness in 2018 (Figure 11a). However, the number found in any, one recording of a plot was only about half the number found if the records from all the recordings were combined (Figure 11b). Gains and losses between recordings were reasonably evenly balanced (Figure 12). The number of species per plot across all recordings is given in Appendix 9.

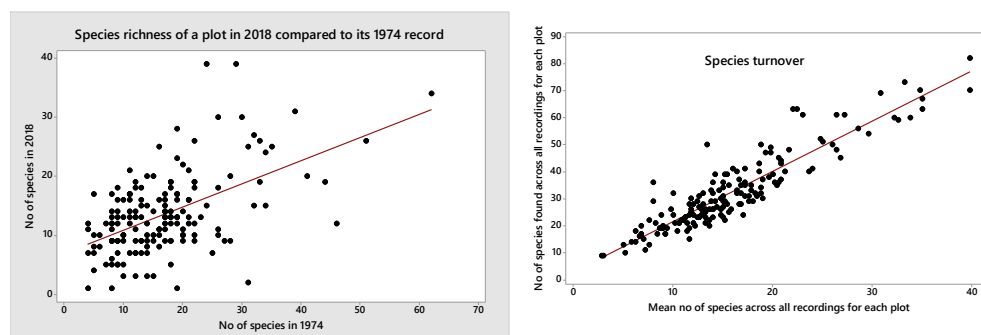


Figure 11. (a) Species richness per plot in 2018 compared to 1974 ($sppno_{2018} = 6.9 + 0.39 \cdot sppno_{1974}$; $R^2 = 29\%$, $F = 66.4$, $Df 1, 162$, $p < 0.001$); (b) Mean number of species recorded for a plot across the five recordings versus the number of species found in all recordings ($totsppno = 3 + 1.8 \cdot meanno$, $F = 853$, $DF 1, 162$, $p < 0.001$)

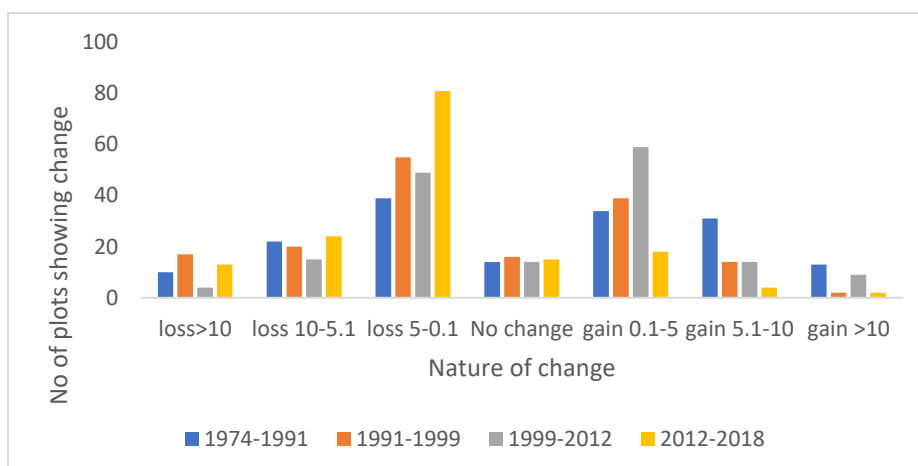


Figure 12. Change in species richness per plot for different recording intervals

There were 5326 records for the presence of a given species in a given plot on at least one recording but 2227 (41%) are 'singletons' – a species recorded in a particular plot on only one of the five recordings. For example, *Hypericum hirsutum* was recorded from 76 plots overall but only from one recording in 37 plots and from only 4 plots on all five occasions (Table 12). The low consistency species often have more ruderal traits. At the other end of the spectrum 1532 records (29%) are for species recorded in four or five of the recordings from a given plot, for example *Mercurialis perennis* was recorded from 154 of the 164 plots at one or other of the recording times, and in 106 plots was present in all five recordings.

- Species richness at the plot level often showed large fluctuations from one recording to the next, with both increases and decreases being common.
- In any one plot only a few species were recorded across all five recordings, with many species turning up only once or twice.

Table 12. Species recorded from at least 30 plots across the five recordings, grouped by consistency of presence in a plot: high consistency means that in >75% of plots the species was recorded in at least 4 of the recordings; low consistency the species was recorded in only 1 or 2 occasions.

	No of plots in which present	No of years recorded from each plot				
		1	2	3	4	5
High consistency						
<i>Rubus fruticosus</i>	160	6	13	14	28	99
<i>Poa trivialis</i>	161	10	10	25	46	70
<i>Brachypodium sylvaticum</i>	160	9	11	16	69	55
<i>Urtica dioica</i>	147	11	18	22	21	75
<i>Mercurialis perennis</i>	154	17	14	9	8	106
<i>Deschampsia cespitosa</i>	149	20	16	25	49	39
Low consistency						
<i>Veronica chamaedrys</i>	69	32	20	7	7	3

<i>Potentilla sterilis</i>	37	20	8	6	2	1
<i>Hypericum hirsutum</i>	76	37	21	10	4	4
<i>Lonicera periclymenum</i>	49	23	15	7	2	2
<i>Stachys sylvatica</i>	34	14	13	4	3	0
<i>Taraxacum officinalis</i>	52	33	9	4	6	0
<i>Heracleum sphondylium</i>	33	24	3	5	0	1
<i>Angelica sylvestris</i>	47	28	12	3	3	1
<i>Clematis vitalba</i>	47	33	7	4	1	2
<i>Cerastium fontinalis</i>	34	21	8	5	0	0
<i>Hedera helix</i>	41	16	19	4	0	2
<i>Scropularia nodosa</i>	40	22	13	4	1	0
<i>Juncus effusus</i>	46	23	18	3	1	1
<i>Holcus mollis</i>	41	32	5	4	0	0
<i>Cardamine flexuosa</i>	42	23	15	4	0	0
<i>Arctium minus</i>	32	25	5	2	0	0
<i>Stellaria media</i>	37	28	7	2	0	0
<i>Epilobium montanum</i>	60	47	10	3	0	0
<i>Ranunculus ficaria</i>	31	28	2	1	0	0
<i>Cirsium vulgare</i>	34	31	2	1	0	0
<i>Rubus caesius</i>	34	27	6	0	1	0
<i>Chamerion angustifolium</i>	44	35	9	0	0	0
<i>Epilobium hirsutum</i>	31	30	1	0	0	0
<i>Sonchus oleoraceus</i>	36	32	4	0	0	0

5.5 Plot similarity across time and space

Some of the turnover of species described in the previous section might be 'crypto-turnover', where a species is wrongly recorded as present (perhaps through a misidentification) or a species that is present is missed. If the pool of species is limited and the variation between recordings is simply a crypto-turnover effect then the similarity of lists between recordings might be expected to be about the same over time. However, the mean Sorensen Similarity Index based on comparing the species in a plot with each of the lists from previous recordings, declines with an increase in the interval between recording times (Figure 13).

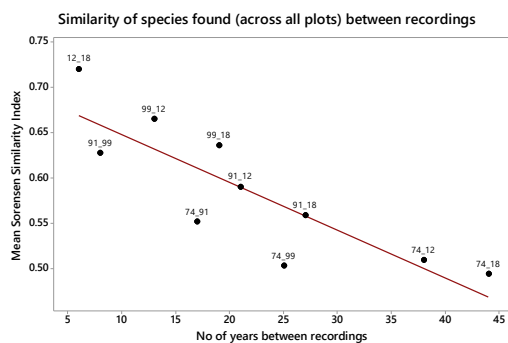


Figure 13. Decreasing similarity of a plot record with its previous recording with increasing time interval between recordings. The regression line is based on individual plot values but only the mean values for each year-on-year comparison are shown: i.e. 12_18 is the mean similarity for the plots in 2012 compared to 2018; 74_18 is the mean for the plots in 1974 compared to 2018). %similarity = $70 - 0.5 \times \text{Year_difference}$; DF 1,1633, $p < 0.001$, $R^2 = 12\%$.

In a second set of similarity analyses each plot was compared with every other plot from the same recording time to assess homogeneity (Keith et al., 2009). There was overall a significant increase in mean similarity i.e. increased homogeneity in the first two decades. This trend was reversed in the subsequent two decades with more plot-pair comparisons showing decreased similarity (Table 13). However while on average pairs of plots were more similar to each other in 1999 than in 1974, about 30% of plot-pair comparisons were less similar (decreasing homogeneity); a similar proportion showed an increased similarity (increasing homogeneity) in 2018 compared to the value for 1999, even though on average homogeneity was decreasing (Figure 14). Across the 1974-2018 period as a whole the closed woodland plots have become more similar to each other, with the twentieth century stands in particular becoming more similar to the older woodland (Table 14). This form of increasing homogeneity could be considered a positive change unlike situations where increased homogeneity is ascribed *inter alia* to nitrogen pollution (Keith et al., 2009).

Table 13. Mean (\pm SE) similarity of plots at each recording time based on 13366 plot-pair comparisons for each recording period.

	1974	1991	1999	2012	2018
Mean % similarity	37 \pm 0.1	42 \pm 0.1	45 \pm 0.1	43 \pm 0.1	42 \pm 0.1

Table 14. Mean (\pm SE) change in similarity (2018-1974) for plot pairs of a particular woodland group: positive values = increase in homogeneity. (The number of comparisons is given in brackets below the mean.)

Woodland group (see table 4)	Pre-1800	19 th century stands	20 th century stands	Rides and glades
Pre-1800	9.8 \pm 0.5 (1240)	5.7 \pm 0.4 (1979)	16.9 \pm 0.9 (435)	7.1 \pm 0.6
19 th century stands		1.3 \pm 0.2 (4656)	10.5 \pm 0.5 (1455)	1.5 \pm 0.3 (2231)
20 th century stands			9.8 \pm 1.8 (105)	4.5 \pm 0.9 (105)
Rides and glades				6.8 \pm 0.8 (253)

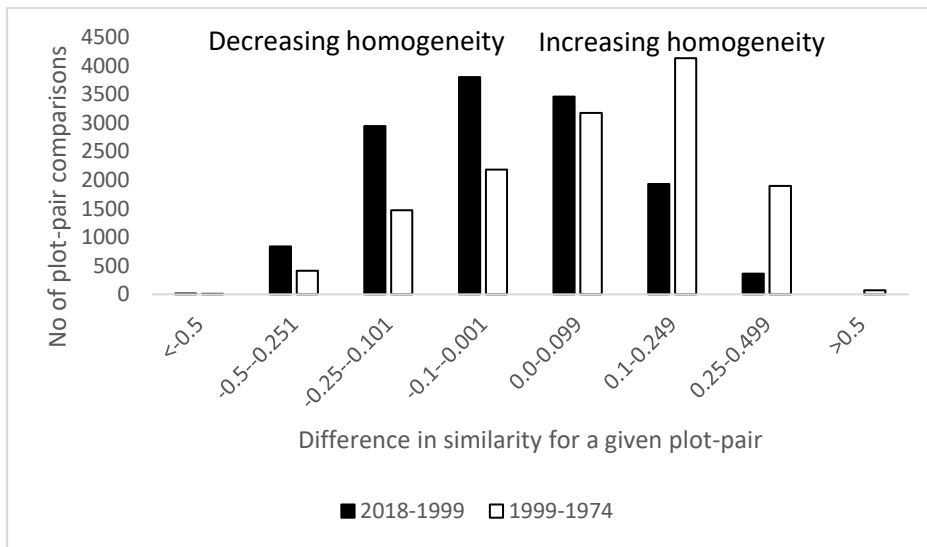


Figure 14. Distribution of differences in the Similarity Index for any given plot-pair, for a period of increasing homogeneity overall (1974-199) and decreasing homogeneity (1999-2018).

- *The similarity (Sorensen's Index) between recordings from the same plot steadily declined with increasing time interval between recordings.*
- *The similarity between plots from the same recording time (homogeneity) was highest in the 1990s, but then declined again somewhat. Homogeneity went both up and down in different parts of the Woods between each recording.*
- *A major reason for increasing homogeneity was that the 20th century plantation plots became more similar to the older woodland and less like the Ride and Glade plots.*

5.6 Decorana Analysis for all plots, all recordings

The initial DECORANA run used the results from all plots across all five recordings. The mean positions for the different woodland plot groups at each recording time are shown via the connecting lines on Figure 15. The Rides and Glade plots are strongly separated from the woodland plots except for the 1974 records of the young 20th C plantations. However, over the next 45 years these latter plots became more like the rest of the woodland. Plots in the mature 19th century plantations, mainly on the top of the hill (shallower, more calcareous soils), often with a strong beech component in the canopy, diverged from the mainly ash and sycamore woodland on the lower moister slopes.

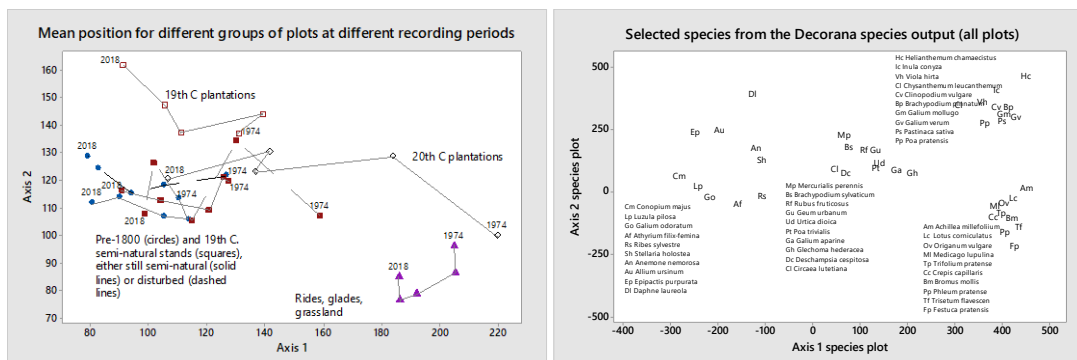


Figure 15. DECORANA output axes 1 and 2: (a) mean scores for plots of different types for different recording times; (b) selected species locations on the axes.

As Corney et al. (2008) found when analysing change just from 1974-1999 the first axis appears to be related to light availability. Axis 1 scores for plots are significantly correlated with the canopy cover estimates made along the diagonal of the plot (Figure 16) with 27 % of the variation explained. (Axis 1 = $198.59 - 1.004 \cdot \text{Canopy Cover}$; DF 1, 818; $p < 0.001$). The regression lines for each of the years considered separately are similar. The woodland plots have generally shifted to the left over the recording period, i.e more shaded conditions.

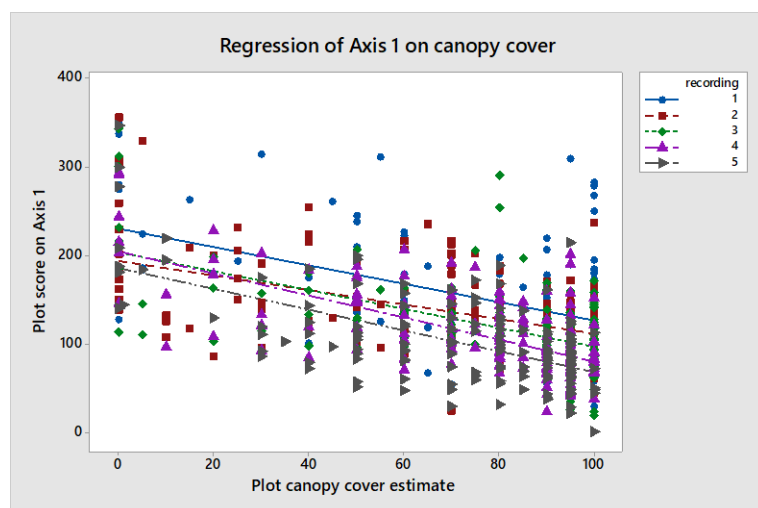


Figure 16. Correlation between plot position (all recordings combined) on axis 1 and canopy cover estimate (>2.5m height along SW-NE diagonal). The lines show the regressions for each recording period analysed separately.

Non-woodland species cluster at the positive (low canopy cover) end of Axis 1, with Woodland-specialists (which tend to be more shade-tolerant) at the negative end; Woodland generalists in the middle (Figure 17). There is a strong correlation between EIV-Light scores and the position of species on Axis 1 (Axis 1 score = $-384.2 + 96.97 \cdot \text{Light score}$; $R^2 = 47\%$; 227 DF, $P < 0.001$).

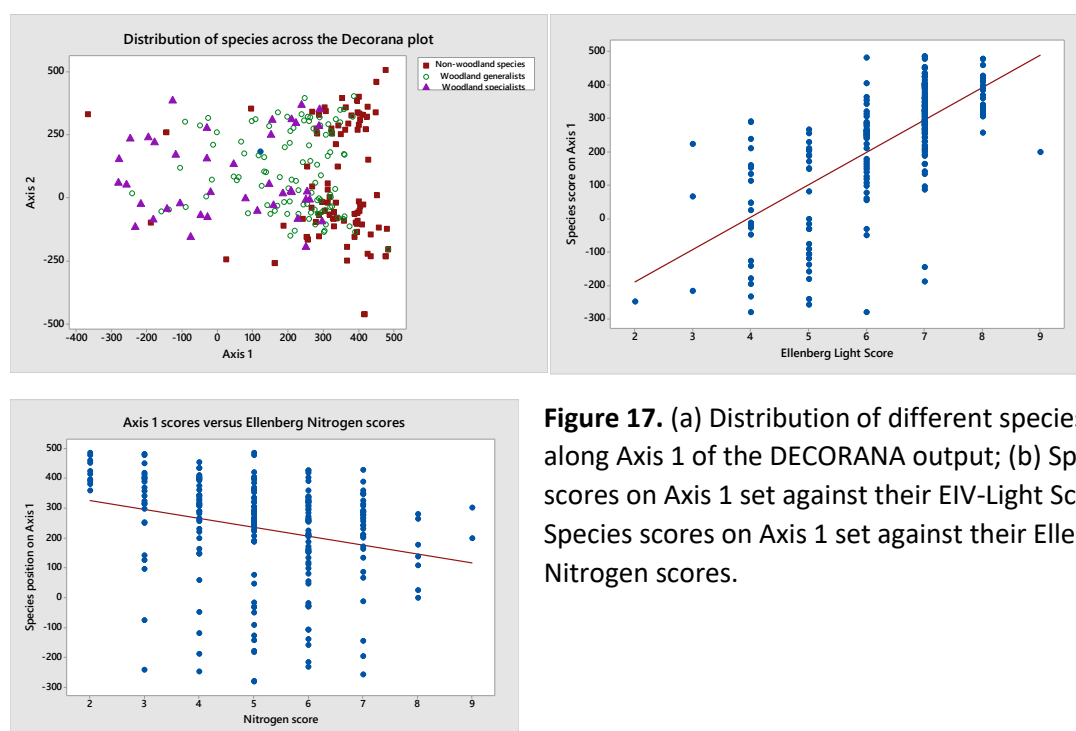


Figure 17. (a) Distribution of different species groups along Axis 1 of the DECORANA output; (b) Species scores on Axis 1 set against their EIV-Light Score; (c) Species scores on Axis 1 set against their Ellenberg Nitrogen scores.

Species scores on Axis 1 showed a significant negative correlation with EIV-Nitrogen scores but the R^2 was only 4.9%. As it seems unlikely that plots would be becoming less nitrogen rich over time (there is direct evidence for increased soil nitrogen between 1974 and 1991 for example (Farmer, 1995)) this may be an artefact from the reduction of some high light but also high nitrogen scoring species.

Axis 2 shows a significant correlation with EIV-Reaction (pH) scores although the R^2 is again rather low, only 9.7% (Axis 2 Score = $-320.4 + 63 \times \text{Reaction score}$; 227 DF, $p < 0.001$ and a weak but non-significant ($p = 0.14$) tendency towards dryer conditions based on EIV-Moisture scores (Figure 18). This latter is however also supported by a plot of species mean precipitation requirements (Hill et al., 2004). (Axis 2 score = $793 - 0.71 \times \text{mean precipitation}$; $F = 47$, DF 1, 229; $p < 0.001$; $R^2 = 16\%$).

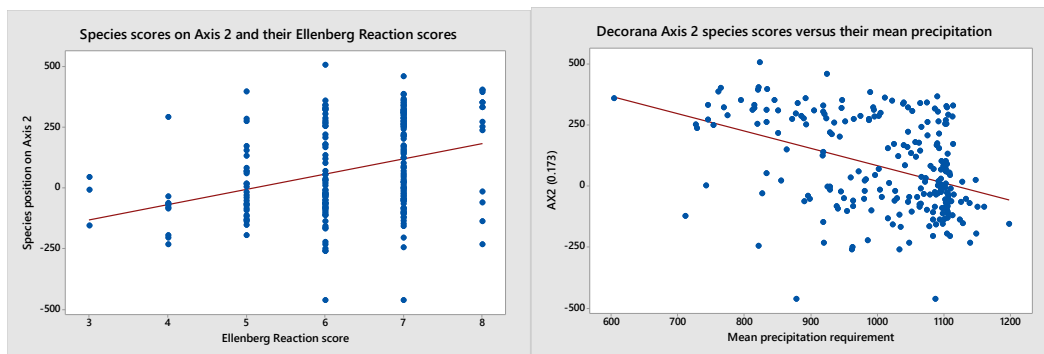


Figure 18. Axis 2 species scores against (a) Ellenberg Reaction (pH) values and (b) mean precipitation requirement from Hill et al. (2004).

A second Decorana run excluded the Rides and Glade plots, the 19th and 20th century plantations on open ground, leaving the 99 plots that had clustered together most on the first run. There was still a tendency towards convergence of the plot scores over time (Figures 19, 20); again the species split with Woodland Specialists towards the low end of Axis 1, Non-woodland species at the high end; and the strong correlation between Axis 1 and EIV-Light scores. Axis 2 has a weaker link to EIV-Reaction scores. There was a small increase in soil acidity (reduction in pH) in soils from about a quarter of the plots across the Woods from 1974 to 1991 when the biggest change seems to have occurred (Farmer, 1995). There was no relationship with EIV-Nitrogen scores.

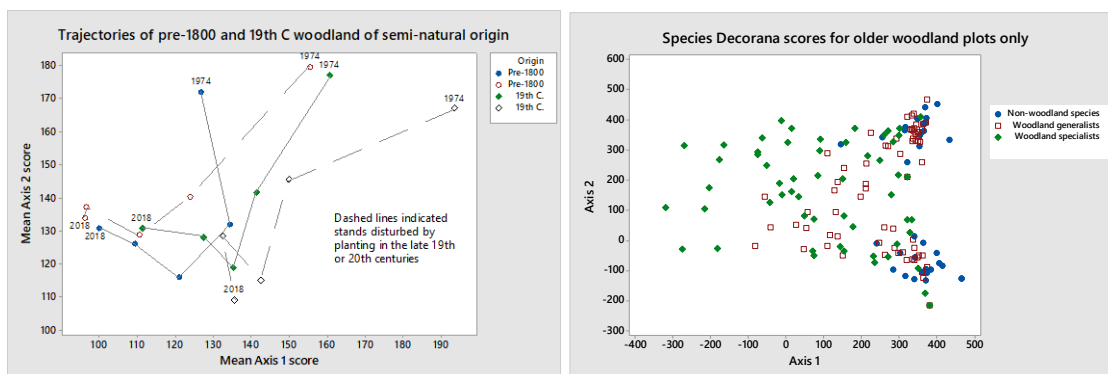


Figure 19. Decorana output for (a) plots and (b) species for the older woodland only.

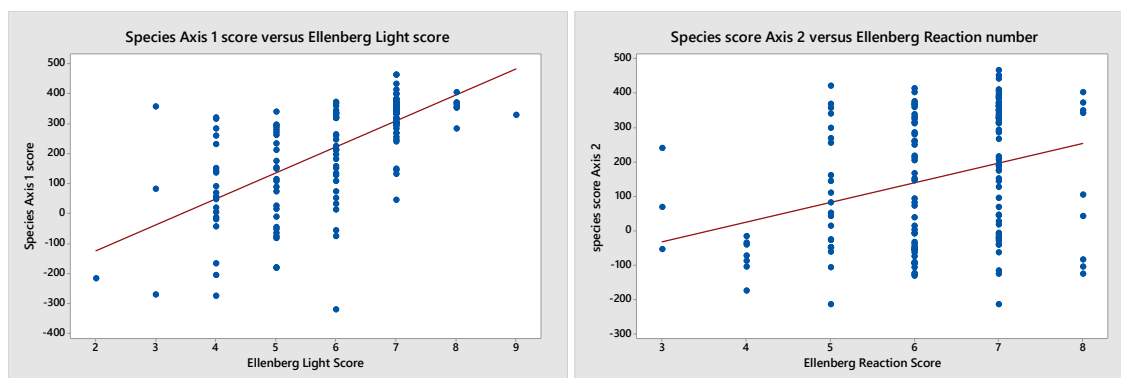


Figure 20. (a) Axis 1 scores versus species EIV- Light scores (Axis 1= $-299+87*L$; $F=116$, $DF1,159$; $R^2=40\%$); (b) Axis 2 scores versus species EIV-Reaction scores (Axis 2= $-205+57*R$; $F=17.5$ $DF 1, 155$; $R^2=8\%$)

- Trends in the older stands of semi-natural origin appear to be partly an effect of increased canopy cover – i.e. the plots were becoming more shady.
- EIV-Light Scores per plot were negatively correlated with canopy cover and there was a general decline in EIV-Light Score per plot over the 45 yr period.
- Soil acidification may have contributed to some floral changes between 1974 and 1991; there were small decreases in EIV-Reaction (pH) scores.
- No thermophilisation of the ground flora was detected in terms of shifts in the mean January or mean July temperatures of the species or plot scores; there was a slight trend towards species associated with higher annual rainfall, but this may be because of a shift to more shady florals.
- There was no overall change in EIV-Nitrogen scores. There was an increase for the 20th Century plantation group of plots, but other plots often showed decreases. Some high Nitrogen species such as *Alliaria petiolata* are however increasing. There was also a weak negative relationship between an increase in Nitrogen score and a decline in species richness (but R^2 less than 10%)

5.7 Major changes in individual species occurrence

For most species there has been little change in their overall occurrence in the woodland: species frequency in 2018 is strongly correlated with that in 1974 (Figure 21). Table 15 gives the species showing a greatest deviation from this relationship. Those decreasing over the period (below the line) tend to be the larger, more light-demanding species; those increasing include a strong graminoid component.

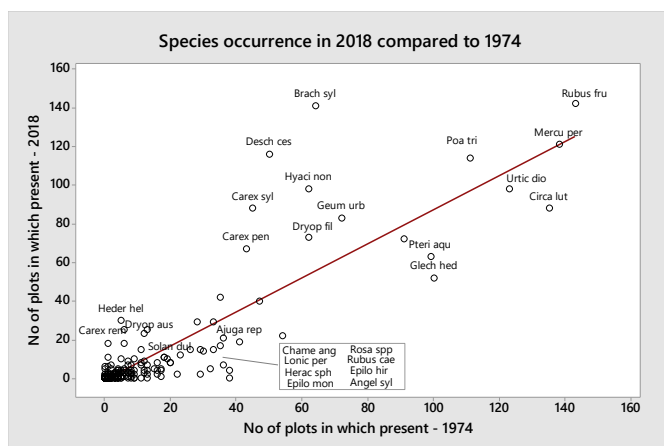


Figure 21. Relationship between number of plots in a which a species occurred in 2018 compared to the frequency of its occurrence in 1974. ($2018occ = -0.87+0.88*1974occ$; $F=765$, $DF 1, 233$; $R^2=75\%$)

Table 15. Species tending to increase or decrease over time (no of plots in which present)

Decreasing over time	1974	1991	1999	2012	2018
Graminoids					
<i>Festuca gigantea</i>	23	23	15	12	7
Short herbs					
<i>Ajuga reptans</i>	27	8	10	15	10
<i>Circaea lutetiana</i>	84	57	51	67	56
<i>Glechoma hederacea</i>	57	65	56	46	34
<i>Mercurialis perennis</i>	84	80	70	71	72
Tall herbs					
<i>Angelica sylvestris</i>	20	8	1	0	0
<i>Chamerion angustifolium</i>	29	7	0	2	0
<i>Epilobium hirsutum</i>	15	2	1	4	1
<i>Epilobium montanum</i>	20	10	5	3	1
<i>Heracleum sphondylium</i>	11	1	0	1	0
<i>Lonicera periclymenum</i>	28	21	5	13	10
<i>Pteridium aquilinum</i>	69	56	50	42	38
<i>Rosa spp</i>	19	12	7	14	7
<i>Rubus caesius</i>	20	0	2	3	1
<i>Solanum dulcamara</i>	13	2	0	1	0
<i>Urtica dioica</i>	76	77	69	57	55
Increasing over time					
Fern					
<i>Dryopteris austriaca</i>	5	14	21	18	19
Graminoid					
<i>Brachypodium sylvaticum</i>	33	82	87	89	87
<i>Carex pendula</i>	30	25	29	38	41
<i>Carex remota</i>	1	4	16	15	13
<i>Carex sylvestris</i>	26	38	56	60	56
<i>Deschampsia cespitosa</i>	27	67	82	81	75
Short herb					
<i>Geum urbanum</i>	33	31	36	58	48
<i>Hyacinthoides non-scripta</i>	47	51	60	65	65
<i>Hedera helix</i> (on ground)	1	0	1	18	13

- For most species there has been little change in their total occurrence from 1974-2018, but for a small group of species there have been either substantial increases or decreases in occurrence.
- Those that have declined most tend to be tall herbs, while short herbs and graminoids have increased are common amongst the increasers.

5.8 Changes in within-plot frequency – circlet data

The previous sections have focussed on species presence/absence in the plots, because most species occur only at low cover. However there have been some notable changes in frequency within plots

(measured as occurrence in the thirteen circlets (0.01m²) distributed across the diagonals and cover (Domin scores from 1991 onward) discussed in the next section.

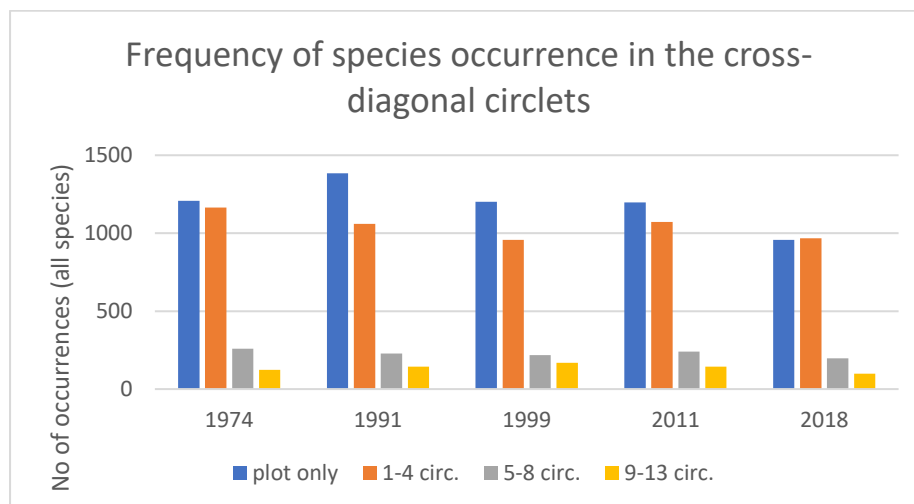


Figure 22. Species occurrences in the 13 circlets recorded in each plot – all species.

In most plots most species were present only as scattered plants so while they would be recorded from the plot they might not be picked up in the circlets or if they were only in one or two of them (Figure 22). Detection in the circlets was affected by the growth form of the species: species growing as scattered individuals such as *Dryopteris filix-mas* and *Arum maculatum* were rarely detected in more than one or two circlets when present: gregarious species such as *Poa trivialis* and *Mercurialis perennis*, if present in a plot, were likely to be there in abundance (Figure 23); large spreading species such as *Rubus fruticosus* or *Pteridium aquilinum* might occupy a large part of the plot but be rooted at only a few points, so not picked up so much by the circlets.

A few species showed the increases in circlet frequency over time such as *Brachypodium sylvaticum* and in the last two recordings *Hedera helix*. Others declined, notably *Chamerion angustifolium*, which also was reduced in its overall frequency of plot occurrences, where *Rubus fruticosus* retained its presence in plots but was reduced in cover in the middle recordings.

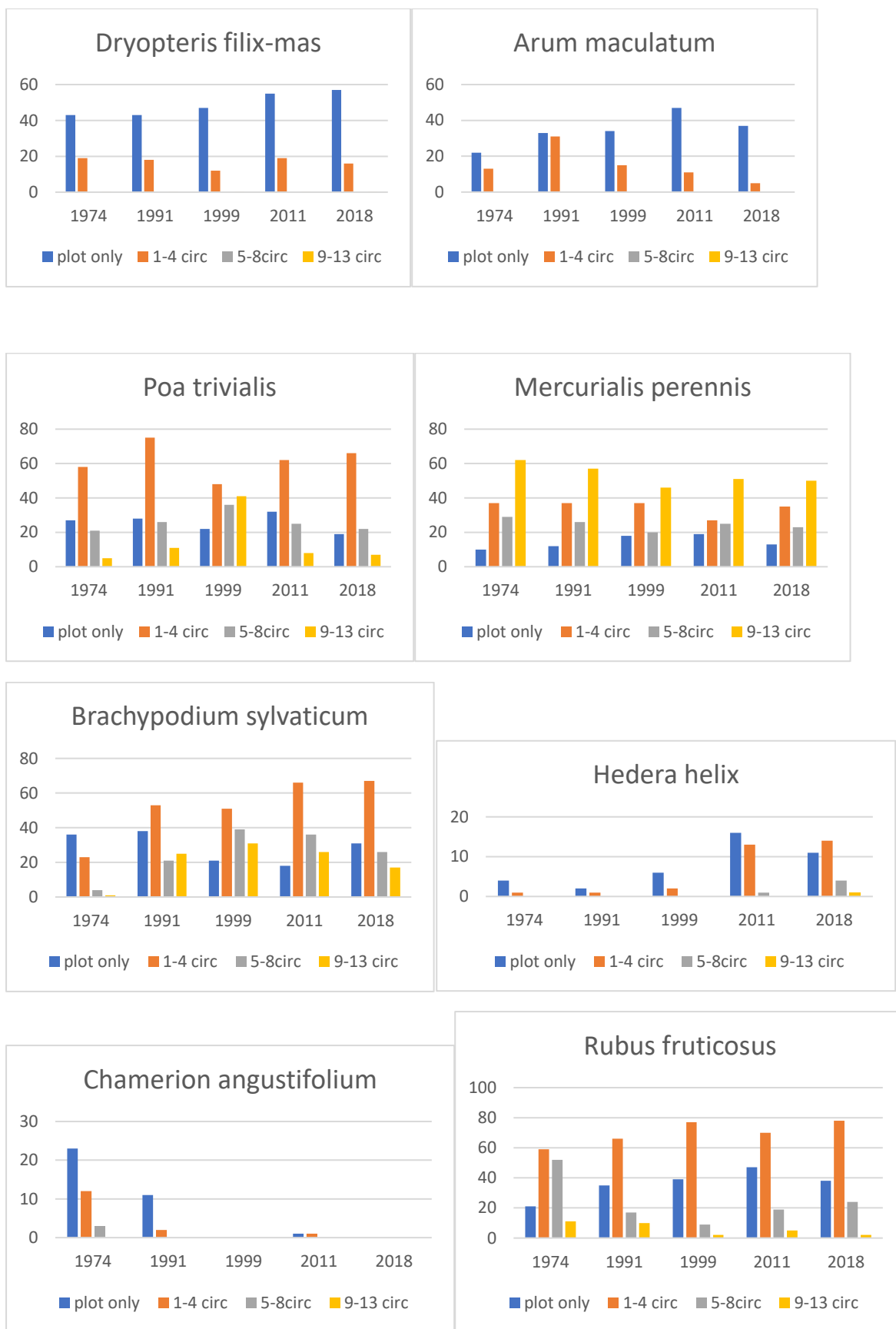


Figure 23. Species showing different patterns of circlet detection.

5.9 Changes in cover of individual species

The general vegetation cover estimated along the diagonal (see section 5.1) takes no account of overlapping layers of species, nor of the occurrence of some of the taller species (*Rubus fruticosus*, *Urtica dioica*, *Pteridium aquilinum*) as part of the Mid-cover estimates. The sum of the individual species cover estimates may therefore be more than 100%. For 1991–2018 recordings the Domin scores were converted to percentage covers by taking the mid-point of the range. For the 1974 recording, the ‘ecosig’ 5-point score was converted to percentages, again by taking the mid-point of the range. For other species an estimate of the Domin equivalent for 1974 was derived using the relationship between circlet frequencies and cover estimates from the 1991–2018 recordings. This was then converted to a percentage score.

Most species contributed less than 1% mean cover at any one recording with just about 12 species dominating the cover estimates. Some of these showed big changes between 1974 and 2018 (Figure 24).

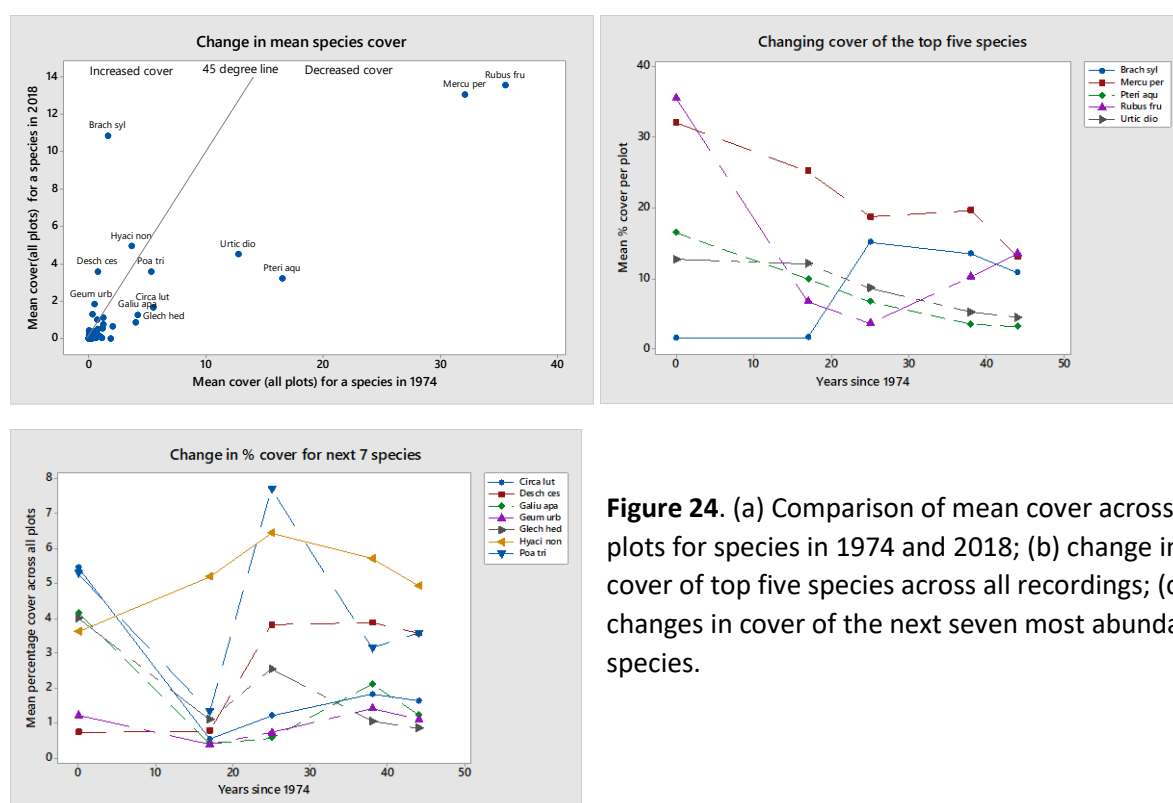


Figure 24. (a) Comparison of mean cover across all plots for species in 1974 and 2018; (b) change in cover of top five species across all recordings; (c) changes in cover of the next seven most abundant species.

Three of the top five (*Mercurialis perennis*, *Pteridium aquilinum* and *Urtica dioica*) showed steady declines across the 5 recordings; *Rubus fruticosus* showed a precipitous drop during the first 20 years but has been regaining ground since. *Brachypodium sylvaticum* increased sharply during the 1990s but has been declining since (Figure 24b). Amongst the next seven species *Hyacinthoides non-scripta* and *Deschampsia cespitosa* increased during the 1990s but may now be starting to decline; *Circaea lutetiana*, *Galium aparine* showed initial declines but then some recovery; *Glechoma hederacea* generally declined apart from a small recovery between 1991 and 1999; *Geum urbanum* shows very little change across the recordings; the line for *Poa trivialis* is very erratic possibly because later in the season its above-ground parts may not be obvious making it difficult to judge its cover (Figure 24c).

The most obvious change to the appearance and structure of the ground flora was the increase in cover of *Brachypodium sylvaticum* from 1974 to 1999, with a parallel decline in bramble *Rubus fruticosus* and the reversal of that trend in the subsequent two decades (Figure 25). The decrease in *Brachypodium* cover (>10%) was particularly marked in the plots where *Rubus* showed a corresponding increase of more than 10% (Table 16).

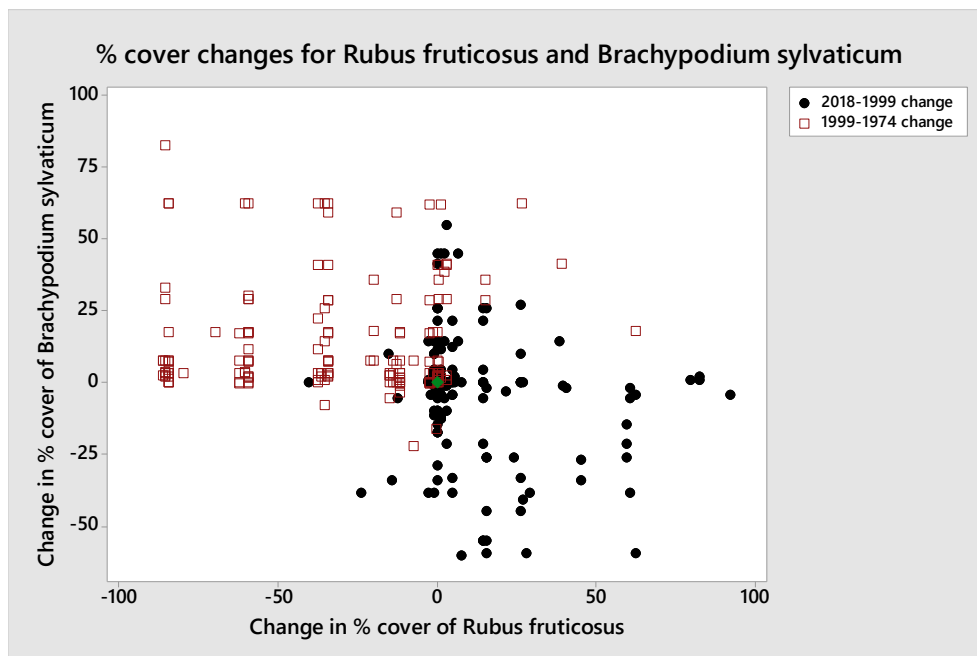


Figure 25. Changes in cover of *Brachypodium sylvaticum* and *Rubus fruticosus* in the periods 1974-1999 and 1999-2018.

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	14893	14892.5	34.85	0.000
rfboth	1	14893	14892.5	34.85	0.000
Error	327	139738	427.3		
Lack-of-Fit	58	42561	733.8	2.03	0.000
Pure Error	269	97177	361.3		
Total	328	154631			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
20.6721	9.63%	9.35%	8.44%

Regression Equation

$$\text{bsboth} = 2.44 - 0.1981 \text{ rfboth}$$

Table 16. Association between increasing *Rubus* cover and decreasing *Brachypodium* cover in the period 1999-2018.

	Number of plots		
	Increasing bramble 1999-2018(>10%)	Change in bramble cover 10% or less	Decreasing bramble 1999-2018
Increasing <i>Brachypodium</i> 1999-2018 (>10%)	5	19	0
Change 10% or less	15	78	3
Decreasing <i>Brachypodium</i> 1999-2018 (>10%)	21	15	2

This result led me to look at changing frequencies of species more generally over these two period (Figure 26). There is overall a negative correlation between the change in the number of plots in which a species was recorded in the first period (1999 freq. – 1974 freq.) and its change in the second period (2018 freq. – 1999 freq.), although there were also some species that increased in both and others that decreased in both periods.

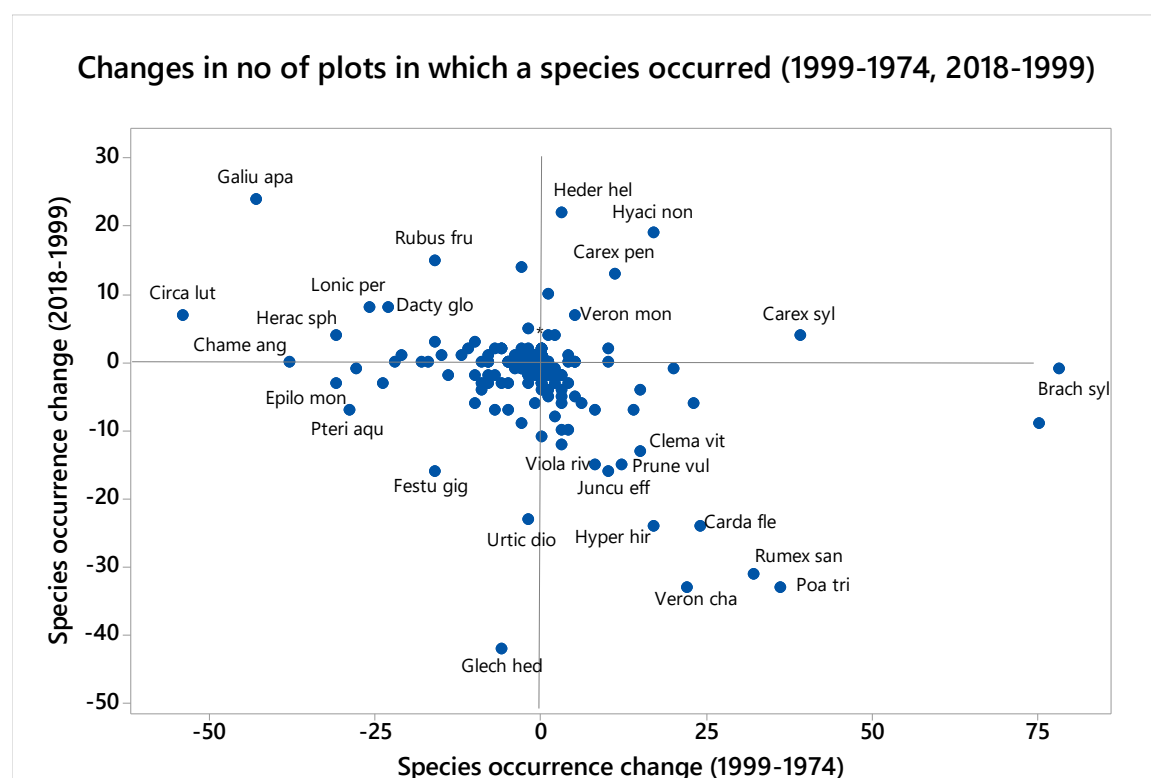


Figure 26. Change in species occurrence before and after 1999.

- Most species were present in plots with only low cover-abundance, whether measured by frequency in 13 sub-quadrats recorded across the main plot or by overall cover estimated by eye.
- A small number of species dominate the high frequency/high cover values which tend also to be the species with high overall plot occurrences such as *Rubus fruticosus* or *Mercurialis perennis*.
- Changes in within plot cover-abundance tend to be similar to changes in overall frequency of occurrence (no of plots in which a species was present), e.g. declining *Chamerion angustifolium*, increasing *Brachypodium sylvaticum* and *Hedera helix*.
- For a few species the trends were different: bramble *Rubus fruticosus* showed large within-plot declines between 1974 and 1999 but little overall change in number of plots in which it occurred.
- The biggest single change in the vegetation over the 45 years was the decline in cover of bramble and rise in *Brachypodium sylvaticum* between 1974 and 1999, and the reversal of this trend between 1999-2018.
- There was a general trend for species that had been increasing up to 1999 to then decrease in the period from 1999-2018.

5.10 Biomass estimates

These are based on the Phytocalc approach, using the percentage cover estimates for each species derived from the Domin cover scores (those for 1974 derived by backcasting) (Appendix 6).

The marked drop in biomass between 1974 and 1991 is largely driven by the drop in bramble cover (Figure 27). The same stem length for each species has been used in the equations for all recordings. The biomass may therefore be over-estimated for bramble during the 1990s when its cover was low because stem lengths (one of the parameters used) were also much less.

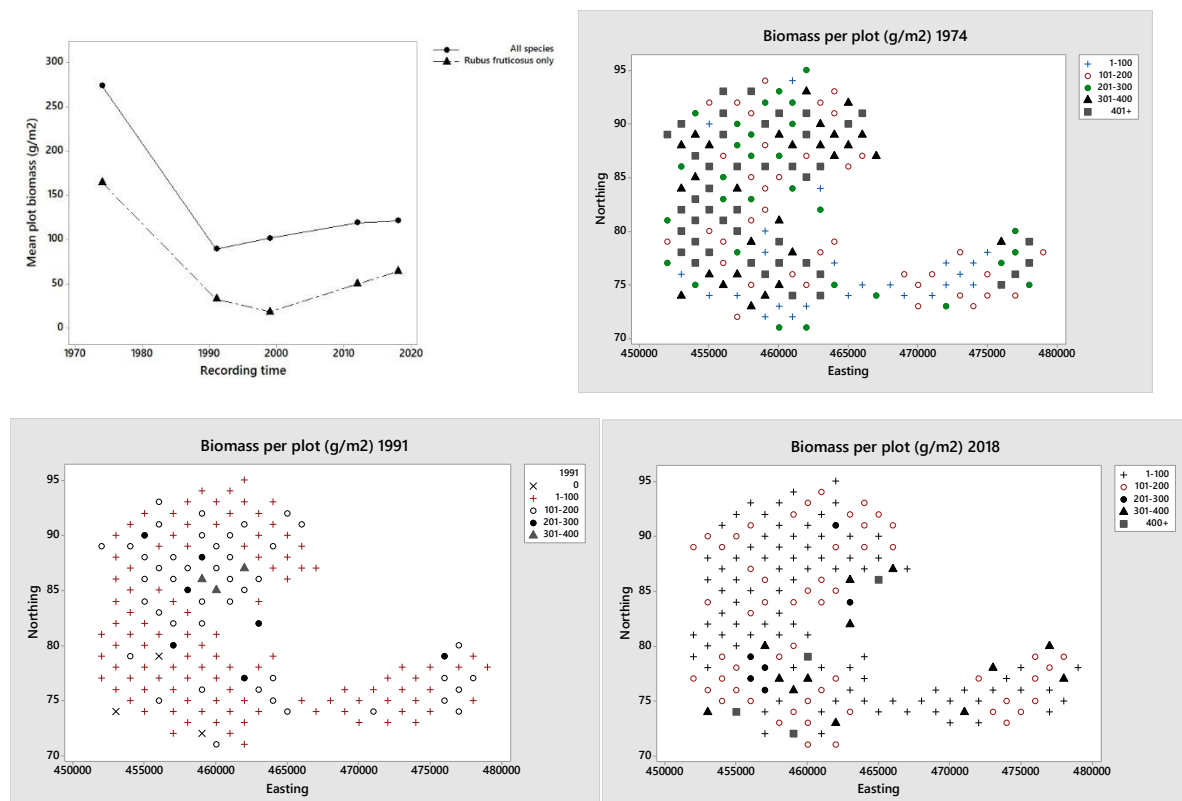


Figure 27. (a) Mean biomass changes for all plots across the recordings; (b) 1974 biomass per plot; (c) 1991 biomass per plot; (d) 2018 biomass per plot.

In each year there was considerable variation between plots, with some conifer and beech stands having virtually no ground flora whatsoever, whereas dense open grassy areas or thinned areas with a strong bramble cover having estimates of over 300g/m² (3000 kg/ha) (Figure 28).

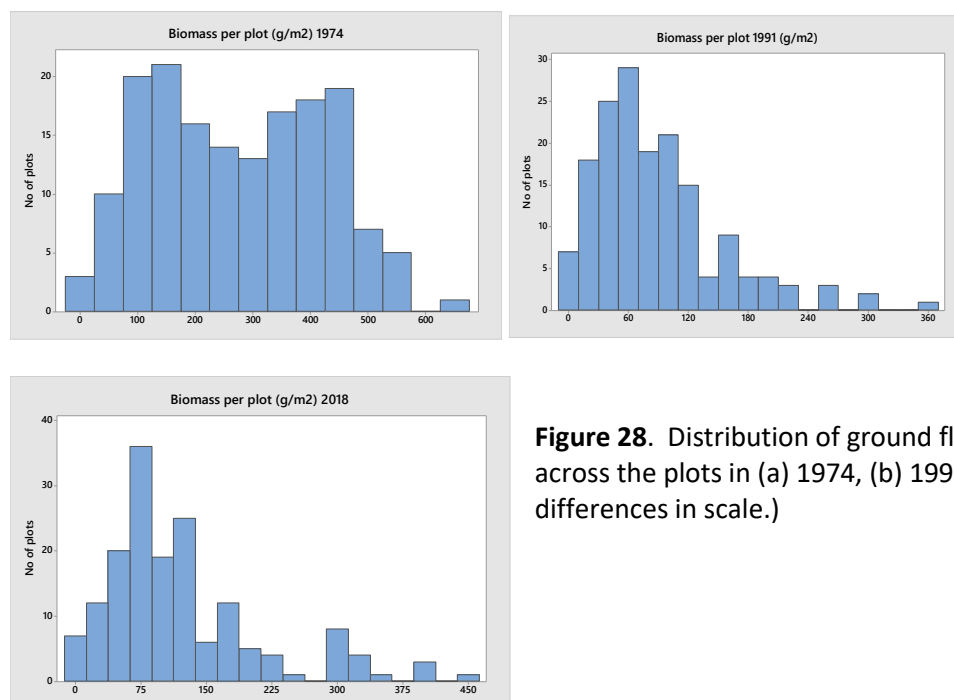


Figure 28. Distribution of ground flora dry weights across the plots in (a) 1974, (b) 1991 and (c) 2018. (Note differences in scale.)

How credible are these figures, given the range of assumptions and simplifications involved in the calculations: in particular is the big decline between 1974 and 1991 real? Table 17 provides some estimates of biomass/production of the ground flora from other sources. The 1974 values are at the high end of the estimates, but consistent with the extensive, dense bramble cover that was then present, as estimated from the cover values recorded, the bramble biomass directly measured by me in some stands in 1974, and personal recollection. Chris Perrins noted that the bird researchers sometimes laid a ladder across the top of the bramble to compress it to get to the nest boxes!

Table 17 Estimates of woodland ground flora above ground biomass/production

Reference	Values g/m ²	Comments
Ovington (1955)	0-210 0-410 35-315 (-700)	Thetford plantations, depending on tree species Bedgebury, Kent, depending on tree species Abbotswood, Forest of Dean. Highest values where 'rank growth' of bracken and bramble under pine/larch
Ford and Newbould (1977)	0.8-191	Stands during a sweet chestnut coppice cycle in Kent; from 1-15 yrs old
Kirby (1980)	100-400	Bramble only. Three stands in Wytham, measured in 1974
Hutchings (1978)	20-200 75	<i>Mercurialis</i> only, from literature Bramble only, growing under hazel shade.
K Taylor pers. comm	65	Bramble only, Meathop Wood Cumbria.
Al-Mufti et al. (1977)	550-650 1000 600 240 130 100	<i>Urtica dioica</i> , in open, Lathkilldale <i>Pteridium aquilinum</i> , in open conditions, Lathkilldale <i>Chamerion angustifolium</i> , in open conditions, Lathkilldale <i>Poa-Urtica</i> stand, Totley Wood. <i>Holcus-Hyacinthoides</i> stand, Totley Wood <i>Holcus-Pteridium</i> stand, Totley Wood

- *Biomass per plot, estimated using the Phytocalc approach, declined sharply from 1974 to 1991 but has shown a slight upward trend since.*
- *The decline (and recovery) in biomass was driven largely by the change in the cover of bramble.*

6. Discussion

Over 200 species have been recorded from the plots over the five recordings but only about a dozen for the most part woodland generalists contribute the bulk of the occurrences, cover and biomass. Amongst the most abundance species there were differing patterns with declines for *Urtica*, *Mercurialis* and *Pteridium* in cover and occurrence, stability in occurrence but decline and some recovery in cover and biomass for *Rubus*; an increase in occurrence, cover and biomass for *Brachypodium*. These are also likely to contribute most to the functioning of the ground flora – e.g. its nutrient cycling.

6.1 Stability or change over the 45 yr period

The ground flora observed over the 45-year period can be interpreted as showing stability or various forms of change depending on the spatial scale and measure considered.

- Overall vegetation cover showed a small dip in the 1990s followed by some recovery, but the decline in biomass was much greater and has only partially been restored.
- There was a minor decline species richness at the plot scale across the Woods but a more marked decline if the species found in the full set of plots is considered.

Other long-term studies of woodland ground flora plots show mixed patterns: for example Klynge et al. (2020) working in ancient woodland in Denmark, found an increase in mean plot-richness but a decline in the number of species found across the whole set of plots.

The composition of the plots has been changing with a decrease in similarity between records from the same plot with increasing time intervals, suggesting a directional change in composition which was also confirmed by the Decorana analysis. The main woodland areas appeared to be becoming more similar. Homogeneity of plots was greatest in the 1990s but has been declining again since. Other studies across Europe have reported increases in homogeneity over time (Cholewińska et al., 2020; Hülber et al., 2008; Keith et al., 2009; Naaf and Wulf, 2010; Strubelt et al., 2017; Van Den Berge et al., 2019), but decreases were reported by Hester et al., (2019). In Wytham the homogenisation seems to be mainly from the vegetation succession in the 20th century plantations and effects of shading as stands mature, both of which might be considered positive changes.

6.2 Drivers of change

Since the Second World War broadleaved woodland in Britain has been subject to a variety of different impacts (Hopkins and Kirby, 2007). On the whole there has been less management of the woods and stands, formerly regularly cut over as coppice, have been left to grow as high forest. Grazing pressure from deer has generally increased (Kirby 2001; Ward 2005). Levels of deposition of sulphur dioxide leading to soil acidification built up and then have declined; nitrogen deposition built-up and remains fairly steady. The climate has been steadily changing.

The two factors that emerged as the main drivers of the change in the vegetation in Wytham from 1974-2018, were increasing shade and deer browsing, not surprisingly as these have been highlighted in a range of other long-term vegetation studies in Britain (Baeten et al., 2012;

Crampton et al., 1998; Kirby et al., 2005) and on the Continent (Baeten et al., 2009; Chytrý and Danihelka, 1993; Fischer et al., 2009; Cholewińska et al., 2020; Hedl et al., 2010; Hedwall et al., 2019; Persson et al., 1987; Strubelt et al., 2019; Vild et al., 2017; Walther and Grundmann, 2001).

Reduced openness. When the Woods came to the University they were much more open as a consequence of a history of regular coppice management and wartime fellings; much of Radbrook Common was rough grass and bracken, Pasticks was largely arable fields, ringed by thin shelterbelts. In the 1950s much of the open ground was planted. After 1954 when rabbits were more-or-less wiped out by myxomatosis a cohort of ash and sycamore regeneration got away that forms much of current canopy (Anon, 1950; Mihók et al., 2009; Osmaston, 1959,) (Figure 29).

In 1974 the legacy of this openness and disturbance remained in the flora, in for example the higher contribution of non-woodland species, the abundance of *Chamerion angustifolium*, which subsequently more or less disappeared from the plots. Although the overall mean canopy cover did not change much between 1974 and 2018, the tree population had become denser (increased basal area) and taller such that the shade in the closed plots would have increased. This could cause the general shift towards more shade-tolerant species in the flora as indicated by the Decorana outputs.

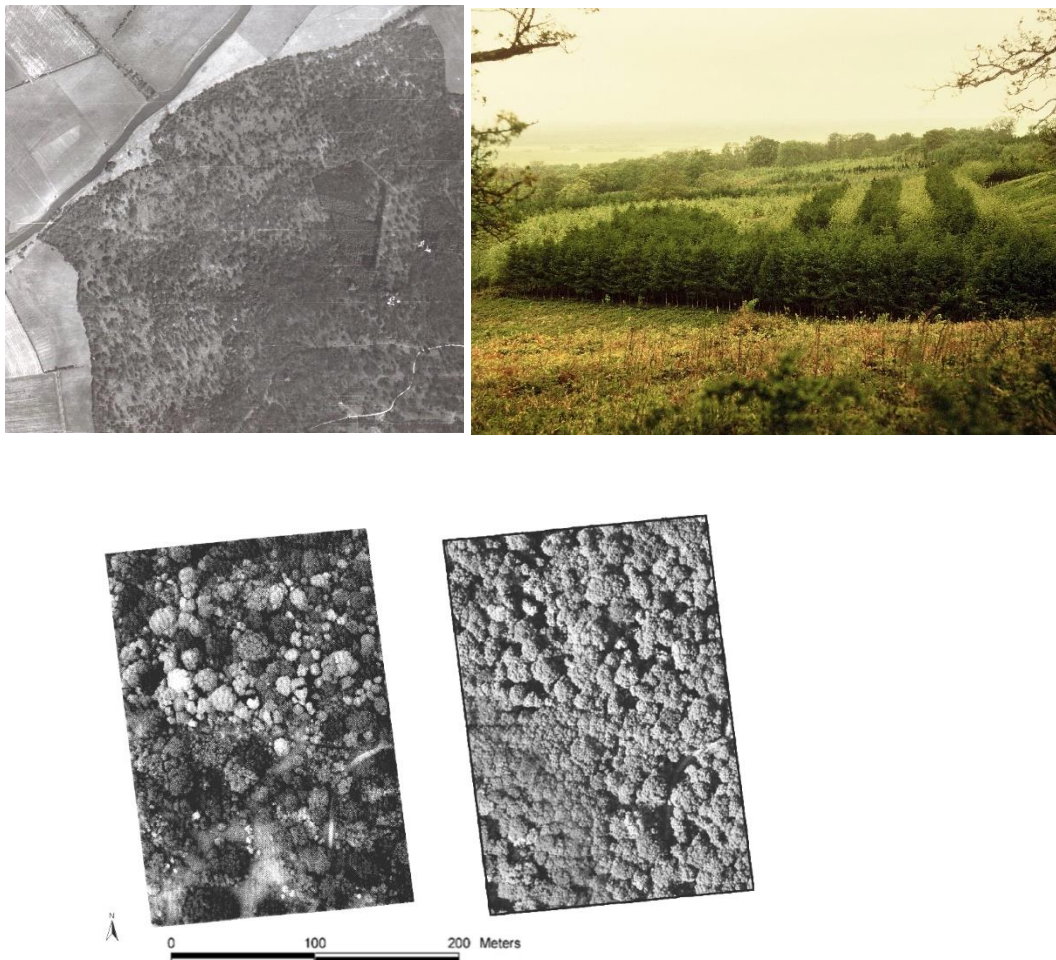


Figure 29. A more open woodland: (a) aerial photograph of the Great Wood in 1946, copyright Cambridge University; (b) Radbrook Common from Sundays Hill in 1958 showing some of the new planting, copyright Wytham Photographic collection (c) the canopy near 3 Pines ride in 1962 (left) copyright Department of Zoology, Oxford; and 1999 with gaps filled mainly by the 1950s ash cohort (copyright Google Earth image).

Where plantation stands had been thinned between recordings the species richness of the plot was more likely to increase in the subsequent recording than in the rest of the Woods (Figure 30). The same effect was seen in some of the unmanaged plots where a major tree fall had occurred. No more than 22 plots were affected in this way in any recording interval. The richness increase did not always happen: if thinning led to heavy bramble growth the competition from this might offset any benefit from reduced tree competition.

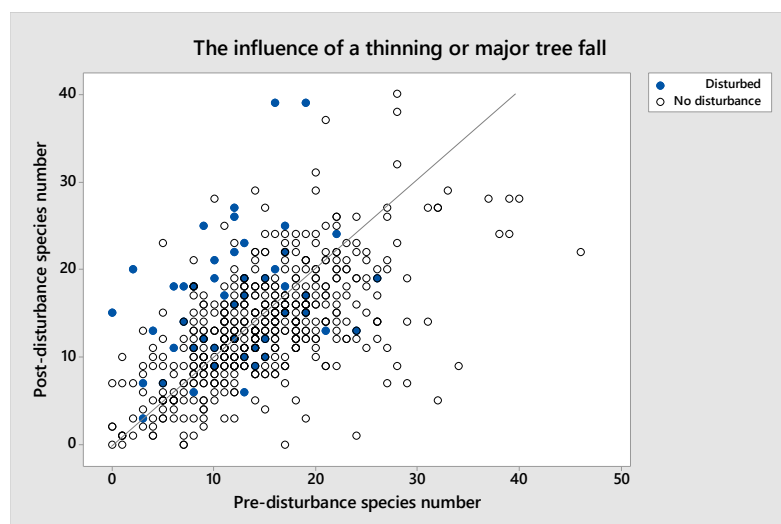


Figure 30. Effects of disturbance (thinning or major tree fall) opening the canopy on species richness per plot

Changing deer impacts. Deer pressure increased between 1974 and 1991; pressure remained high during the 1990s but has come down since (Appendix 10). Bramble can be an important food item for fallow deer particularly in the autumn and winter (Putman, 1986) and the decline in cover/biomass up to the mid-1990s and its subsequent spread back fits the changing deer population pattern. Bramble has been seen to do better within various small exclosures erected at different times in the Woods, although the response is much slower in shade than in open conditions (Morecroft et al., 2001). The recovery of the vegetation may however be a slower process than the changes that happened when grazing pressure initially increases, nor may it be a simple reverse of those initial changes (Tanentzap et al., 2012, Nuttle et al., 2014).

The spread back of bramble (which appears to be continuing) has potential implications for other species both plant and animal. It is plausible that the declines in cover of *Brachypodium sylvaticum* in some plots since 1999 is caused by increased competition from the bramble which in Wytham can form canopies 1-1.5 metres above the ground in dense stands. This is above the height of most woodland ground flora species and in a small experiment in East Anglia it was found that cutting back bramble increased the richness of other plant species (Kirby and Woodell, 1998).

In 1974 there was no link between bramble cover in Wytham and plot species richness, but the 2018 data are suggestive of a developing curvilinear relationship. Low bramble cover may be associated with both high and low species richness because the low bramble cover may be caused by grazing in open grassland (high richness) or by dense shade in beech plots (low richness); intermediate shade levels and reduced grazing may allow a range of species as well as bramble to thrive, but then if bramble cover gets too dense this may become the factor limiting species richness of smaller herbs (Figure 31). In the 13 plots where bramble increased by more than 25% mean

species richness dropped by a mean of 6.5 species whereas most plots showed only smaller decreases.

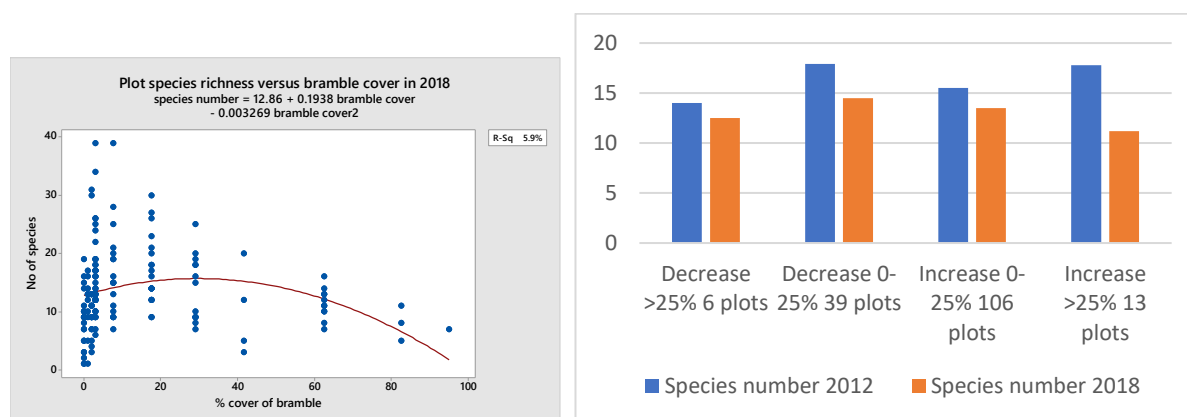


Figure 31 Might bramble start to limit species richness: (a) 2018 plot richness versus 2018 bramble cover; (b) change in plot richness 2012-2018 for different levels of bramble cover change.

Developing bramble thickets may provide more cover for small birds -wren and chiffchaff for example may nest in low mats of bramble (Fuller, 1995; Perrins and Overall 2001). The decline of bank voles in Wytham in the 1990s has been linked to the past decline in low vegetation cover such as bramble (Buesching et al., 2010), but badgers may be disadvantaged and abandon setts in dense stands (Chris Newman, personal communication).

Eutrophication. Nitrogen deposition has increasingly been recognised as having an impact on the composition and richness of open habitats such as grassland and heaths (Bobbink et al. 1998; Maskell et al. 2010; Smart et al. 2005). On the Continent various resurveys of vegetation have reported increases in nitrogen-indicator species or mean plot EIV-Nitrogen values (Brunet et al., 1998; Falkengren-Grerup and Diekmann, 2003; Förster et al., 2017; Hedwall et al., 2019; Reinecke et al., 2014; Thimonier et al., 1994). However, in other long-term studies of woodland vegetation shifts towards a more nutrient demanding flora did not appear to be related to nitrogen deposition (Verheyen et al., 2012). In Britain Keith et al. (2009) and Pitcairn et al. (1998) report nitrogen effects on the flora. Kirby et al. (2005) while not finding any overall shift towards more eutrophic vegetation report changes in species abundance were linked to modelled nitrogen deposition patterns.

At Wytham Farmer (1994, 1995) found a large increase in in nitrogen between 1974 and 1991 in samples from about a quarter of the plots, suggesting that there is the potential for a significant nitrogen effect (Corney et al., 2008). However no clear evidence for this has come through in this analysis in terms of, for example, an increase in high EIV-N-score species or in mean EIV-N plot scores. This might be for the following reasons:

- Firstly high levels of shade may limit plant growth, such that species that might otherwise increase with increased nitrogen availability are unable to do so.
- Secondly Wytham is a relatively nutrient-rich site to start with, so that unlike with more acid woodland assemblages the species that might benefit from increased availability of nitrogen are already present and any assemblage changes are more limited and less obvious.

Nevertheless the spread of *Alliaria petiolata* (EIV-N 7) in parts of the Woods may be an indicator of an nitrogen impact. In plot 455084 for example it was not recorded at all in the first three recordings; in 2012 and 2018 it was two or three plants; in 2019 it was scored at 4-10% cover and 11-25% in 2020. On the south-west edge of Radbrook Common both it and *Anthriscus sylvestris* are

more obvious than in the past. *Allium ursinum* (EIV-N 7) was only marked in Marley Wood in the 1960s on Mick Southern's map of rare plants, but is now widespread and spreading in the Great Wood (Figure 32); it was not recorded in the first two recordings in any of the plots, 2 in 1999, 5 in 2012, 6 in 2018.



Figure 32. Mick Southern's map from the 1950s of rare plants in Wytham. *Allium ursinum* is shown only at one point in Marley Wood, contrasting with its current and spreading abundance in the Great Wood.

Galium aparine might also be expected to benefit from increased nitrogen levels. Along the western edge of the Woods (453086) there are places where in the spring it does form a dense mat 10-20m in from the boundary with arable fields. After an increase in occurrences in 2012, there was a drop in 2018. This may be a species that was underestimated that year because of an earlier than usual die-off in the drought compared to 2012 which was a wet year, and a slightly later recording time.

Against this background, the decline of *Urtica dioica* is then unexpected: it is a species that is particularly associated with nutrient-rich conditions, although available phosphate rather than nitrogen tends to be its limiting factor (Pigott and Taylor, 1964). Prior to 1954 the Woods and surrounding estate held very high populations of rabbits (Elton, 1942-1965). The soil disturbance associated with their burrowing may have increased phosphate levels locally benefitting the nettles. After the rabbits died out from myxomatosis, in the parts of the Woods where shading increased, the potential for nettle growth may then have been reduced.

Climate change effects. Kirby et al. (2005) found some evidence for climatic effects on woodland species occurrence and abundance across Britain. In Wytham, however, comparison of the mean January and mean July temperature requirements for species occurrences across the recordings provided no indication of thermophilisation of the flora. Some changes may be happening with individual species – as with the nitrogen impacts – but so far these do not seem to be reflected in gross vegetation change. There was an indication from the Decorana analysis of some changes in the balance of species moisture requirements but this may reflect the more humid conditions associated with increased shade. The tree canopy by creating a cooler microclimate also effectively buffers the ground flora against some of climate change that affects open habitats (De Frenne et al., 2013, Landuyt et al., 2019).

6.3 Do species changes in Wytham match with national trends across Britain

Various studies have looked at plant species changes across the country over the last few decades (detailed results in Appendix 11).

Hill et al. (2004) included data for each species from the New Atlas of the British and Irish Flora (Preston et al., 2002) that assessed its change in distribution since the first atlas (Perring and

Walters, 1976), i.e 1930-1960 records compared to 1987-1999 with allowance for differences in recording effort. There was no correlation between the New Atlas change index for a species and the change in the number of plot occurrences for that species in Wytham from 1974 to 1999 (a broadly comparable period). Large discrepancies occurred for some species with *Brachypodium sylvaticum* and *Deschampsia cespitosa* show big increases in Wytham but little change nationally, while *Chamerion angustifolium*, *Circaea lutetiana* and *Galium aparine* declined over this period in Wytham, with little change nationally.

Data for change from another BSBI project looked at change between 1987 and 2004 through a resurvey of 811 tetrads (2x2km national grid squares) (Braithwaite et al., 2006). The results were compared for changes in the Wytham data from 1991 - 1999 recordings as most comparable, and using only species present in at least 10 plots across the two recordings to reduce the effects of random turnover of rarely occurring species. There was a significant relationship but still much scatter (R^2 only 10%), notably from some of the graminoids (Figure 33).

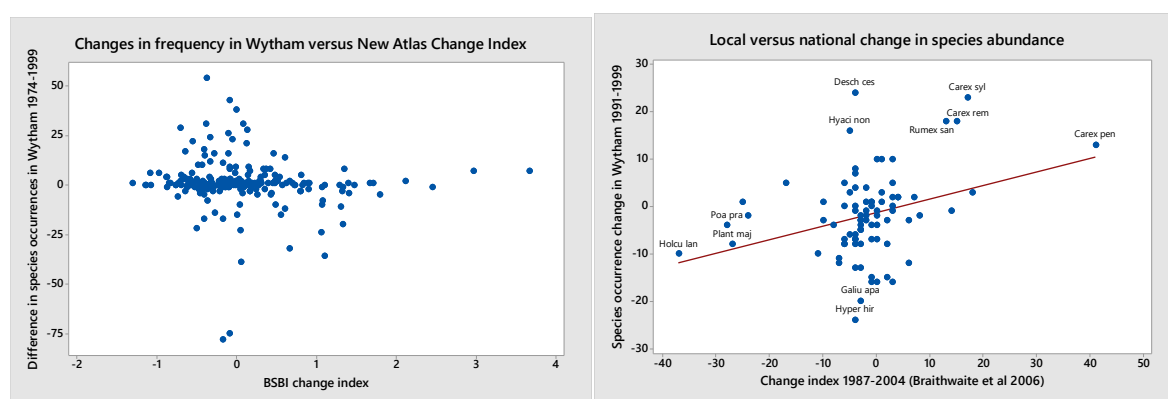


Figure 33. (a) Comparison of change in Wytham plot occurrences with national frequency change index ; (b) Change in species occurrence (no of plots) in Wytham 1974-1999 versus results from the BSBI survey 1987-2004. ($Y = -1.32 + 0.28x$; $p < 0.01$; $F = 9.4$ DF1,81)

The third comparison was with data from 103 broadleaved woods spread across Britain, surveyed initially in 1971 and revisited around 2001 (Kirby et al., 2005). In the national survey species records were grouped according to whether they showed significant increases, decreases or no change between 1971 and 2001, either in terms of the numbers of plots occupied or the number of sites in which they were found. The mean change for the 162 species that were in the Wytham recordings for each of these groups are shown in Figure 32. The trends in the national survey are generally not reflected in what happened in Wytham: the mean occurrences in Wytham for species that either significantly increased or decreased nationally were not distinct (Figure 34).

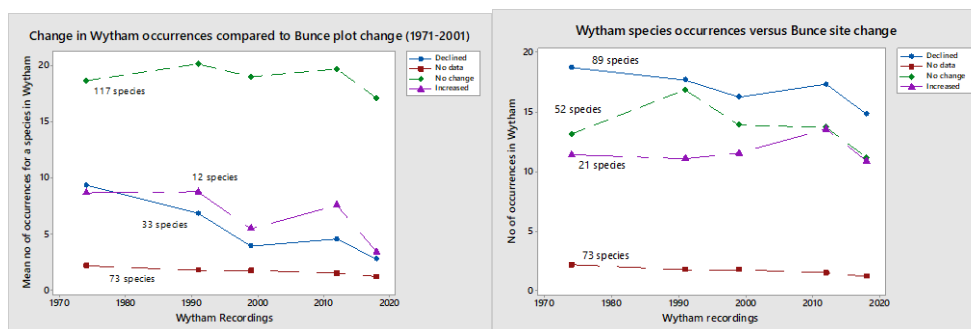


Figure 34. Comparison of changes at Wytham with species changes at a national level: mean no of occurrences for species at Wytham compared to their trend in the national survey in terms of (a) number of plots occupied and (b) number of sites in which present.

Brachypodium sylvaticum increased substantially at Wytham, while *Galium aparine* declined (1974-1999) but both species showed no change in frequency at either plot or site level nationally. *Circaea lutetiana* declined at Wytham, showed no change at site level nationally but did show national plot decline. *Deschampsia cespitosa* increased at Wytham showed no change at national site level but declined in plot numbers nationally. Local conditions at a particular site – notably at Wytham the heavy deer pressure between 1974 and 1999 - may override national and regional scale trends for particular species. Caution is needed therefore in applying national survey data to predict what will happen to a species at a given site, or extrapolating site-level observations to deduce national trends.

6.4 The Dawkins plots in the context of other long-term vegetation studies in British woods

Long-term change in woodland ground floras can be detected in a variety of ways, through comparisons of species lists from known areas, such as:

- Keith et al. (2009)'s resurvey of stands looked at in the 1930s in Dorset;
- Hester et al. (2019)'s revisiting of E.L. Birse's relevés in Scottish woods;
- the repeat of the 1971 broadleaved woodland survey (Kirby et al., 2005);
- the resurvey of the two small woods on the Rothamsted Estate in Hertfordshire showing colonisation of recent woodland (Harmer et al., 2001);
- revisiting Cotswold beech forests to look for signs of acidification and eutrophication (Ling, 2003);
- Remapping vegetation blocks as with Rackham (2003) re-assessment of part of Gamlingay Wood, first surveyed by Adamson (1912).

Long-term studies of the structure and composition of vegetation are particularly important because of the time-scales over which forest processes operate. Legacies of natural events, land management and land-use as seen in the distinctive characteristics of ancient woodland (Peterken, 1977, Rackham, 2003) interact with more recent pressures from, for example climate change and increased nitrogen deposition to affect the patterns in plant distributions, soil litter and nutrient dynamics (Blondeel et al. 2018; Maes et al. 2019a; Perring et al. 2018).

Permanent plots studies can be particularly useful in this respect because they allow direct observation of changes, their causes and consequences (Bakker et al., 1996, Barker-Plotkin and Foster, 2006, Perrin et al., 2006). In Britain, permanent transects and plots to study woodland stand structure have been re-recorded primarily in stands left to minimum intervention, including in areas devastated by the 1987 Great Storm (Backmeroff and Peterken, 1988, Butt et al., 2009, Mountford

and Peterken, 1998, Mountford and Peterken, 2000, Mountford et al., 1998, Peterken and Backmeroff, 1988, Peterken and Jones, 1987, Peterken and Jones, 1989, Peterken and Stace, 1987).

The emphasis has tended to be on the changes in the woody layers but ground flora change has been considered in some cases, for example at Lady Park Wood in the Wye Valley (Baeten et al., 2012; Peterken and Mountford, 2017), the Denny transect in the New Forest (Mountford, 2001; Mountford et al., 1999) and in the The Mens in Sussex (Tittensor, 2002). The Dawkins plot records at Wytham are however probably unique in Britain in terms of the numbers of recordings; the period over which these have been spread, and through their inclusion of a range of woodland origins and management types.

6.5 Long-term plots for detection or documentation of change?

A distinction is often drawn in the conservation literature between long-term surveillance and monitoring: the key difference being that monitoring implies that there is a target against which the results will be judged that may trigger action if the target is not met (Goldsmith, 2012). The Wytham recordings are, as in the title of the original report, a *surveillance* programme. They document the changes that have taken place.

The plot recording is unlikely to pick up new trends at an early stage when it might be most effective to take action. For example, casual observations indicate some non-native species are spreading in the Woods. However, the single plot record *Nectaroscordum siculum* (honey garlic) in 2018 and the single records for *Impatiens parviflora* from 2012 and 2018 could not be used on their own as evidence for the need for a control programme. Even if the recording cycle were shortened to 5 years it might still take 5-10 years for there to be sufficient records to document a statistically significant trend. Any further shortening of the interval however would increase the risk that the process of laying out and recording the plots starts to affect the vegetation.

If we wait until we can detect statistically from the plot data that deer are having an impact or that *Impatiens* has spread before implementing control measure it may be too late to be effective. However as with other large surveillance projects such as the transects at Lady Park Wood, the results from the Dawkins plots can be used as part of wider integrated monitoring programmes (Natural England, 2012).

7. The Future

Every wood is different and we should not expect the changes that happen in Wytham to be exactly mirrored elsewhere but some principles would seem to be general.

- The ground flora is not static, but varies over time and spatially across a wood.
- The patterns of change observed vary with the measures used (species richness, cover, biomass, similarity/homogeneity indices).
- Drivers of change operate at different temporal and spatial scales, gradual change associated with increased shading contrasting with more dramatic effects from deer build-up and subsequent control.
- Local level drivers (changing shade levels, deer pressure) may in the short-term swamp any effects of slower acting regional/global drivers such as nitrogen build-up or climate change.
- Different types of species show varying responses to these factors – some increasing, some decreasing – notably the spread of graminoids, the loss of tall herbs such as *Chamerion*, the decline and recovery of bramble.

- Legacy effects are common such as the greater richness of specialists in the older woodland for example; woods have ecological memory built-in (Ogle et al., 2015).

7.1. Looking to the impact of Ash Dieback

The next big change for the woodland ground flora in Wytham is likely to follow from the impact of Ash Dieback. This was confirmed as present about three years ago and is now starting to have a serious impact on the tree canopy. At least in the short-term the Woods may become more open and this will have implications for the ground flora (Mitchell et al., 2016), but the effects on individual species will be influenced by interactions between canopy opening, ingrowth of other tree species, what happens to the grazing pressure and competition within the ground flora.

Where ash cover is low, even complete dieback may not alter the overall canopy cover that much (<25%) and there may be little effect on ground flora species richness. If large gaps develop there may be an initial increase in ground flora cover and species richness. There may also be scope for some regeneration of oak.

Where it is already present sycamore is the tree most likely to benefit from the reduction in ash (Needham et al., 2016). Elsewhere hazel, hawthorn and blackthorn may fill gaps creating a dense lower canopy with only occasional emergent taller trees. All these species cast a heavier shade than ash, so in the longer term vegetation cover may be reduced.

There will be an interaction with bramble cover. The recovery of bramble since 2012 will be accelerated by loss of ash – assuming that deer numbers remain low. Although *Brachypodium* might be expected generally to increase after Ash Dieback (Mitchell et al. 2016) this might be limited by bramble expansion. Increased bramble could also reduce the species richness somewhat at the plot scale although it is unlikely to reduce richness over the Woods as a whole. If, as predicted, the canopy space is filled by more shady species the bramble may be less successful and opportunities for other ground flora species increased.

Opening of the canopy and death of trees is likely to increase nutrient availability at ground level, increasing the potential for spread of species such as *Alliaria petiolata*, *Allium ursinum* and *Galium aparine*, even though the direct change in the canopy is unlikely to benefit them.

The next planned recording of the Dawkins plots in 2023 will tell us how well these predictions are being fulfilled.

Appendix 1. Notes on post position and plot markers as at 2020

Plot no	Notes on post position and plot markers; the final column is a non-differential 10 – figure GPS for the post position except for a few plots where it is stated in the notes that it is for one of the plot markers (Add SP to get full gridref)	
452077	ok	4519207714
452079	ok	4520107920
452081	Marker 6.7 m at 323 degrees true from current post	4519208110
452089	new post 2018; SW marker approx 1m south of big dead tree; both markers seen	4519708912
453074	GPS position is for n.e. corner of plot	4531607426
453076	in position; n.e. plot marker in base of bendy ash	4529407617
453078	ok, s.w corner at ride edge; blue post at 7.5, 2.5. No signal at post or 2nd plot marker. Same in 2020.	4529707802
453080	ok, but slightly offset, c2m away in ditch; both markers seen	4528808004
453082	New post 2018; both markers seen	4530608203
453084	New post 2018 Post marker in ride, 1.3m 105 degrees from new post; both markers seen; both markers seen	4530208398
453086	New post 2018; brash pile just beyond first plot marker; dead log across n.e. corner hiding marker but it was seen. Post marker about 10 m in from boundary ride along north edge of access track marking boundary between thinned and unthinned beech. New post 2018	4530008596
453088	New post 2018; ok post position on access track; first marker seen, under brash pile; second marker deep about 50cm beyond base of ash.	4528608812
453090	New post 2018 Marker 5m from post on true bearing of 360 degrees; out of ground. Metal marker needs to go into ground as well as new post; both markers seen.	4529909015
454075	ok; both markers seen	4540807516
454077	ok; both markers seen	4539207708
454079	ok,n.e. corner by ditch; giant oak close by; both markers seen	4539607907
454081	ok	4541208093
454083	New post 2018; ok big chestnut in plot;	4540608291
454085	New post 2018;	4539608507
454087	ok; both markers seen	4540708711
454089	ok. 2020 bearing for plot seemed closer to 45 degrees from post.	4541308907
454091	post just south of big Acer cam; post marker 2.5.m on 93 degrees true from current post;both plot markers seen	4539809099
455074	Ok, s.w. plot marker not found; massive bramble thicket but second marker just beyond it and accessible; same in 2020; NE marker is 3 m on 318 degrees true from ash c60 sm dbh.	4549907415
455076	post 2m south of marker	4549107602
455078	New post 2018; ok, marker 1.6m 130 degrees off towards ride;	4548407801
455080	ok; post a bit wobbly; ne marker outside old fence, 40cm south of fencepost; both markers seen	4549908004
455082	ok	4549408207
455084	New post 2018; 7.5 m from large sycamore bearing 127 degrees true upslope towards hawthorn with clematis; second plot marker is downslope of giant ash in fork in buttress root, SW of major root. New post 2018	4549208400

455086	dead oak c7,1; both markers found; first at base of small sycamore. 2020 stand thinned. Sycamore by first marker now just a stump. Dead oak still standing. Post was moved but has now been replaced in correct position	4550208590
455088	New post 2018 ok, giant ash just beyond n.e.corner; oak former leading tree collapsed;	4549208825
455090	New post 2018; about 3 m north of large oak.	4549209005
455092	Fallen and hidden under scrub; marker 8.2 m on 82 degrees true from current post. Second plot marker may be easier to find - 5.4 m from big oak on bearing 82 degrees true. 2020 plot refound, post still hidden.	4550209215
456075	ok; first marker in middle of ride	4559807506
456077	Post wrong; correct position 4.7m at 67 degrees magnetic from post; both markers seen	4560607706
456079	New post 2018; brash in n.e. corner; beech 9,1 50cm dbh;41 dbh 1.5,2.5	4560407898
456081	marker 50cm offset; s.w corner just in path	4558008106
456083	new post 2018; marker c3m southwest of big ash (now fallen) and 2.7 m from large thorn; marker in badger entrance; bird cage in west quadrant of plot; Both plot markers found.	4560108319
456085	New post 2018; s.w. corner just in new track; bearing may be 45 degrees rather than 48	4559608515
456087	ok, large poplar in s.e. corner; markers deep; both seen	4558608692
456089	ok, first marker in ditch and about 25cm deep; second marker found ok	4559808914
456091	New post 2018, 2m from base of big thuya; first plot marker at base of young oak; second at base of big spruce; mapl by n.e. corner of plot;	4560109107
456093	New post 2018 on marker. 10m 363 degrees true from old post	4560309314
457072	New post 2018 at sw plot corner; ash 0.0, 5.0; cleared to make pond aug 18; first marker survives	4571407204
457074	okplot covers ride junction; first plot marker in ride, 2nd just in thicket	4568907394
457076	grid marker position 2.9 m at 190 degrees from the post; both markers seen	4570307606
457078	ok, ride corner of chestnut coppice; both markers seen	4570307801
457080	ok grid point 3.4 m on 16degrees true from current post; first plot marker 4.8 m north of strainer post; second done on sound	4570007999
457082	ok, s.e corner of plot open	4569008196
457084	ok, ride in north west half of plot	4570108408
457086	New post 2018, position is 3 m across slope from large ash towards smaller sycamore	4568108607
457088	New post 2018steep bank, syc coppice, limestone outcrop; post marker between standing dead and ash with butt sweep. New post 2018	4570508804
457090	ok, ride through southern half of plot; second marker approx 2m from big rideside ash, 237 degrees true; 1st marker in middle of ride; post marker about 2.5 m from current post position 312 degrees true	4569509004
457092	ok, south west half of plot scrub	4569809202
458073	New post 2018. edge of poplar stand post marker in corner of glade; both markers seen.	4580007304
458075	ok both markers seen; easiest to find second one as first in thicket close to ride	4579807512
458077	ok 1st plot marker on ride side of ditch c.2m north of ash; both markers seen	4578107696
458079	New post 2018 6.2 m on bearing 126 degrees true from nest box tree; second marker seen but under log; first seen	4579307908
458081	ok	4579908109
458083	ok	4579508309

458085	new post 2018	4580208519
458087	ok but post offset, marker 2.4m n-w of post 320 degrees true; both markers seen; 2020 post down, peg left at post marker position	4580208702
458089	dead oak in close to north east corner of plot; both markers seen	4580708903
458091	ok, poor signal at post but seems to be in right place	4579809114
458093	Current post wrong. Marker 5.5 m on 345 degrees true . 2.2 m on 270 degrees from large oak with squirrel trap remains; oak 103 cm 9,6 in plot; dying ash 40c 9,2.	4580009310
459072	New post 2018 post marker close to base of thorn and c4m west of large ash; both markers seen	4589607215
459074	New post 2018 plot straddles boundary of larch palntation ride 3m wide 2.7,0.0; 4, 10.0. Post position c.25m from northern stand boundary along ride and 10 m in from ride centre; 5.2 m from small sycamore by ivy larch on bearing 6.5 degrees true; 10m from mishapen sycamore by ride on bearing 250 degrees true	4590407414
459076	New post 2018;both plot markers found	4590407604
459078	ok done but needs gps; both markers found	4589607800
459080	Both markers seen, 1st by badger path on ridge, second 1.5 m south of dying giant beech; big beech in plot no 910 blue tag	4588508009
459082	New post both markers seen; post on ride edge	4589208207
459084	ok but offset, 4.5m from post at 14.5 degrees true by road; sw plot marker on verge 18.6m from current post position on 32 degrees true; both seen;	4589608418
459086	ok	4589708596
459088	marker 2.2 m on true bearing 117; 64 cm sycamore in plot 2.2, 2.5	4591908785
459090	ok post has signal but marker actually 1.5m at 320 degrees true; by tree 1206 in Smithsonian plot; both markers found	4589809001
459092	ok	4590109206
459094	ok	4590709409
460071	by fence and elder; about 8 m from giant hazel, due south; first marker on sw edge of ride	4601007096
460073	ok, but marker at c1m on 190 degrees true; done; both markers found	4599207304
460075	Post down but marker at c4m on 180 degrees true in ride; both markers seen, first on edge of brash pile.2019 new post is on wrong (south) side of ride!	4599607508
460077	New post 2018 2nd plot marker not found; first seen.	4599907704
460079	marker1.5 m 315 degrees from post; first marker found, second marker about 1.5 m south of ash tree	4599207899
460081	ok	4599108104
460085	New post 2018; ok, large sycamore on plot west edge. Both markers found	4599608511
460087	ok, 71 cm oak 8.2,9.5 in plot	4600408704
460089	New post 2018, marker 2m north of large douglas fir	4599408911
460091	New post 2018; 15.5m on 5degrees true from post with weather button; halfway between two ashes	4600309107
460093	ok; large aspen in plot1.5, 8	4599909297
461072	ok. Non-standard post but ok; both markers seen	4609207208
461074	shaded track across nw-sediagonal just ne of line; sparse bracken g/f in 91; oak with syc u/storey; post marker is 5m on bearing 320 degrees true from post; Both plot markers seen, but second is at an angle and quite deep. 2020 post down, but in right place.	4610007404
461076	New post 2018 both plot markers seen	4610707591

461078	new post 2018; bearing closer to 45 degrees from post	4609807806
461084	fallen 2m from base of sycamore new post 2018	4609608415
461086	4.6m 325 degrees true from weather button post; both markers seen	857700000
461088	ride just clips n.e. Corner of plot sycamore 41cm 5,10	4610408790
461090	New post 2018 326 degrees true 6.5 m from post with weather button; post marker in stream bed at s. end of collapsed willow; n.e. plot marker under hazel	4609609010
461092	ok	4609209204
461094	New post 2018; close to oak 34 nestbox; 3.9m from tree base; 280 degrees true from nest box tree	4610209407
462071	post replaced, in right position	4620207109
462073	ok; first plot marker between two elders; post marker signal about 0.5 m se of new post	4620207311
462075	New post 2018, both markers found	4620707503
462077	new post 2018; marker by base of big conifer, about 10 m off. 2020 NE marker not found; angle closer to 45 degree.	4620907696
462085	ok; giant oak is about halfway between plot marker and post, slightly to north; NE marker is in tree roots of ash which just outside plot	4619708508
462087	ok but offset; 1.5m north of post; south-west marker under field maple roots; both seen	4620108709
462089	Ok; plot s.w. in glade; ne just north of pit; giant ash just outside northern edge.	4620208897
462091	New post 6.7 m on marker; 353 degrees true from old post position; both markers seen	4619709108
462093	ok	4621509297
462095	ok	4619609501
463074	post and markers ok	4629907418
463076	New post 2018; first plot marker about 4 m at bearing of 280 from matt post (seen); post marker by base of sycamore, second marker under stump	4630207626
463078	ok; 2020 NE marker on ride edge	4629807797
463082	new post 2018 Dense thicket in south-west corner of plot; stump to west;	4629508204
463084	ok; giant chestnut outside mid-east of plot; new post 2018; NE marker 1.5m south-west of horse chestnut; sw marker 1m north-east of small syc with lost top	4629908414
463086	2020 post fallen; SW marker under stump, NE marker seen	4629608599
463088	New post 2018; oak 120cm 6.5, 5.0 in plot	4629808818
463090	ok	4630609003
463092	Non standard post but right position; ash stool north-west corner; bird box 148 on stool at 8,7; both markers seen	4630409215
464075	ok, both markers present	4640107517
464077	new post 2018 NE plot marker at base of hawthorn; both seen	4638907707
464079	New post 2018 marker 11.3 100 degrees true from base of thorn; second plot marker 1.3 m out in field from first post below strainer on corner. Last recording too much in enclosure; both markers definitely there but 45 degrees from post	4640007908
464087	New post 2018; large oak (59cm) just out of plot by s.w. corner;	4640008697
464089	s.w plot marker just in ride; both seen	4639008895
464091	ok but in right position; both markers seen	4639909115
464093	ok; both markers seen; 2020 second done on sound; ? under root	4640009300
465074	ok; bearing seems to be 45 degrees from post (ie magnetic, not true) but both plot markers found	4650107412

465086	new post 2018 Giant ash in plot c6, 6 now just a stump. Marker about half way between large oak near boundary fence and medium sized sycamore: 120 degrees true to oak; 314 degrees true to sycamore	4650008609
465088	post replaced ok	4650408806
465090	in marsh	4649709004
465092	ok; both markers seen	4650009208
466075	post marker by ride 4.7 m on bearing 202 true from current post; first plot marker ok 9.5 m on true bearing from post of 56.5 degrees; second is at base of giant beech on nw side but no signal;.gps for first marker	4661007512
466087	ok	4659908697
466089	ok, marker 50cm north of post; 2020 post broken	4660108904
466091	post 2m 48 degrees from marker	4659709105
467074	ok but mislabelled as 468074; both markers seen	4669407401
467087	ok but no plot markers	0
468075	offset marker 4 m at 158 degrees true	4679907498
469074	ok giant lime c5,2	4690707414
469076	ok; both markers seen	4689507590
470073	new post 2018; marker 2m north of mishapen sycamore stool. SW plot marker in base of big beech, sound only, second is partly under a root (not close to a tree)	4720207305
470075	ok, 2m n.e. of nest box 24, bearing more like 45 degrees	4699807491
471074	new post 2018; by tree close to tree with nestbox 104; sw marker part under root; both seen	4710407410
471076	New post 2018; Old post not in right place in 2012; plot recorded wrongly in 2012 therefore. Right place about 24 m away due east. 6.2m from larch with nest box 15 on at bearing 228 degrees true.	4709907619
472073	ok; large ash just north of plot c 8, 11	4720607314
472075	ok,First plot marker 2m at 7 degrees from base of large pine; second marker at base of hazel; in 2020 second marker under log	4719607511
472077	new post 2018; 5.5m at approx 350 degrees from kinky elm; both markers seen	4720307704
473074	ok most of plot a glade	4730007400
473076	marker is 6.6m on bearing 123 degrees true from current post, the other side of the lime; first plot marker seen; second plot marker near base of large lime.	4729907579
473078	New post 2018 marker by base of sycamore; large oak 1 m north west of first plot marker	4729907800
474073	ok, both markers seen	4740107310
474075	ok both plot markers seen,	4740007498
474077	ok; 3m at 325 degrees from tree 0076; both plot markers seen,	4739707708
475074	ok; both markers seen	4750807410
475076	ok	4747707617
475078	ok but offset	4750107800
476075	Post offset. Marker position is at base of large tree; both markers seen	4759907506
476077	New post 2018 both markers found; twisty trees in south-east corner.	4760107707
476079	plot marker under apple tree. GPS is for the appletree; post not checked	4761307919
477074	ok, both plot markers found	4770207418
477076	ok, second marker deep but both seen. SW marker 3m south of bendy ash. 2020 NE marker 5 m norther of large sycamore labelled 0069	4769907632
477078	no post marker ; first plot marker found, second found on edge of ride	4769907809

477080	ok, massive oak, post 93 degrees magnetic 9m from oak. Fairly impenetrable, but both plot markers found. Second marker more accessible from path through n.e. of plot.	4770208002
478075	ok, both markers found	4779107517
478077	post off set c 0.5m north of marker; first plot marker about 1m east of ash group; second marker in root pit, no longer vertical	4779407708
478079	ok	4779907910
479078	Post marker 2.4m 132 degrees true from post; first plot marker in log pile. Second plot marker present found from maple coordinates 7.4 east, 9.9 north, but this tree has now fallen. Second marker is 1.8 m west of ash with distinctive butt sweep. Old rubbish dump area so lots of false signals. second maple is at 7.5, 3.5	4790007806

Appendix 2. Recorders and recording dates

	1974	1991	1999	2012	2018
Recorders contributing to the campaign (not to every plot)	Wayne Adams, Colyear Dawkins, David Field, Phillip Lloyd.	Keith Kirby, Rachel Thomas, Heather Robertson.	Emma Goldberg, Jeanette Hall, Hannah Iles, Rebecca (Watson) Isted, Keith Kirby,	Dawn Bazely, Emma Goldberg, Rebecca Isted, Keith Kirby, Suzanne Perry, Rebecca Tibbetts.	Keith Kirby, Jeanette Hall
452077	10/07/1974	04/07/1991	25/07/2002	13/06/2012	18/07/2018
452079	10/07/1974	04/07/1991	23/07/2001	15/06/2012	18/07/2018
452081	10/07/1974	09/08/1991	23/07/2001	16/06/2011	16/07/2018
452089	19/06/1974	02/07/1991	02/05/2002	21/06/2011	12/07/2018
453074	09/10/1974	Not recorded	25/07/2002	19/07/2012	17/07/2018
453076	10/07/1974	04/07/1991	23/07/2001	15/06/2011	18/07/2018
453078	14/06/1974	04/07/1991	09/05/2002	28/05/2012	17/07/2018
453080	14/06/1974	23/05/1991	22/06/1999	15/06/2011	16/07/2018
453082	14/06/1974	23/05/1991	23/07/2001	15/06/2011	16/07/2018
453084	19/06/1974	23/05/1991	22/06/1999	05/06/2012	19/07/2018
453086	19/06/1974	23/05/1991	24/07/2001	06/06/2012	19/07/2018
453088	05/07/1974	02/07/1991	22/06/1999	21/06/2011	16/07/2018
453090	19/06/1974	02/07/1991	02/05/2002	21/06/2011	12/07/2018
454075	17/07/1974	09/08/1991	23/07/2001	15/06/2011	18/07/2018
454077	11/07/1974	04/07/1991	20/07/2001	15/06/2011	21/08/2018
454079	14/07/1974	09/08/1991	23/07/2001	13/06/2012	21/08/2018
454081	14/06/1974	23/05/1991	23/07/2001	16/06/2011	16/07/2018
454083	14/06/1974	23/05/1991	23/07/2001	15/06/2011	16/07/2018
454085	05/06/1974	23/05/1991	02/05/2002	05/06/2012	16/07/2018
454087	05/07/1974	02/07/1991	24/07/2001	16/06/2011	16/07/2018
454089	08/07/1974	02/07/1991	24/07/2001	21/06/2011	12/07/2018
454091	19/06/1974	01/07/1991	02/05/2002	20/07/2011	12/07/2018
455074	09/10/1974	09/08/1991	20/08/1999	28/05/2012	14/08/2018
455076	18/07/1974	04/07/1991	23/07/2001	19/07/2011	21/08/2018
455078	18/07/1974	09/08/1991	23/06/1999	15/06/2011	18/07/2018
455080	10/07/1974	23/05/1991	20/07/2001	28/05/2012	18/07/2018
455082	14/06/1974	23/05/1991	23/06/1999	05/06/2012	18/07/2018
455084	05/06/1974	23/05/1991	09/05/2002	19/06/2012	18/07/2018
455086	08/07/1974	23/05/1991	23/06/1999	05/06/2012	11/07/2018
455088	05/07/1974	02/07/1991	24/07/2001	21/06/2011	11/07/2018
455090	05/07/1974	01/07/1991	23/06/1999	21/06/2011	11/07/2018
455092	19/06/1974	01/07/1991	02/05/2002	19/06/2012	12/07/2018
456075	07/06/1974	09/08/1991	23/07/2001	28/05/2012	21/08/2018
456077	18/07/1974	04/07/1991	20/07/2001	13/06/2012	21/08/2018
456079	18/07/1974	04/07/1991	20/07/2001	19/07/2012	22/08/2018
456081	30/05/1974	23/05/1991	24/07/2001	28/05/2012	16/07/2018
456083	30/05/1974	23/05/1991	24/07/2001	05/06/2012	19/07/2018
456085	05/06/1974	23/05/1991	09/05/2002	19/06/2012	11/07/2018
456087	23/08/1974	02/07/1991	24/07/2001	21/06/2011	11/07/2018
456089	11/06/1974	01/07/1991	24/07/2001	21/06/2011	11/07/2018

456091	08/07/1974	02/07/1991	09/05/2002	20/07/2011	12/07/2018
456093	12/06/1974	01/07/1991	02/05/2002	21/07/2011	12/07/2018
457072	09/10/1974	20/05/1992	20/08/1999	28/05/2012	13/08/2018
457074	18/07/1974	09/08/1991	23/07/2001	28/05/2012	21/08/2018
457076	07/06/1974	04/07/1991	23/06/1999	13/06/2012	14/08/2018
457078	18/07/1974	04/07/1991	20/07/2001	22/06/2011	14/08/2018
457080	07/06/1974	20/05/1991	18/08/1999	06/07/2012	22/08/2018
457082	23/05/1974	03/07/1991	24/07/2001	28/05/2012	11/07/2018
457084	30/05/1974	20/05/1991	24/07/2001	05/06/2012	29/06/2018
457086	02/09/1974	15/08/1991	24/07/2001	05/06/2012	06/07/2018
457088	12/06/1974	02/07/1991	22/06/1999	20/07/2011	06/07/2018
457090	11/06/1974	01/07/1991	24/07/2001	20/07/2011	04/07/2018
457092	12/06/1974	15/08/1991	08/05/2002	23/06/2011	04/07/2018
458073	07/08/1973	09/08/1991	08/05/2002	20/06/2012	13/08/2018
458075	07/08/1974	09/08/1991	08/05/2002	19/07/2011	13/08/2018
458077	07/06/1974	07/08/1991	08/05/2002	19/07/2011	14/08/2018
458079	07/06/1974	07/08/1991	25/07/2001	22/06/2011	07/08/2018
458081	06/08/1974	03/07/1991	25/07/2001	20/06/2011	06/08/2018
458083	30/05/1974	20/05/1991	18/07/2001	20/06/2011	06/08/2018
458085	30/05/1974	20/05/1991	18/07/2001	20/06/2011	06/07/2018
458087	21/05/1974	15/08/1991	18/07/2001	20/06/2011	06/07/2018
458089	11/06/1974	15/08/1991	17/07/2001	18/06/2012	04/07/2018
458091	11/06/1974	15/08/1991	17/07/2001	23/06/2011	04/07/2018
458093	12/06/1974	15/08/1991	02/05/2002	21/07/2011	04/07/2018
459072	07/08/1974	09/08/1991	08/05/2002	11/06/2012	13/08/2018
459074	30/07/1974	07/08/1991	23/06/1999	20/06/2012	14/08/2018
459076	24/07/1974	07/08/1991	25/07/2001	19/07/2012	07/08/2018
459078	24/07/1974	07/08/1991	23/06/1999	22/06/2011	07/08/2018
459080	28/06/1974	03/07/1991	25/07/2001	20/06/2011	22/08/2018
459082	02/07/1974	03/07/1991	24/06/1999	20/06/2011	22/08/2018
459084	30/05/1974	21/05/1991	18/07/2001	20/06/2011	03/07/2018
459086	21/05/1974	20/05/1991	24/06/1999	17/06/2011	03/07/2018
459088	29/05/1974	20/05/1991	18/07/2001	20/07/2011	03/07/2018
459090	31/05/1974	21/05/1991	24/06/1999	19/07/2011	03/07/2018
459092	11/06/1974	15/08/1991	17/07/2001	22/07/2011	03/07/2018
459094	12/06/1974	15/08/1991	21/06/1999	19/06/2012	04/07/2018
460071	21/08/1974	20/05/1992	08/05/2002	19/07/2012	13/08/2018
460073	12/07/1974	07/08/1991	25/07/2001	22/06/2011	13/08/2018
460075	30/07/1974	07/08/1991	08/05/2002	22/06/2011	07/08/2018
460077	21/08/1974	07/08/1991	25/07/2001	22/06/2011	07/08/2018
460079	07/08/1974	07/08/1991	25/07/2001	11/06/2012	06/08/2018
460081	28/06/1974	09/08/1991	25/07/2001	20/06/2011	06/08/2018
460085	28/06/1974	21/05/1991	20/08/1999	17/06/2011	03/07/2018
460087	21/05/1974	20/05/1991	18/07/2001	17/06/2011	03/07/2018
460089	11/06/1974	21/05/1991	02/05/2002	19/07/2011	28/06/2018
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461084	06/08/1974	16/08/1991	07/05/2002	29/05/2012	03/07/2018
461086	21/05/1974	21/05/1991	18/07/2001	17/06/2011	25/06/2018
461088	31/05/1974	21/05/1991	22/06/1999	21/07/2011	28/06/2018
461090	31/05/1974	21/05/1991	25/07/2002	18/06/2012	28/06/2018
461092	22/08/1974	02/07/1991	21/06/1999	23/06/2011	28/06/2018
461094	12/06/1974	15/08/1991	17/07/2001	23/06/2011	04/07/2018
462071	21/08/1974	20/05/1991	08/05/2002	19/07/2012	13/08/2018
462073	07/08/1974	08/08/1991	24/07/2002	11/06/2012	07/08/2018
462075	30/07/1974	07/08/1991	25/07/2001	11/06/2012	07/08/2018
462077	30/07/1974	07/08/1991	25/07/2001	04/06/2012	06/08/2018
462085	28/06/1974	03/07/1991	18/07/2001	20/06/2011	25/06/2018
462087	21/05/1974	20/05/1991	18/07/2001	17/06/2011	25/06/2018
462089	11/06/1974	20/05/1991	02/05/2002	18/06/2012	28/06/2018
462091	11/06/1974	02/07/1991	17/07/2001	21/07/2011	28/06/2018
462093	12/06/1974	15/08/1991	17/07/2001	21/07/2011	28/06/2018
462095	12/06/1974	15/08/1991	17/07/2001	21/07/2011	28/06/2018
463074	07/08/1974	03/07/1991	18/08/1999	11/06/2012	01/08/2018
463076	30/07/1974	08/08/1971	25/07/2001	04/06/2012	06/08/2018
463078	30/07/1974	03/07/1991	25/07/2001	22/06/2011	23/07/2018
463082	27/08/1974	16/08/1991	25/07/2001	29/05/2012	24/07/2018
463084	27/08/1974	16/08/1991	07/05/2002	29/05/2012	24/07/2018
463086	21/05/1974	20/05/1991	22/06/1999	20/06/2011	24/07/2018
463088	31/05/1974	20/05/1991	07/05/2002	19/07/2011	20/06/2018
463090	21/05/1974	20/05/1991	21/06/1999	23/06/2011	20/06/2018
463092	21/05/1974	20/05/1991	25/07/2002	18/06/2012	20/06/2018
464075	12/07/1974	08/08/1991	27/07/2001	04/06/2012	01/08/2018
464077	09/08/1974	03/07/1991	24/07/2002	18/07/2011	24/07/2018
464079	27/08/1974	03/07/1991	24/07/2002	07/06/2012	24/07/2018
464087	31/05/1974	20/05/1991	07/05/2002	29/05/2012	20/06/2018
464089	22/05/1974	22/05/1991	17/07/2001	21/07/2011	20/06/2018
464091	21/05/1974	22/05/1991	16/07/2001	21/07/2011	20/06/2018
464093	21/05/1974		17/07/2001	23/06/2011	20/06/2018
465074	12/07/1974	08/08/1991	27/07/2001	18/07/2011	31/07/2018
465086	21/05/1974	20/05/1991	25/07/2002	18/07/2011	25/06/2018
465088	23/05/1974	20/05/1991	21/06/1999	21/07/2011	19/06/2018
465090	23/08/1974	20/05/1991	16/07/2001	23/06/2011	19/06/2018
465092	21/05/1974	20/05/1991	21/06/1999	23/06/2011	19/06/2018
466075	12/07/1974	08/08/1991	24/07/2002	04/06/2012	31/07/2018
466087	15/05/1974	20/05/1991	16/07/2001	23/06/2011	19/06/2018
466089	26/06/1974	10/08/1991	16/07/2001	29/05/2012	19/06/2018
466091	21/05/1974	22/05/1991	16/07/2001	21/07/2011	19/06/2018
467074	12/07/1974	08/08/1991	24/06/1999	18/07/2011	31/07/2018
467087	15/05/1974	16/08/1991	24/07/2001	22/07/2011	22/08/2018
468075	05/08/1974	08/08/1991	24/07/2002	18/07/2011	31/07/2018
469074	25/07/1974	08/08/1991	24/07/2002	04/06/2012	31/07/2018

469076	08/08/1974	08/08/1991	24/06/1999	18/07/2011	31/07/2018
470073	25/07/1974	08/08/1991	27/07/2001	18/07/2011	31/07/2018
470075	08/08/1974	08/08/1991	27/07/2001	04/06/2012	31/07/2018
471074	05/08/1974	08/08/1991	24/06/1999	19/07/2012	31/07/2018
471076	08/08/1974	06/08/1991	27/07/2001	18/07/2011	30/07/2018
472073	25/07/1974	06/08/1991	27/07/2001	04/06/2012	30/07/2018
472075	25/07/1974	06/08/1991	27/07/2001	18/07/2011	30/07/2018
472077	05/08/1974	06/08/1991	08/05/2002	07/06/2012	30/07/2018
473074	02/08/1974	06/08/1991	27/07/2001	12/06/2012	30/07/2018
473076	25/07/1974	06/08/1991	08/05/2002	07/06/2012	30/07/2018
473078	05/08/1974	06/08/1991	08/05/2002	12/06/2012	30/07/2018
474073	02/08/1974	06/08/1991	27/07/2001	18/07/2011	25/07/2018
474075	09/08/1974	06/08/1991	27/07/2001	07/06/2012	25/07/2018
474077	08/08/1974	06/08/1991	08/05/2002	18/07/2011	25/07/2018
475074	02/08/1974	05/08/1991	18/08/1999	12/06/2012	23/07/2018
475076	08/08/1974	06/08/1991	27/07/2001	07/06/2012	23/07/2018
475078	05/08/1974	06/08/1991	18/08/1999	07/06/2012	23/07/2018
476075	02/08/1974	10/07/1991	07/05/2002	22/07/2011	23/07/2018
476077	01/08/1974	05/08/1991	25/07/2002	12/06/2012	25/07/2018
476079	09/08/1974	22/05/1992	25/07/2002	12/06/2012	23/07/2018
477074	02/08/1974	05/08/1991	07/05/2002	22/07/2011	25/07/2018
477076	21/08/1974	05/08/1991	18/08/1999	22/07/2011	25/07/2018
477078	01/08/1974	05/08/1991	07/05/2002	22/07/2011	25/07/2018
477080	09/08/1974	16/08/1991	18/08/1999	22/07/2011	25/07/2018
478075	02/08/1974	05/08/1991	07/05/2002	12/06/2012	25/07/2018
478077	01/08/1974	05/08/1991	07/05/2002	22/07/2011	25/07/2018
478079	01/08/1974	05/08/1991	18/08/1999	22/07/2011	23/07/2018
479078	01/08/1974	05/08/1991	25/07/2002	22/07/2011	01/08/2018

Appendix 3. Classification of species according to different sets of characteristics

The values for different species are given in Appendix 4.

Woodland species type. Species are classified as Non-woodland (1), Woodland Generalists (2) or Woodland Specialists (3) based on the approach in Kirby et al. (2012). The two Woodland categories are based on a list of species commonly associated with woodland habitats, originally published in Ratcliffe (1977) but expanded somewhat as the basis for the woodland survey card used in the 1980s (Kirby, 1988). The Woodland Specialists were then defined by species that were thought to have some association with ancient woodland in at least some parts of Britain. Specialists also tend to be more shade-tolerant and more likely to be stress-tolerators than Woodland Generalists (Kimberley et al., 2013) and are less likely to occur in other habitats as judged by the lists used to produce the National Vegetation Classification (Rodwell, 1991).

Ellenberg Indicator Values were initially developed for central Europe (Ellenberg, 1988). The values for Light, Reaction, Nitrogen and Moisture were used in these analyses are those adjusted for British conditions by Hill et al. (2004).

Value	Light scores (L)
1	Plant in deep shade
2	Between 1 and 3
3	Shad plant, mostly less than 5% relative illumination; seldom more than 30% illumination when trees are in full leaf.
4	Between 3 and 5
5	Semi-shade plant, rarely in full light, but generally with more than 10% relative illumination when trees are in leaf.
6	Between 5 and 7
7	Plant generally in well-lit places but also occurring in partial shade.
8	Light-loving plant rarely found where relative illumination is less than 40%
9	Plant in full light, found mostly in full sun.

Value	Moisture Scores (F)
1	Indicator of extreme dryness, restricted to soils that often dry out for some time
2	Between 1 and 3
3	Dry-site indicator more often found on dry ground ahtn in moist places
4	Between 3 and 5
5	Moist site indicator, mainly on fresh soils of average dampness
6	Between 5 and 6
7	Dampness indicator, mainly on constantly moist or damp but not wet soils
8	Between 7 and 9
9	Wet-site indicator, often on water saturated, badly aerated soils.
10	Indicator of shallow-water sites that may lack standing wouter for extensive periods
11	Plant rooting under water, but at least for a time exposed above or plant floating on the surface
12	Submerged plant, permanently or almost constantly under water

Value	Reaction scores (R), which refers to environmental acidity
1	Indicator of extreme acidity, never found on weakly acid or on basic soils.
2	Between 1 and 3
3	Acidity indicator, mainly on acid soils, but exceptionally also on nearly neutral ones.

4	Between 3 and 5
5	Indicator of moderately acid soils, only occasionally found on very acid or on neutral to basic soils
6	Between 5 and 7.
7	Indicator of weakly acid to weakly basic conditions; never found on very acid soils.
8	Between 7 and 9.
9	Indicator of basic reaction, always found on calcareous or other high-pH soils.

Value	Nitrogen values (N) give a general indication of preference for soil fertility
1	Indicator of extremely infertile sites
2	Between 1 and 3
3	Indicator of more or less infertile sites
4	Between 3 and 5
5	Indicator of sites of intermediate fertility
6	Between 5 and 7
7	Plant often found in richly fertile places
8	Between 7 and 9
9	Indicator of extremely rich conditions such as cattle-resting places or near polluted rivers.

Plant strategy scores (Grime et al., 2007)

Species were given a score based on their strategy classification (Ruderal, Competitor, Stress-tolerator) with the scores for intermediate strategy types being split between the main category as illustrated below.

	Competitive score	Stress score	Ruderal score
Species Strategy type			
C	100		
S		100	
R			100
CS	50	50	
CSR	33.3	33.3	33.3
Etc.			

Climatic requirements

These are means for the 10-km squares in which a species occurs in Britain, Ireland and the Channel Islands as presented in Hill et al. (2004).

- Mean July temperature °C
- Mean January temperature °C
- Annual precipitation (mm)

Appendix 4. Species characteristics used in interpreting change.

NW, WG, WS = Non-woodland, Woodland Generalist, Woodland Specialist species; Ellenberg scores for Light, Moisture, Reaction and Nitrogen; Plant Strategy Scores for Competitive, Stress-tolerant and Ruderal components; Mean January temperature, Mean July Temperature and Mean precipitation for 10-km squares where the species occurs – more detail in Appendix 3.

	NW, WG,		Ellenberg scores			Strategy score		Climate values		
Species name	WS	Light	Moist.	React.	Nitro.	Comp.	Stress	Jan.temp	Jul.temp.	Precip.
Achillea millefolium	1	7	5	6	4	41.7	16.7	3.5	14.5	1103
Aegopodium podagraria	2	6	5	6	7	41.7	16.7	3.6	14.6	1064
Agrimonia eupatoria	1	7	4	7	4	33.3	33.3	3.8	15.1	953
Agrostis capillaris	2	6	5	4	4	33.3	33.3	3.5	14.5	1104
Agrostis gigantea	2	7	6	6	7	50.0	0.0	3.6	15.3	889
Agrostis stolonifera	2	7	6	7	6	50.0	0.0	3.6	14.5	1101
Ajuga reptans	2	5	7	5	5	33.3	33.3	3.4	14.6	1095
Alliaria petiolata	2	5	6	7	8	50.0	0.0	3.6	15.1	935
Allium ursinum	3	4	6	7	7	16.7	41.7	3.5	14.8	1065
Alopecurus pratensis	1	7	5	6	7	66.7	16.7	3.5	14.7	1032
Anagallis arvensis	1	7	4	6	5		33.3	4.0	15.2	962
Anemone nemorosa	3	5	6	5	4	16.7	41.7	3.3	14.5	1113
Angelica sylvestris	2	7	8	6	5	75.0	0.0	3.5	14.4	1109
Anisantha sterilis	1	7	5	8	7	25.0	0.0	3.8	15.3	893
Anthoxanthum odoratum	2	7	6	4	3	16.7	41.7	3.5	14.4	1106
Anthriscus sylvestris	2	6	5	7	7	50.0	0.0	3.6	14.6	1039
Arctium lappa	2	9	5	7	9	50.0	0.0	3.8	16.0	769
Arctium minus	2	6	4	7	5	50.0	0.0	3.7	14.7	1051
Arenaria serpyllifolia	1	8	3	7	5	0.0	50.0	3.6	14.9	986
Arrhenatherum elatius	2	7	5	7	7	66.7	16.7	3.6	14.5	1089
Arum maculatum	3	4	5	7	7	16.7	41.7	3.9	15.3	931
Astragalus glycyphyllos	1	6	4	7	3			3.4	15.7	711
Athyrium filix-femina	3	5	7	5	6	75.0	25.0	3.5	14.4	1132
Bellis perennis	1	8	5	6	4	16.7	16.7	3.5	14.5	1105
Blechnum spicant	3	5	6	3	3	0.0	100.0	3.5	14.1	1198
Brachypodium pinnatum	1	7	3	8	3	50.0	50.0	3.6	15.9	745
Brachypodium sylvaticum	3	6	5	6	5	25.0	75.0	3.7	14.7	1062
Bromopsis erecta	1	7	4	8	3	41.7	41.7	3.7	15.9	764
Bromopsis ramosa	3	4	6	7	7	33.3	33.3	3.5	14.9	995
Bromus hordeaceus	1	8	4	7	4	0.0	0.0	3.7	14.7	1051
Bryonia dioica	2	7	5	7	7	66.7	16.7	3.6	16.0	726
Calamagrostis epigejos	3	7	7	7	6	75.0	25.0	3.7	15.7	812
Calystegia sepium	2	7	8	7	7	75.0	0.0	3.8	14.9	1021
Campanula trachelium	3	4	5	7	6	33.3	33.3	3.6	16.0	753
Cardamine flexuosa	2	5	7	6	6	0.0	25.0	3.5	14.5	1110
Cardamine pratensis	2	7	8	5	4	16.7	16.7	3.5	14.4	1104
Carex acutiformis	3	7	8	7	6	75.0	25.0	3.5	15.3	889
Carex flacca	1	7	5	6	2	0.0	100.0	3.5	14.5	1104
Carex hirta	2	7	7	7	6	66.7	16.7	3.7	15.0	963
Carex otrubae	1	6	8	7	7	41.7	16.7	4.0	15.3	939

Carex panicea	1	8	8	4	2	0.0	100.0	3.5	14.3	1139
Carex pendula	3	5	8	7	6	25.0	75.0	3.9	15.3	928
Carex remota	3	4	8	6	6	33.3	33.3	3.7	14.8	1063
Carex riparia	2	7	8	7	7	66.7	33.3	3.9	15.7	814
Carex sylvatica	3	4	5	6	5	0.0	100.0	3.6	14.8	1050
Centaurea nigra	1	7	5	6	5	33.3	33.3	3.6	14.5	1093
Centaurium erythraea	1	8	5	6	3	0.0	50.0	4.0	15.1	980
Cerastium fontanum	1	7	5	5	4	16.7	16.7	3.5	14.4	1106
Chamerion angustifolium	2	6	5	6	5	100.0	0.0	3.4	14.5	1075
Circaea lutetiana	2	4	6	7	6	50.0	0.0	3.7	14.9	1041
Cirsium arvense	1	8	6	7	6	100.0	0.0	3.6	14.5	1092
Cirsium eriophorum	1	8	4	8	5	16.7	16.7	3.6	16.0	745
Cirsium palustre	2	7	8	5	4	50.0	0.0	3.5	14.5	1105
Cirsium vulgare	2	7	5	6	6	50.0	0.0	3.5	14.5	1103
Clematis vitalba	2	6	4	8	5	50.0	50.0	4.0	16.0	815
Clinopodium vulgare	1	7	4	7	4	16.7	66.7	3.5	15.4	880
Conopodium majus	3	6	5	5	5	0.0	50.0	3.5	14.5	1102
Convolvulus arvensis	1	7	4	8	6	50.0	0.0	3.8	15.2	929
Crepis capillaris	1	7	4	7	4	0.0	25.0	3.6	14.6	1074
Cruciata laevipes	1	6	5	7	5	33.3	33.3	3.2	15.2	892
Cynosurus cristatus	1	7	5	6	4	33.3	33.3	3.5	14.5	1103
Dactylis glomerata	2	7	5	7	6	66.7	16.7	3.6	14.5	1091
Dactylorhiza fuchsii	2	7	8	7	3	16.7	66.7	3.5	14.7	1063
Daphne laureola	3	4	5	7	5	50.0	50.0	3.7	16.0	760
Daucus carota	1	8	4	7	3	16.7	41.7	4.0	15.0	989
Deschampsia cespitosa	2	6	6	5	4	41.7	41.7	3.5	14.4	1099
Dipsacus fullonum	1	8	7	7	7	50.0		3.8	15.6	863
Dryopteris affinis	3	5	6	5	5	41.7	41.7	3.5	14.3	1160
Dryopteris dilatata	2	5	6	4	5	41.7	41.7	3.5	14.4	1114
Dryopteris filix-mas	2	5	6	5	5	41.7	41.7	3.5	14.5	1096
Elytrigia repens	1	7	5	7	7	75.0	0.0	3.6	14.6	1046
Epilobium hirsutum	2	7	8	7	7	100.0	0.0	3.8	15.0	971
Epilobium montanum	2	6	6	6	6	33.3	33.3	3.5	14.5	1091
Epilobium parviflorum	1	7	9	7	5	33.3	33.3	3.8	14.9	996
Epilobium tetragonum	2	6	7	5	5			3.9	15.9	834
Epipactis helleborine	3	4	5	7	4	0.0	100.0	3.6	15.3	946
Epipactis purpurata	3	2	5	8	4	0.0	0.0	3.6	16.3	728
Equisetum arvense	1	7	6	6	6	50.0	0.0	3.5	14.5	1087
Equisetum telmateia	3	6	8	7	6	50.0	25.0	3.8	15.2	950
Eupatorium cannabinum	2	7	8	6	7	66.7	16.7	3.9	15.2	974
Euphorbia amygdaloides	3	4	5	6	6	0.0	0.0	4.1	16.1	827
Festuca arundinacea	1	8	6	7	6	33.3	33.3	3.6	14.9	980
Festuca gigantea	3	5	6	7	7	33.3	33.3	3.6	15.1	981
Festuca ovina	2	7	5	4	2	0.0	100.0	3.5	14.5	1109
Festuca pratensis	1	7	6	6	6	33.3	33.3	3.6	14.9	985
Festuca rubra	2	8	5	6	5	33.3	33.3	3.5	14.5	1104
Filipendula ulmaria	2	7	8	6	5	75.0	25.0	3.5	14.5	1105
Fragaria vesca	3	6	5	6	4	33.3	33.3	3.5	14.6	1091

Galium aparine	2	6	6	7	8	50.0	0.0	3.6	14.6	1080
Galium mollugo	1	7	4	7	4	66.7	16.7	3.5	15.3	905
Galium odoratum	3	3	5	7	6	41.7	41.7	3.4	14.7	1086
Galium palustre	2	7	9	5	4	41.7	16.7	3.5	14.5	1105
Galium uliginosum	1	7	9	6	4	16.7	66.7	3.2	14.9	961
Galium verum	1	7	4	6	2	41.7	41.7	3.5	14.6	1045
Geranium dissectum	1	7	5	7	6	0.0	25.0	3.7	14.8	1011
Geranium molle	1	7	5	6	5	0.0	25.0	3.7	14.8	1026
Geranium robertianum	3	5	6	6	6	16.7	16.7	3.5	14.6	1092
Geum urbanum	2	4	6	7	7	16.7	66.7	3.6	14.7	1044
Glechoma hederacea	2	6	6	7	7	33.3	33.3	3.6	14.9	1001
Glyceria fluitans	1	7	10	6	6	50.0	0.0	3.5	14.5	1098
Glyceria spp	1					0.0	0.0	3.5	14.5	1098
Hedera helix	2	4	5	7	6	50.0	50.0	3.6	14.6	1086
Helianthemum nummularium	1	7	4	7	2	0.0	100.0	3.0	14.8	924
Helictotrichon pubescens	1	7	4	7	3	16.7	66.7	3.5	14.6	1038
Heracleum sphondylium	2	7	5	7	7	50.0	0.0	3.6	14.5	1088
Holcus lanatus	2	7	6	6	5	33.3	33.3	3.5	14.4	1106
Holcus mollis	3	6	6	3	3	66.7	16.7	3.4	14.5	1101
Hordeum secalinum	1	8	6	7	6	33.3	33.3	3.8	16.0	742
Humulus lupulus	2	6	7	7	8	100.0	0.0	3.8	15.8	833
Hyacinthoides non-scripta	3	5	5	5	6	0.0	50.0	3.6	14.6	1092
Hypericum hirsutum	3	6	5	7	5	16.7	66.7	3.3	15.3	832
Hypericum maculatum	2	6	6	5	5	41.7	16.7	3.6	15.0	1016
Hypericum perforatum	2	7	4	7	5	41.7	16.7	3.6	15.1	951
Hypericum pulchrum	3	6	5	4	3	0.0	100.0	3.5	14.3	1148
Hypericum tetrapterum	3	7	8	6	4	33.3	33.3	3.7	14.9	1025
Hypochaeris radicata	1	8	4	5	3	33.3	33.3	3.5	14.5	1104
Impatiens parviflora	1	4	5	7	8	50.0		3.5	15.7	821
Inula conyzae	2	7	3	8	3	0.0	75.0	3.9	15.9	821
Juncus effusus	2	7	7	4	4	75.0	25.0	3.5	14.4	1108
Juncus inflexus	1	7	7	7	5	50.0	50.0	3.8	15.2	925
Knautia arvensis	1	7	3	8	4	33.3	33.3	3.8	15.2	919
Lamium galeobdolon	3	4	5	7	6	25.0	75.0	3.7	15.8	855
Lapsana communis	2	6	4	7	7	25.0	0.0	3.6	14.7	1059
Lathyrus pratensis	1	7	6	6	5	33.3	33.3	3.6	14.5	1079
Leontodon hispidus	1	8	4	7	3	16.7	66.7	3.6	15.2	918
Leucanthemum vulgare	1	8	4	7	4	41.7	16.7	3.6	14.6	1074
Linum catharticum	1	8	5	7	2	0.0	50.0	3.5	14.4	1113
Listera ovata	3	6	5	7	5	16.7	66.7	3.6	14.8	1001
Lithospermum officinale	1	6	5	8	5	40.0	40.0	3.9	15.8	820
Lolium perenne	1	8	5	6	6	41.7	16.7	3.6	14.5	1096
Lonicera periclymenum	3	5	6	5	5	50.0	50.0	3.6	14.5	1102
Lotus corniculatus	1	7	4	6	2	16.7	66.7	3.5	14.5	1104
Lotus pedunculatus	1	7	8	6	4	66.7	16.7	3.6	14.7	1072
Luzula pilosa	3	5	5	5	3	0.0	100.0	3.2	14.4	1127
Lycopus europaeus	2	7	8	7	6	50.0	0.0	3.8	15.2	995

Lysimachia nemorum	3	5	7	4	5	33.3	33.3	3.4	14.4	1150
Lysimachia nummularia	1	5	7	5	5	33.3	33.3	3.7	15.5	895
Lysimachia vulgaris	3	7	9	7	5	75.0	25.0	3.7	15.2	943
Lythrum salicaria	2	7	9	7	5	66.7	16.7	4.0	15.0	1024
Medicago lupulina	1	7	4	8	4	0.0	25.0	3.8	15.0	963
Medicago sativa	1	7	4	6	5	66.7	16.7	3.5	16.2	604
Melica uniflora	3	4	5	7	5	25.0	75.0	3.5	15.0	1015
Mentha aquatica	2	7	8	7	5	75.0	0.0	3.7	14.7	1065
Mentha arvensis	2	6	7	7	6	50.0	0.0	3.6	14.9	1017
Mercurialis perennis	3	3	6	7	7	50.0	50.0	3.2	14.8	1045
Milium effusum	3	4	5	6	5	16.7	66.7	3.6	15.3	928
Moehringia trinervia	3	4	5	7	6	0.0	50.0	3.5	15.0	982
Myosotis arvensis	2	7	5	6	6	0.0	25.0	3.5	14.6	1056
Myosotis ramosissima	1	8	3	6	3	0.0	50.0	3.8	15.5	823
Narcissus pseudonarcissus	3	7	5	6	5	0.0	50.0	3.7	15.6	920
Odontites vernus	1	7	5	6	5	0.0	0.0	3.7	14.7	1047
Ononis repens	1	8	4	6	3	16.7	66.7	3.8	15.3	878
Ophioglossum vulgatum	3	8	7	7	3	16.7	41.7	3.6	15.1	964
Origanum vulgare	1	6	4	7	4	41.7	41.7	3.7	15.3	898
Oxalis acetosella	3	4	6	4	4	16.7	66.7	3.4	14.4	1138
Paris quadrifolia	3	3	6	7	6	0.0	0.0	3.2	15.3	877
Pastinaca sativa	1	7	4	7	5	50.0	0.0	3.8	16.0	774
Phleum pratense	1	8	5	7	6	33.3	33.3	3.5	14.8	1023
Phyllitis scolopendrium	3	4	5	7	5	0.0	100.0	3.8	14.8	1048
Pimpinella major	3	7	5	7	6	33.3	33.3	3.6	15.5	819
Plantago major	1	7	5	6	7	16.7	16.7	3.5	14.5	1102
Platanthera chlorantha	3	5	5	7	4	0.0	75.0	3.4	14.7	1147
Poa annua	2	7	5	6	7	0.0	0.0	3.5	14.5	1105
Poa pratensis	1	7	5	6	5	33.3	33.3	3.5	14.5	1102
Poa trivialis	2	7	6	6	6	41.7	16.7	3.6	14.5	1095
Polygala vulgaris	1	8	5	6	3	0.0	100.0	3.5	14.4	1114
Polygonum aviculare	1	7	5	6	7	0.0	0.0	3.7	14.8	1039
Polystichum setiferum	3	4	5	5	6	0.0	0.0	4.1	15.0	1032
Potentilla anserina	2	8	7	7	6	41.7	16.7	3.6	14.6	1083
Potentilla reptans	2	7	5	7	5	41.7	16.7	3.8	15.1	959
Potentilla sterilis	3	5	5	5	5	0.0	100.0	3.6	14.7	1071
Primula vulgaris	3	5	5	6	4	16.7	66.7	3.5	14.5	1108
Prunella vulgaris	2	7	5	6	4	33.3	33.3	3.5	14.4	1106
Pteridium aquilinum	2	6	5	3	3	100.0	0.0	3.5	14.5	1109
Pulicaria dysenterica	1	7	7	7	4	50.0	50.0	4.0	15.5	885
Ranunculus acris	1	7	6	6	4	33.3	33.3	3.5	14.4	1106
Ranunculus auricomus	3	6	7	6	5	16.7	41.7	3.3	15.1	922
Ranunculus ficaria	2	6	6	6	6	0.0	25.0	3.6	14.5	1084
Ranunculus repens	2	6	7	6	7	50.0	0.0	3.5	14.5	1105
Ribes rubrum	3	5	7	7	6	50.0	50.0	3.3	15.1	944
Ribes uva-crispa	2	5	5	7	6	50.0	50.0	3.4	14.8	1006
Rosa canina	2	6	5	7	6	50.0	50.0	3.7	15.1	993
Rubus caesius	3	7	7	7	6	50.0	50.0	3.8	15.6	851

Rubus fruticosus	2	6	6	6	6	50.0	50.0	3.6	14.6	1089
Rubus idaeus	2	6	5	5	5	50.0	50.0	3.4	14.5	1095
Rumex acetosa	2	7	5	5	4	33.3	33.3	3.5	14.4	1105
Rumex crispus	1	8	6	7	6	25.0	0.0	3.6	14.5	1087
Rumex obtusifolius	2	7	5	7	9	50.0	0.0	3.6	14.5	1100
Rumex sanguineus	2	5	7	7	7	33.3	33.3	3.8	15.0	1003
Sanguisorba minor	1	7	4	8	3	0.0	100.0	3.7	15.6	844
Sanicula europaea	3	4	5	7	5	0.0	100.0	3.5	14.7	1090
Scrophularia auriculata	2	7	8	7	7	50.0	0.0	3.9	15.4	918
Scrophularia nodosa	3	5	6	7	6	50.0	0.0	3.6	14.7	1069
Senecio jacobaea	1	7	4	6	4	25.0	0.0	3.6	14.5	1102
Senecio sylvaticus	2	7	5	5	6	0.0	0.0	3.6	14.9	987
Senecio vulgaris	1	7	5	7	7	0.0	0.0	3.6	14.6	1075
Silene dioica	3	5	6	6	7	33.3	33.3	3.4	14.6	1065
Solanum dulcamara	2	7	8	7	7	66.7	16.7	3.8	15.2	945
Sonchus oleraceus	1	7	5	7	7	25.0	0.0	3.7	14.8	1031
Stachys officinalis	3	7	5	5	3	0.0	100.0	3.6	15.4	940
Stachys sylvatica	3	6	6	7	8	75.0	0.0	3.6	14.7	1064
Stellaria graminea	2	7	6	5	4	33.3	33.3	3.5	14.6	1065
Stellaria holostea	3	5	5	6	6	33.3	33.3	3.5	14.7	1058
Stellaria media	2	7	5	6	7	0.0	0.0	3.6	14.5	1095
Stellaria uliginosa	2	7	8	5	5	41.7	16.7	3.5	14.4	1128
Succisa pratensis	2	7	7	5	2	0.0	100.0	3.5	14.4	1124
Symphytum officinale	1	7	7	7	8	75.0	0.0	3.7	15.4	871
Tamus communis	3	6	5	7	6	75.0	0.0	3.8	15.7	850
Taraxacum officinale agg.	2	7	5	7	6	16.7	16.7	3.5	14.5	1104
Torilis japonica	2	7	5	7	7	16.7	41.7	3.7	14.9	1004
Trifolium pratense	1	7	5	7	5	33.3	33.3	3.6	14.5	1100
Trifolium repens	1	7	5	6	6	41.7	16.7	3.5	14.5	1105
Trisetum flavescens	1	7	4	7	4	33.3	33.3	3.6	15.2	918
Tussilago farfara	1	7	6	6	6	50.0	0.0	3.5	14.5	1085
Ulex europaeus	2	7	5	5	3	50.0	50.0	3.6	14.6	1090
Urtica dioica	2	6	6	7	8	100.0	0.0	3.6	14.5	1102
Verbascum thapsus	1	7	4	7	5	20.0	40.0	3.7	15.2	918
Veronica arvensis	1	8	4	6	5	0.0	50.0	3.5	14.6	1077
Veronica beccabunga	1	7	10	6	6	50.0	0.0	3.6	14.7	1034
Veronica chamaedrys	2	6	5	6	5	33.3	33.3	3.5	14.5	1095
Veronica hederifolia	2	6	5	7	6	0.0	25.0	3.7	15.1	918
Veronica montana	3	4	6	6	6	16.7	66.7	3.6	14.9	1029
Veronica officinalis	2	6	5	4	4	16.7	66.7	3.4	14.4	1125
Veronica serpyllifolia	1	7	5	6	5	16.7	16.7	3.5	14.5	1104
Vicia cracca	1	7	6	7	5	66.7	16.7	3.6	14.5	1083
Vicia sativa	1	7	4	7	4	16.7	16.7	3.7	14.9	991
Vicia sepium	3	6	5	6	6	66.7	16.7	3.5	14.5	1095
Vicia tenuifolia	1	8	3	8	2	50.0	25.0	3.6	14.5	1083
Viola hirta	2	7	4	8	2	0.0	100.0	3.7	15.7	795
Viola odorata	3	5	5	7	7	33.3	33.3	3.8	15.7	833
Viola riviniana	3	6	5	5	4	0.0	100.0	3.5	14.4	1112

Appendix 5. Estimating species cover for the 1974 recordings.

From 1991 onward the cover of each ground flora species (excluding tree and shrub seedlings) had been estimated using the Domin scale. The Domin values were then converted to percentage cover values using mid-point values for scores above 3. However for the 1974 recordings cover was estimated on a simpler scoring system and only for six ground flora species

Conversion of 1974 cover scores and Domin values to percentage cover estimates

Domin scores and % range	% cover equivalent	1974 cover score	% cover equivalent
1	1		
2	2	1 1-5%	2.5
3	3		
4 4-10%	7.5	2 6-25%	15
5 11-25%	17.5		
6 26-33%	29	3 26-50%	37.5
7 34-50%	41.5		
8 51-75%	62.5	4 51-75%	62.5
9 76-90%	82.5	5 76-100%	87.5
10 91-100%	95		

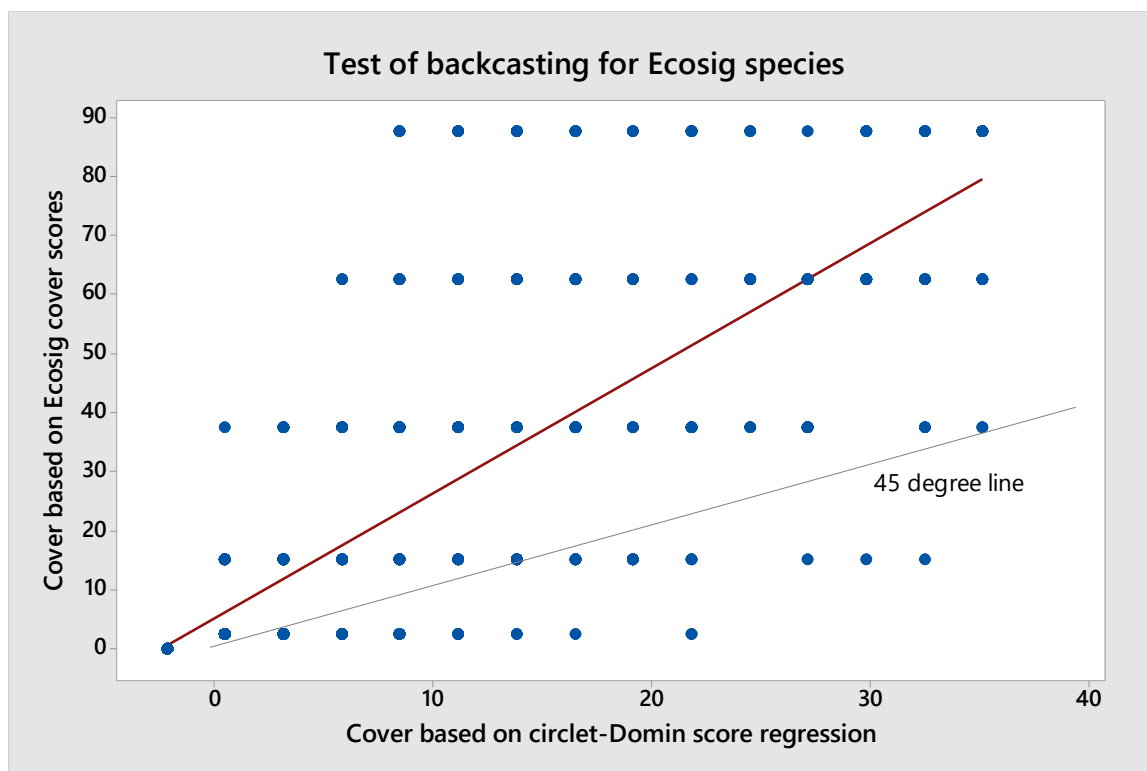
In the 1974 recording cover was estimated only for six species and only on a five-point scale. For these six species the cover score was again converted to percentage cover using the mid-point of the range. Fortunately, the six species had been chosen because they were among the commonest and biggest species (*Chamerion angustifolium*, *Hyacinthoides non-scripta*, *Mercurialis perennis*, *Rubus fruticosus*, *Pteridium aquilinum*, *Urtica dioica*).

For the remaining species a backcast was made of their likely cover in 1974 based on the frequency with which they were recorded in the thirteen 0.01 m² circular quadrats (cirlclets) that were recorded across the diagonals of each plot. The procedure was as follows.

- The cirlclet values for each species present in a plot from the 1991-2018 recordings were increased by 1 to allow for species that were in the plot but not picked up in the cirlclet. Every species now had a score of 1-14 (frequency in cirlclets/plot) and an accompany domin score.
- A regression was performed of the % cover (from the Domin value) on the cirlclet score. Cover = -2.2 + 2.66 * cirlclet score; $R^2 = 42\%$; F = 7338, DF 1, 10,233
- This equation was used to calculate a likely cover for each species in 1974 from the cirlclet records for that species in 1974.

The result was tested by comparing the cover predictions for the six species for which a cover score had been given in 1974 with their backcast. There was a good correlation ($R^2 = 62\%$) (74cover = 5.2 + 2.1 * backcast; F = 11898, DF 1 737) but the backcasting was underestimating the cover based on the scores given in 1974 particularly of *Pteridium aquilinum* and *Rubus fruticosus* (R^2 increased to 77% when these were removed). These are potentially the largest species in the ground flora with a large area of foliage per stem: so relatively fewer cirlclet records (based on rooted presence) would occur for a given foliage cover.

Therefore I have used the backcast covers for the species in 1974 where a direct cover score was not available.



Appendix 6 Converting cover values to dry weight/net primary production

Many of the ground flora species in Wytham are perennials but much of the above ground material dies back over-winter and re-grows again each year. If it is assumed that net accumulation of carbon below ground is more or less stable then estimates of above ground biomass are roughly equivalent to net primary production (NPP) of the ground flora.

Above-ground biomass can be estimated by direct harvesting (although differential peaks in production between species complicate this). I am not aware of any data based on this approach for the ground flora as a whole in Wytham. Schulze et al. (2009) and Bolte et al., (2004) give another approach which calculates above-ground NPP for individual species based on their cover and shoot length. The allometric equations used were derived from measurements in forest stands in north Germany for individual species or species groups such as 'small herbs', 'tall grasses' etc.

The form of the equation is:

$$P = aPC^bMS^c$$

P= Above ground biomass (dry matter, 105°, g/m²); PC= Percentage cover (species, species group); MS= Mean shoot length (above ground, cm); a,b,c Empirical parameters obtained by fitting measured data in the original study (Bolte et al. 2004).

Examples of coefficients for selected species and groups (Schulze et al., 2009)

Species/species group	Coefficient a	Coefficient b	Coefficient c	Stem length – range (cm)	Stem length – mean (cm)
<i>Mercurialis perennis</i>	0.0258	1.3338	0.6425		
<i>Brachypodium sylvaticum</i>	0.0076	1.2545	1.0600		
Small herbs	0.1186	0.966	0.4311	5-15	10
Middle herbs	0.0687	1.259	0.3624	10-40	15
Tall herbs	0.0037	1.5158	0.8057	20-160	55
Small grasses	0.0426	0.9779	0.9083	20-60	35
Middle grasses	0.0047	1.0748	1.4184	30-80	50
Tall grasses	0.0001	1.2050	2.0590	30-120	70
Fern	0.0445	1.4812	0.2582	30-90	55
Tall fern	0.0003	1.2634	1.5391	50-215	100
Dwarf shrub (not used in Wytham analysis)	0.1641	1.0080	0.9028	10-40	20
Shrub	0.0003	0.9658	2.2250	25-120	55

I have assumed that this equation can simply be applied to the Wytham situation. Continental colleagues who have used the system and also have some experience of Wytham feel this is probably reasonable.

The stem-length data can be made more site-specific. Checking the mean values suggested for different species in Schulze et al. (2009) against values in Stace (1991) and Grime et al. (2007) suggested that several of the values, notably for *Mercurialis perennis*, were rather low. This may be because they are derived from forests with a higher proportion of beech and conifers in the canopy (high shade levels) compared to Wytham where ash is the most abundant tree.

I therefore made some measurements of species in Wytham (1/7/2015) concentrating on the top (in cover terms) 14 species. For these I ended up with about 10 lengths per species from different parts of the Woods, with 1-5 lengths for a further 50 species. Wytham values where available were used in the subsequent analysis.

The list below shows the coefficients and stem-length values used in the analysis.

Species abbreviation	coeff. a.	coeff. b.	coeff. c.	stemlength
Achil mil	0.06875	1.259378	0.362368	15
Aegop pod	0.003679	1.515838	0.805736	55
Agrim eup	0.06875	1.259378	0.362368	15
Agrop rep	0.0001	1.205	2.059	70
Agros cap	0.010444	1.078613	1.263931	50
Agros gig	0.010444	1.078613	1.263931	50
Agros sto	0.010444	1.078613	1.263931	50
Ajuga rep	0.06875	1.259378	0.362368	15
Allia pet	0.003679	1.515838	0.805736	47.5
Alliu urs	0.06875	1.259378	0.362368	32
Alope pra	0.010444	1.078613	1.263931	50
Anaga arv	0.1187	0.9663	0.4311	10
Anemo nem	0.118599	0.966259	0.431136	10
Angel syl	0.003679	1.515838	0.805736	35
Antho odo	0.042591	0.977943	0.908297	35
Anthr syl	0.003679	1.515838	0.805736	55
Arcti lap	0.003679	1.515838	0.805736	105
Arcti min	0.003679	1.515838	0.805736	105
Arena ser	0.118599	0.966259	0.431136	10
Arrhe ela	0.000102	1.205021	2.05899	70
Arum mac	0.118599	0.966259	0.431136	27.43
Astra gly	0.003679	1.515838	0.805736	55
Athyr fil	0.044473	1.481156	0.258235	55
Belli per	0.118599	0.966259	0.431136	10
Beton off	0.003679	1.515838	0.805736	55
Blech spi	0.003679	1.515838	0.805736	55
Brach pin	0.007579	1.254531	1.60022	50
Brach syl	0.007579	1.254531	1.06022	54.55
Bromu ere	0.004699	1.074758	1.418451	50
Bromu mol	0.004699	1.074758	1.418451	50
Bromu ste	0.004699	1.074758	1.418451	50
Bryon dio	0.003679	1.515838	0.805736	55
Calam epi	0.0001	1.205	2.059	70
Calys sep	0.003679	1.515838	0.805736	55
Campa tra	0.003679	1.515838	0.805736	55
Carda fle	0.06875	1.259378	0.362368	15
Carda pra	0.06875	1.259378	0.362368	15
Carex acu	0.0001	1.205	2.059	70
Carex fla	0.010444	1.078613	1.263931	50
Carex hir	0.042591	0.977943	0.908297	35
Carex otr	0.042591	0.977943	0.908297	35
Carex pan	0.042591	0.977943	0.908297	35
Carex pen	0.000102	1.205021	2.05899	99
Carex rem	0.004699	1.074758	1.418451	37

Carex rip	0.000102	1.205021	2.05899	70
Carex syl	0.042591	0.977943	0.908297	38
Centa ery	0.0687	1.2594	0.3624	30
Centa nig	0.003679	1.515838	0.805736	55
Ceras fon	0.06875	1.259378	0.362368	15
Chame ang	0.003679	1.515838	0.805736	55
Chrys leu	0.06875	1.259378	0.362368	70
Circa lut	0.06875	1.259378	0.362368	23.5
Cirsi arv	0.003679	1.515838	0.805736	80
Cirsi eri	0.003679	1.515838	0.805736	55
Cirsi pal	0.003679	1.515838	0.805736	55
Cirsi vul	0.003679	1.515838	0.805736	60
Clema vit	0.003679	1.515838	0.805736	55
Clino vul	0.06875	1.259378	0.362368	15
Conop maj	0.06875	1.259378	0.362368	15
Convo arv	0.06875	1.259378	0.362368	15
Crepi cap	0.06875	1.259378	0.362368	15
Cynos cri	0.0047	1.0748	1.4185	50
Dacty fuc	0.06875	1.259378	0.362368	25
Dacty glo	9.68E-05	0.922753	2.521483	72
Daphn lau	0.000322	0.965765	2.225042	55
Daucu car	0.003679	1.515838	0.805736	55
Desch ces	0.000102	1.205021	2.05899	46.7
Dipsa ful	0.003679	1.515838	0.805736	55
Dryop aff	0.044473	1.481156	0.258235	55
Dryop aus	0.003858	1.288694	1.181135	55
Dryop fil	0.001718	1.399681	1.08307	58.75
Epilo hir	0.003679	1.515838	0.805736	55
Epilo mon	0.003679	1.515838	0.805736	55
Epilo par	0.003679	1.515838	0.805736	55
Epilo tet	0.003679	1.515838	0.805736	55
Epipa hel	0.06875	1.259378	0.362368	15
Epipa pur	0.06875	1.259378	0.362368	15
Equis arv	0.042591	0.977943	0.908297	35
Equis tel	0.000102	1.205021	2.05899	100
Eupat can	0.003679	1.515838	0.805736	55
Eupho amy	0.06875	1.259378	0.362368	58
Festu aru	0.0047	1.0748	1.4185	50
Festu gig	0.000102	1.205021	2.05899	62
Festu ovi	0.042591	0.977943	0.908297	35
Festu pra	0.0047	1.0748	1.4185	50
Festu rub	0.042591	0.977943	0.908297	35
Filip ulm	0.003679	1.515838	0.805736	55
Fraga ves	0.118599	0.966259	0.431136	10
Galeo lut	0.16176	1.283234	0.362368	43
Galiu apa	0.06875	1.259378	0.362368	85.27
Galiu cru	0.06875	1.259378	0.362368	15
Galiu mol	0.06875	1.259378	0.362368	15

Galiu odo	1.642853	1.03076	0.003816	15
Galiu pal	0.06875	1.259378	0.362368	15
Galiu uli	0.06875	1.259378	0.362368	15
Galiu ver	0.06875	1.259378	0.362368	25
Geran dis	1.642853	1.03076	0.003816	15
Geran mol	0.06875	1.259378	0.362368	15
Geran rob	0.06875	1.259378	0.362368	40
Geum urb	0.06875	1.259378	0.362368	34.38
Glech hed	0.06875	1.259378	0.362368	49
Glyce flu	0.0047	1.0748	1.4185	50
Glyce pli	0.0047	1.0748	1.4185	50
Glyce spp	0.0047	1.0748	1.4185	50
Heder hel	0.003679	1.515838	0.805736	38
Helia cha	1.642853	1.03076	0.003816	15
Helic pub	0.0047	1.0748	1.4185	50
Herac sph	0.003679	1.515838	0.805736	55
Hiera spp	0.003679	1.515838	0.805736	55
Holcu lan	0.004699	1.074758	1.418451	71.25
Holcu mol	0.004699	1.074758	1.418451	71.25
Horde sec	0.0047	1.0748	1.4185	50
Humul lup	0.003679	1.515838	0.805736	55
Hyaci non	0.06875	1.259378	0.362368	44.38
Hyper hir	0.003679	1.515838	0.805736	55
Hyper mac	0.06875	1.259378	0.362368	15
Hyper per	0.06875	1.259378	0.362368	15
Hyper pul	0.06875	1.259378	0.362368	15
Hyper tet	0.06875	1.259378	0.362368	15
Hypoc rad	0.1187	0.9663	0.4311	10
Impat par	0.0013	1.55	0.9015	20
Inula con	0.003679	1.515838	0.805736	55
Juncu eff	0.004699	1.074758	1.418451	50
Juncu inf	0.004699	1.074758	1.418451	50
Knaut arv	0.003679	1.515838	0.805736	55
Lapsa com	0.06875	1.259378	0.362368	75
Lathy pra	0.003679	1.515838	0.805736	55
Leont his	0.06875	1.259378	0.362368	15
Linum cat	0.06875	1.259378	0.362368	15
Liste ova	0.06875	1.259378	0.362368	15
Litho off	0.003679	1.515838	0.805736	55
Loliu per	0.004699	1.074758	1.418451	50
Lonic per	0.003679	1.515838	0.805736	55
Lotus cor	0.06875	1.259378	0.362368	15
Lotus uli	0.06875	1.259378	0.362368	15
Luzul pil	0.426	0.9779	0.9083	35
Lycop eur	0.003679	1.515838	0.805736	55
Lysim nem	0.06875	1.259378	0.362368	15
Lysim num	0.06875	1.259378	0.362368	15
Lysim vul	0.003679	1.515838	0.805736	55

Lythr sal	0.003679	1.515838	0.805736	55
Medic lup	0.06875	1.259378	0.362368	15
Medic sat	0.003679	1.515838	0.805736	55
Melic uni	0.028909	0.931749	1.012618	35
Menth aqu	0.06875	1.259378	0.362368	15
Menth arv	0.06875	1.259378	0.362368	15
Mercu per	0.025781	1.333795	0.64248	29.36
Miliu eff	0.0001	1.205	2.059	70
Moehr tri	0.118599	0.966259	0.431136	10
Myoso arv	0.06875	1.259378	0.362368	15
Myoso ram	0.118599	0.966259	0.431136	10
Narci hyb	0.06875	1.259378	0.362368	15
Necta sco	0.06875	1.259378	0.362368	15
Odont ver	0.06875	1.259378	0.362368	15
Ononi rep	0.06875	1.259378	0.362368	15
Ophio vul	0.06875	1.259378	0.362368	15
Orchi sp	0.06875	1.259378	0.362368	15
Origa vul	0.06875	1.259378	0.362368	15
Oxali ace	0.152046	1.109045	0.431136	10
Paris qua	0.06875	1.259378	0.362368	15
Pasti sat	0.003679	1.515838	0.805736	110
Phleu pra	0.000102	1.205021	2.05899	70
Phyll sco	0.445	1.4812	0.2582	55
Pimpi maj	0.003679	1.515838	0.805736	55
Plant maj	0.06875	1.259378	0.362368	15
Plata chl	0.06875	1.259378	0.362368	15
Poa ann	0.042591	0.977943	0.908297	35
Poa pra	0.010444	1.078613	1.263931	50
Poa tri	0.010444	1.078613	1.263931	34.4
Polyg avi	0.003679	1.515838	0.805736	55
Polyg vul	0.06875	1.259378	0.362368	15
Polys set	0.445	1.4812	0.2582	55
Poten ans	0.118599	0.966259	0.431136	10
Poten rep	0.06875	1.259378	0.362368	15
Poten ste	0.118599	0.966259	0.431136	10
Poter san	0.06875	1.259378	0.362368	15
Primu vul	0.118599	0.966259	0.431136	20
Prune vul	0.06875	1.259378	0.362368	20
Pteri aqu	0.000334	1.263397	1.539053	98.6
Pulic dys	0.003679	1.515838	0.805736	55
Ranun acr	0.06875	1.259378	0.362368	15
Ranun aur	0.06875	1.259378	0.362368	15
Ranun fic	0.393043	1.069811	0.431136	10
Ranun rep	0.06875	1.259378	0.362368	32
Ribes syl	0.000322	0.965765	2.225042	55
Ribes uva	0.000322	0.965765	2.225042	55
Rosa spp	0.000322	0.965765	2.225042	55
Rubus cae	0.000322	0.965765	2.225042	55

Rubus fru	0.000322	0.965765	2.225042	78.6
Rubus ida	0.000322	0.965765	2.225042	55
Rumex ace	0.06875	1.259378	0.362368	15
Rumex cri	0.06875	1.259378	0.362368	55
Rumex obt	0.06875	1.259378	0.362368	55
Rumex san	0.06875	1.259378	0.362368	73.3
Sanic eur	0.06875	1.259378	0.362368	10
Scrop aqu	0.06875	1.259378	0.362368	55
Scrop nod	0.06875	1.259378	0.362368	70
Senec jac	0.06875	1.259378	0.362368	15
Senec syl	0.06875	1.259378	0.362368	15
Senec vul	0.06875	1.259378	0.362368	15
Silen dio	0.06875	1.259378	0.362368	52
Solan dul	0.003679	1.515838	0.805736	55
Sonch ole	0.06875	1.259378	0.362368	15
Stach syl	0.06875	1.259378	0.362368	72
Stell als	0.06875	1.259378	0.362368	15
Stell gra	0.06875	1.259378	0.362368	15
Stell hol	0.93754	0.960223	0.362368	15
Stell med	0.06875	1.259378	0.362368	15
Succi pra	0.06875	1.259378	0.362368	15
Symph off	0.003679	1.515838	0.805736	55
Tamus com	0.118599	0.966259	0.431136	10
Tarax off	0.118599	0.966259	0.431136	20
Toril jap	0.003679	1.515838	0.805736	55
Trifo pra	0.06875	1.259378	0.362368	15
Trifo rep	0.118599	0.966259	0.431136	10
Trise fla	0.0047	1.0748	1.4185	50
Tussi far	0.06875	1.259378	0.362368	15
Ulex eur	0.000322	0.965765	2.225042	55
Urtic dio	0.01305	1.105488	0.901261	72.9
Verba tha	0.003679	1.515838	0.805736	55
Veron arv	0.118599	0.966259	0.431136	10
Veron bec	0.118599	0.966259	0.431136	10
Veron cha	0.06875	1.259378	0.362368	15
Veron hed	0.06875	1.259378	0.362368	15
Veron mon	0.06875	1.259378	0.362368	23
Veron off	0.118599	0.966259	0.431136	10
Veron ser	0.06875	1.259378	0.362368	15
Vicia cra	0.06875	1.259378	0.362368	15
Vicia sat	0.003679	1.515838	0.805736	55
Vicia sep	0.06875	1.259378	0.362368	15
Vicia ten	0.06875	1.259378	0.362368	15
Viola hir	0.118599	0.966259	0.431136	10
Viola odo	0.118599	0.966259	0.431136	10
Viola riv	0.118599	0.966259	0.431136	10
Zerna ram	0.000102	1.205021	2.05899	80

Appendix 7. No of plots in which a species occurred in the five recordings, ordered by total number of occurrences across the recordings.

Species	1974	1991	1999	2012	2018	Total occurrences (out of 820)
Rubus fru	143	128	127	141	142	681
Poa tri	111	140	147	127	114	639
Mercu per	138	132	121	122	121	634
Brach syl	64	137	142	146	141	630
Urtic dio	123	129	121	101	98	572
Desch ces	50	101	125	126	116	518
Circa lut	135	88	81	99	88	491
Glech hed	100	110	94	69	52	425
Hyaci non	62	63	79	100	98	402
Geum urb	72	63	73	99	83	390
Galii apa	91	68	48	104	72	383
Pteri aqu	99	78	70	70	63	380
Carex syl	45	61	84	91	88	369
Dryop fil	62	61	59	74	73	329
Carex pen	43	41	54	66	67	271
Arum mac	35	64	49	58	42	248
Viola riv	47	47	55	48	40	237
Rumex san	28	42	60	51	29	210
Festu gig	54	48	38	36	22	198
Galeo lut	33	29	34	35	29	160
Hyper hir	18	59	35	22	11	145
Veron cha	23	35	45	21	12	136
Ajuga rep	41	18	19	27	19	124
Ranun rep	12	30	27	30	23	122
Veron mon	13	23	23	37	25	121
Agros sto	29	34	22	16	15	116
Tamus com	35	25	17	22	17	116
Rosa spp	30	25	20	25	14	114
Dacty glo	36	16	13	18	21	104
Holcu lan	26	28	18	15	15	102
Dryop aus	6	16	26	24	25	97
Lonic per	33	23	7	14	15	92
Tarax off	11	23	15	23	15	87
Primu vul	19	20	22	15	10	86
Angel syl	36	20	8	7	7	78
Juncu eff	13	26	23	8	7	77
Epilo mon	38	22	7	5	4	76
Heder hel	5	3	8	30	30	76
Poten rep	20	21	17	9	8	75
Prune vul	11	20	23	13	8	75
Carex rem	1	6	24	24	18	73
Clema vit	7	21	22	14	9	73
Cirsi arv	16	18	11	16	8	69
Geran rob	6	14	11	19	18	68

Poten ste	12	19	15	12	9	67
Carda fle	3	25	27	7	3	65
Scrop nod	9	21	17	7	10	64
Stach syl	18	15	8	12	11	64
Silen dio	20	14	10	10	8	62
Holcu mol	16	14	11	9	4	54
Chame ang	38	13	0	2	0	53
Ceras fon	8	17	12	13	2	52
Oxali ace	7	10	13	15	7	52
Herac sph	32	7	1	5	5	50
Allia pet	1	10	11	16	11	49
Filip ulm	17	10	8	8	5	48
Stell med	11	19	11	7	0	48
Plant maj	8	15	7	10	7	47
Arrhe ela	15	8	7	10	5	45
Rubus cae	29	1	5	6	2	43
Ribes syl	5	11	10	6	10	42
Arcti min	16	17	1	5	2	41
Lysim nem	1	15	5	13	6	40
Sonch ole	3	21	5	8	3	40
Senec jac	5	19	5	9	1	39
Cirsi vul	4	20	7	5	2	38
Ranun fic	7	10	10	8	0	35
Trifo rep	6	9	9	6	5	35
Anemo						
nem	7	8	5	11	3	34
Solan dul	17	7	1	5	4	34
Viola hir	9	7	8	8	2	34
Zerna ram	13	9	2	5	4	33
Epilo hir	22	2	1	5	2	32
Myoso arv	13	8	1	8	2	32
Poa pra	17	7	3	4	1	32
Festu rub	12	4	5	6	3	30
Eupho amy	4	6	7	7	5	29
Brach pin	8	4	6	5	4	27
Pasti sat	6	8	6	4	3	27
Vicia sep	6	5	4	8	4	27
Clino vul	9	6	5	1	4	25
Juncu inf	7	7	9	1	1	25
Poa ann	4	7	3	7	4	25
Lysim num	11	2	5	0	7	25
Cirsi pal	13	4	4	2	0	23
Carex fla	7	5	3	4	3	22
Convo arv	8	5	3	2	3	21
Equis tel	12	0	4	1	4	21
Galiu ver	5	5	4	4	3	21
Agros cap	5	3	5	4	3	20
Hyper tet	3	13	3	1	0	20

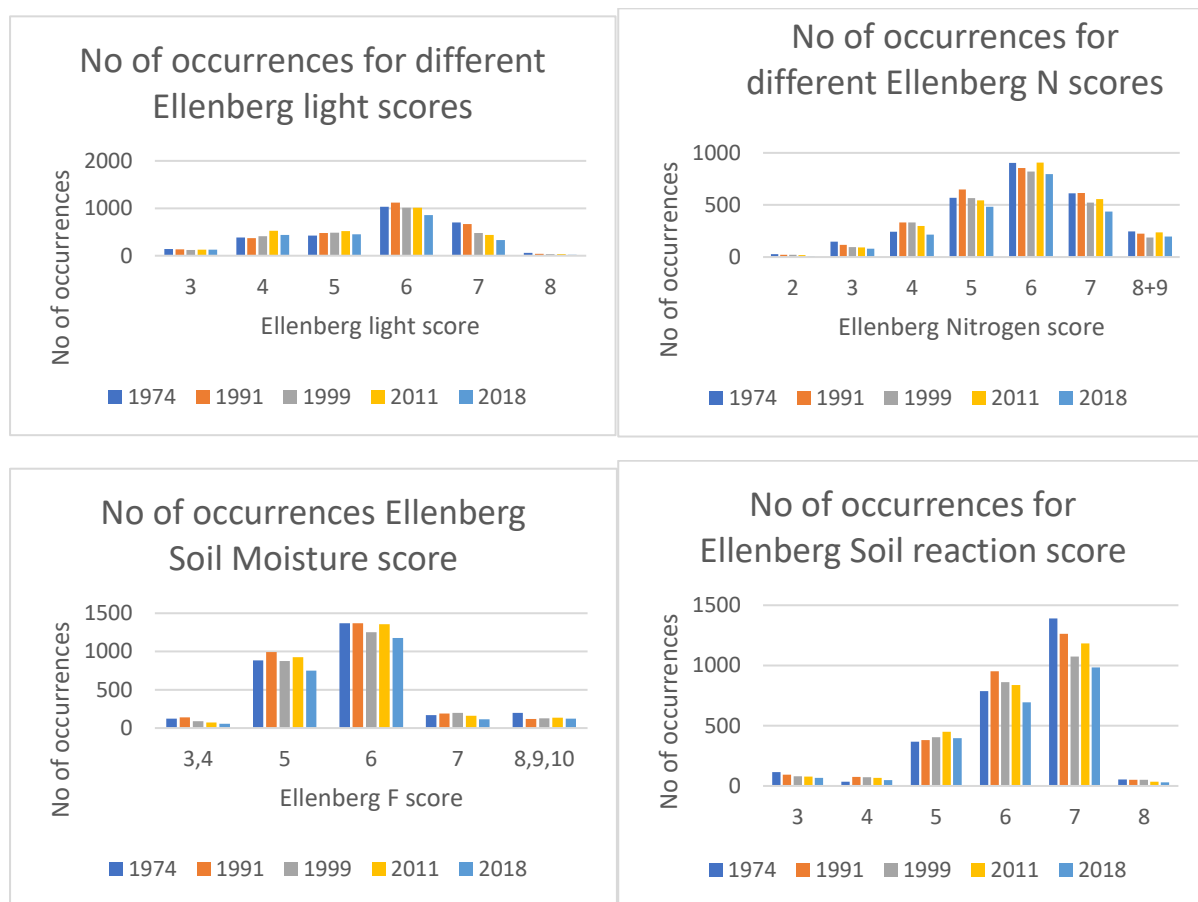
Moehr tri	4	3	3	6	4	20
Veron ser	0	13	3	3	1	20
Fraga ves	9	5	3	2	0	19
Lapsa com	2	4	3	3	7	19
Hyper per	5	9	3	0	0	17
Agrim eup	6	3	2	2	3	16
Athyr fil	0	1	5	5	5	16
Campa tra	6	3	1	5	1	16
Carda pra	0	4	5	6	0	15
Cirsi eri	5	2	2	2	4	15
Menth aqu	4	1	5	2	3	15
Sanic eur	7	2	1	2	3	15
Carex acu	8	2	1	0	3	14
Loliu per	4	2	5	2	1	14
Medic lup	4	5	3	1	1	14
Lotus cor	3	2	3	3	2	13
Alliu urs	0	0	2	5	6	13
Galiu pal	1	2	5	2	2	12
Dacty fuc	8	0	0	2	1	11
Phleu pra	5	2	2	1	1	11
Agrop rep	9	1	0	0	0	10
Crepi cap	3	3	2	1	1	10
Daphn lau	2	2	2	2	2	10
Inula con	1	4	2	1	2	10
Lathy pra	4	1	2	1	2	10
Anthr syl	3	2	0	3	1	9
Toril jap	1	2	3	1	2	9
Tussi far	4	4	1	0	0	9
Achil mil	3	1	1	1	2	8
Eupat can	1	1	1	2	3	8
Helic pub	1	3	3	0	1	8
Poten ans	3	3	1	1	0	8
Ranun acr	4	0	0	4	0	8
Rubus ida	8	0	0	0	0	8
Trifo pra	1	3	2	1	1	8
Belli per	1	2	3	1	0	7
Bromu ere	3	1	3	0	0	7
Bryon dio	4	0	1	1	1	7
Geran mol	0	5	0	2	0	7
Stell gra	2	1	0	3	1	7
Rumex obt	2	0	0	0	5	7
Leont his	3	2	0	0	1	6
Luzul pil	4	2	0	0	0	6
Menth arv	1	5	0	0	0	6
Stell hol	1	2	1	1	1	6
Hiera spp	1	3	0	0	1	5
Humul lup	3	1	0	1	0	5
Litho off	1	0	1	1	2	5

Paris qua	3	0	0	1	1	5
Symph off	5	0	0	0	0	5
Trise fla	2	1	1	0	1	5
Conop maj	0	0	1	3	1	5
Hyper mac	2	1	0	0	2	5
Antho odo	1	1	0	2	0	4
Carex otr	2	1	1	0	0	4
Festu pra	3	1	0	0	0	4
Galiu mol	2	2	0	0	0	4
Galiu odo	0	1	1	1	1	4
Helia cha	1	2	1	0	0	4
Knaut arv	4	0	0	0	0	4
Liste ova	2	0	1	1	0	4
Ribes uva	0	1	0	1	2	4
Scrop aqu	1	3	0	0	0	4
Ulex eur	1	2	0	1	0	4
Carex hir	0	0	1	2	1	4
Bromu ste	2	1	0	0	0	3
Calam epi	2	1	0	0	0	3
Cynos cri	1	2	0	0	0	3
Dryop aff	0	1	1	1	0	3
Equis arv	1	1	0	1	0	3
Galiu cru	1	1	1	0	0	3
Pimpi maj	0	1	0	1	1	3
Pulic dys	2	1	0	0	0	3
Ranun aur	0	2	1	0	0	3
Rumex ace	0	1	1	1	0	3
Stell als	0	1	1	0	1	3
Veron bec	1	1	0	0	1	3
Veron off	1	2	0	0	0	3
Bromu mol	0	0	2	1	0	3
Veron hed	0	0	0	3	0	3
Carex rip	0	0	0	3	0	3
Origa vul	0	0	0	3	0	3
Narci hyb	1	0	1	1	0	3
Arcti lap	2	0	0	1	0	3
Epipa pur	0	0	0	1	2	3
Anaga arv	1	1	0	0	0	2
Beton off	0	1	0	0	1	2
Centa ery	0	2	0	0	0	2
Festu aru	1	1	0	0	0	2
Lotus uli	1	1	0	0	0	2
Lycop eur	1	0	0	1	0	2
Miliu eff	1	1	0	0	0	2
Myoso ram	1	1	0	0	0	2
Phyll sco	1	0	0	0	1	2
Plata chl	0	1	1	0	0	2
Polyg vul	0	1	0	1	0	2

Succi pra	2	0	0	0	0	2
Linum cat	0	0	2	0	0	2
Epipa hel	0	0	1	1	0	2
Impat par	0	0	0	1	1	2
Melic uni	0	0	0	1	1	2
Aegop pod	1	0	0	0	0	1
Blech spi	0	1	0	0	0	1
Calys sep	1	0	0	0	0	1
Festu ovi	0	1	0	0	0	1
Geran dis	0	1	0	0	0	1
Glyce spp	1	0	0	0	0	1
Hyper pul	0	1	0	0	0	1
Hypoc rad	1	0	0	0	0	1
Lysim vul	1	0	0	0	0	1
Lythr sal	1	0	0	0	0	1
Medic sat	0	1	0	0	0	1
Ononi rep	1	0	0	0	0	1
Orchi sp	1	0	0	0	0	1
Polyg avi	0	1	0	0	0	1
Poter san	1	0	0	0	0	1
Veron arv	1	0	0	0	0	1
Vicia cra	0	1	0	0	0	1
Vicia sat	1	0	0	0	0	1
Agros gig	1	0	0	0	0	1
Horde sec	0	0	1	0	0	1
Odont ver	0	0	1	0	0	1
Alope pra	0	0	1	0	0	1
Viola odo	0	0	0	1	0	1
Chrys leu	0	0	0	1	0	1
Ophio vul	0	0	0	1	0	1
Vicia ten	0	0	0	1	0	1
Verba tha	0	0	0	1	0	1
Senec syl	0	0	0	1	0	1
Centa nig	0	0	0	1	0	1
Arena ser	0	0	0	1	0	1
Epilo tet	1	0	0	0	0	1
Epilo par	1	0	0	0	0	1
Glyce flu	1	0	0	0	0	1
Glyce pli	1	0	0	0	0	1
Rumex cri	1	0	0	0	0	1
Carex pan	0	0	1	0	0	1
Galiu uli	0	0	1	0	0	1
Senec vul	0	0	0	0	1	1
Astra gly	0	0	0	0	1	1
Dipsa ful	0	0	0	0	1	1
Necta sco	0	0	0	0	1	1
Polys set	0	0	0	0	1	1
Daucu car	0	0	0	0	1	1

Appendix 8 Change in plant trait patterns.

The numbers of occurrences for the different values of Ellenberg scores are presented below for all the recordings. There is little change. For Light Scores the number of occurrences has generally been maintained at the shady end of spectrum with the losses concentrated amongst the more light-demanding species. There is no obvious pattern for Nitrogen scores or moisture scores. There is a slight suggestion of increased acidification.



Amongst the different plot groups, there are only small changes, mainly a decline in the light score across the board, and a slight decrease in the Reaction score (increasing acidity). There was no change in the Nitrogen score (unlike in some other studies). In terms of Plant Strategy types there was something of a shift towards a higher Stress-tolerant element and reduced Competitor score.

	no of plots	1974		1991		1999		2011		2018	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Ellenberg Reaction (R)											
Pre-1800 semi-natural	29	6.11	0.06	6.15	0.05	6.04	0.05	6.14	0.04	6.09	0.05
Pre-1800 disturbed	40	6.12	0.04	6.06	0.05	6.04	0.05	6.03	0.06	6.07	0.05
19th C semi-natural	19	6.13	0.08	6.08	0.10	5.98	0.09	6.11	0.07	5.95	0.09
19th C disturbed	11	6.06	0.11	5.89	0.15	5.98	0.10	5.91	0.16	5.82	0.15
19th C plantations	27	6.45	0.06	6.43	0.06	6.28	0.05	6.27	0.06	6.30	0.05
20th C plantations	15	6.48	0.09	6.29	0.12	6.24	0.10	6.28	0.05	6.23	0.07
Rides and Glades	23	6.33	0.05	6.25	0.05	6.23	0.06	6.17	0.04	6.27	0.05

Ellenberg Moisture (F)

Pre-1800 semi-natural	29	5.85	0.04	5.82	0.04	5.72	0.03	5.79	0.03	5.80	0.03
Pre-1800 disturbed	40	5.84	0.04	5.71	0.03	5.74	0.05	5.71	0.04	5.73	0.04
19th C semi-natural	19	5.86	0.06	5.68	0.05	5.69	0.04	5.80	0.04	5.76	0.04
19th C disturbed	11	5.84	0.09	5.65	0.09	5.89	0.08	5.62	0.11	5.79	0.10
19th C plantations	27	5.71	0.05	5.63	0.05	5.75	0.05	5.69	0.05	5.64	0.05
20th C plantations	15	5.53	0.09	5.54	0.09	5.83	0.07	5.83	0.08	5.83	0.06
Rides and Glades	23	5.73	0.10	5.65	0.09	5.73	0.10	5.74	0.08	5.74	0.09

Ellenberg Nitrogen (N)

Pre-1800 semi-natural	29	5.85	0.09	5.83	0.05	5.71	0.06	5.89	0.06	5.84	0.07
Pre-1800 disturbed	40	5.86	0.06	5.85	0.06	5.79	0.06	5.86	0.06	5.90	0.07
19th C semi-natural	19	5.99	0.10	5.83	0.11	5.66	0.09	5.87	0.08	5.72	0.10
19th C disturbed	11	5.89	0.06	5.88	0.11	5.87	0.10	5.81	0.15	5.76	0.11
19th C plantations	27	6.11	0.10	6.06	0.07	6.04	0.08	6.00	0.09	5.99	0.08
20th C plantations	15	5.78	0.12	5.79	0.11	5.84	0.09	5.97	0.10	5.98	0.11
Rides and Glades	23	5.75	0.12	5.58	0.09	5.58	0.10	5.69	0.07	5.77	0.08

Ellenberg Light (L)

Pre-1800 semi-natural	29	5.35	0.05	5.47	0.04	5.41	0.04	5.22	0.04	5.25	0.04
Pre-1800 disturbed	40	5.44	0.05	5.37	0.04	5.29	0.04	5.16	0.03	5.15	0.04
19th C semi-natural	19	5.52	0.05	5.50	0.05	5.52	0.08	5.34	0.07	5.33	0.06
19th C disturbed	11	5.75	0.10	5.57	0.15	5.62	0.07	5.45	0.11	5.45	0.11
19th C plantations	27	5.25	0.07	5.46	0.05	5.30	0.06	5.19	0.06	5.04	0.09
20th C plantations	15	6.12	0.14	6.04	0.14	5.67	0.08	5.62	0.11	5.40	0.07
Rides and Glades	23	5.95	0.10	5.98	0.10	5.88	0.10	5.85	0.09	5.84	0.09

Competitor strategy

Pre-1800 semi-natural	29	43.88	1.46	41.81	1.35	39.10	1.11	37.85	1.01	38.77	0.94
Pre-1800 disturbed	40	46.70	1.33	40.20	0.91	36.87	1.22	34.83	1.69	36.22	1.44
19th C semi-natural	19	52.14	1.76	42.19	1.73	38.50	1.05	39.08	0.96	40.21	1.81
19th C disturbed	11	51.18	2.52	43.07	5.74	40.49	2.62	35.52	4.16	39.02	4.35
19th C plantations	27	42.59	1.74	41.71	1.28	40.15	1.39	38.31	1.67	36.34	1.61
20th C plantations	15	44.64	2.00	38.82	3.34	38.44	1.78	38.94	1.27	41.25	2.06
Rides and Glades	23	45.31	1.78	39.05	1.18	38.81	1.03	39.40	1.07	41.60	1.27

Stress-tolerant strategy

Pre-1800 semi-natural	29	38.97	1.88	38.29	1.42	42.35	1.45	43.01	1.21	43.17	1.20
Pre-1800 disturbed	40	32.77	1.44	37.17	1.08	40.52	1.37	42.11	1.04	43.19	1.30
19th C semi-natural	19	28.12	1.59	38.00	1.60	40.43	1.24	39.60	1.46	42.78	1.50
19th C disturbed	11	25.97	1.38	34.82	2.85	37.75	1.42	39.10	2.96	38.63	2.17
19th C plantations	27	36.24	1.65	36.04	1.41	40.49	1.82	42.45	2.05	47.70	2.40
20th C plantations	15	29.28	2.18	31.89	2.29	40.68	2.33	37.37	1.94	41.23	2.08
Rides and Glades	23	29.00	1.39	32.59	1.15	33.60	1.37	31.79	1.47	32.33	1.94

Ruderal strategy

Pre-1800 semi-natural	29	17.16	1.22	19.90	1.00	18.36	0.86	18.73	0.67	17.52	0.77
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Pre-1800 disturbed	40	19.97	0.75	22.03	0.95	22.29	1.14	22.45	1.26	20.08	1.20
19th C semi-natural	19	19.74	1.44	19.81	1.57	20.60	1.22	21.01	1.20	16.26	1.11
19th C disturbed	11	22.85	2.53	22.11	4.83	21.79	2.60	25.39	3.55	22.36	3.34
19th C plantations	27	21.16	0.75	22.25	1.53	19.36	1.09	19.23	1.49	15.97	1.61
20th C plantations	15	25.84	2.05	29.45	2.79	20.87	2.63	23.68	1.54	17.01	2.04
Rides and Glades	23	25.54	0.87	27.97	0.88	27.08	1.08	28.34	1.06	25.98	1.19

Community weighted mean precipitation across the range of a species (Hill et al., 2004)

	1974	1991	1999	2012	2018
Community weighted mean precipitation (mm/yr)	1047±2	1049±2	1052±2	1053±1	1055±2

Appendix 9 Species-richness per plot across all recordings.

		No of vascular plant species (excluding trees and shrubs)					
Plot	All recordings	1974	1991	1999	2012	2018	
452077	31	13	19	21	21	18	Canopy gap 1974-91
452079	24	16	10	7	14	11	Collapsing birch 2012-18
452081	27	13	15	15	16	13	
452089	27	18	13	13	10	9	Thinned c2017
453076	28	11	12	12	13	12	Blackthorn and bramble
453074	47	17		22	26	12	Elm death 1974-91 leaving glade
453078	63	39	39	36	30	31	Across ride
453080	17	8	9	8	12	9	
453082	23	18	14	11	14	13	
453084	35	26	17	16	15	10	
453086	13	9	4	2	3	7	Thinned c2017
453088	39	34	9	8	11	15	Thinned
453090	30	12	12	13	19	18	Large maple collapsed c2010
454075	29	8	18	11	17	17	Shooting line cut c2010
454077	32	15	22	17	20	20	
454079	28	11	15	19	17	21	Large fallen branches c2010
454081	11	11	6	5	7	7	
454083	16	12	9	2	7	3	
454085	9	8	3	2	1	1	
454087	25	17	16	13	11	9	
454089	36	21	21	14	18	12	Young trees over bracken in 1974;
454091	34	17	17	23	20	17	Part now impenetrable thicket
455074	22	5	3	8	14	8	Dense bramble/thorn
455076	28	18	13	17	15	14	
455078	36	15	27	26	19	14	Thinned c2010, bramble regrowth
455080	19	8	8	5	15	9	
455082	28	11	16	19	21	17	
455084	24	8	18	16	18	14	
455086	22	14	11	13	10	7	Thinned 2019
455088	22	11	14	15	19	17	Oak in plot died 1999-2012
455090	26	11	14	15	18	16	
455092	32	19	16	20	16	13	Sallow collapse 1991-1999
456075	73	44	42	29	32	19	Rides becoming more grass dominant
456077	44	26	20	19	21	18	Heavily thinned pre1974
456079	24	7	0	7	18	12	Thinned c2010
456081	21	9	9	4	13	18	Path at sw corner opened up c2010
456083	31	14	17	13	19	12	
456085	19	8	8	10	9	9	
456087	22	11	14	14	15	14	
456089	26	18	14	12	17	9	
456091	47	22	25	21	13	18	Recently cleaned in 1974; thinned 2102-2018, bramble growth
456093	26	10	16	17	15	10	

457072	29	18	22	13	18	5	Just cleared to create pond, bare earth
457074	69	19	39	28	40	28	Thorn thicket cleared c1990, then part regrew
457076	61	41	20	27	24	20	Some felling pre-74
457078	30	10	19	15	12	3	Cut between 74 and 91; again in winter of 12/13
457080	70	24	41	27	43	39	Grassland more scrubby in 1974
457082	43	19	25	23	25	12	Half open in 74; virtually all closed by 2018
457084	40	22	28	22	27	19	
457086	33	19	16	17	17	13	
457088	21	8	13	14	18	13	
457090	60	34	42	33	28	24	
457092	35	11	15	20	23	17	
458073	41	26	14	21	14	11	12 yr old plantation in 74, entering thicket
458075	61	46	22	12	23	12	
458077	33	23	17	22	14	13	Some felling pre-74; bramble growth recently
458079	49	32	5	23	12	27	Beech plantation 74, but then thinned and ride opened more
458081	31	20	12	9	12	10	
458083	10	9	5	3	4	5	
458085	18	10	11	10	11	10	Sycamore thinned 1991, bramble
458087	21	15	8	8	11	9	Part recently thinned in 1974
458089	19	10	13	14	12	9	
458091	29	19	15	4	1	1	Recently thinned in 74; and again in 1991
458093	23	10	9	16	14	13	
459072	32	17	0	2	20	11	Young thicket in 74, thinned c2010
459074	51	31	22	25	22	25	
459076	33	18	17	15	10	13	Conifer nurse recently removed in 1974; thinned c2010
459078	20	13	6	3	3	9	Recently thinned in 74; again c1990, 2011.
459080	34	9	25	19	13	9	Giant beech died 1974-1991, regeneration since
459082	17	9	10	10	8	9	
459084	48	18	28	34	33	19	Roadside widened 1974-91; disturbed by pipeline
459086	29	19	15	24	16	16	
459088	15	11	11	11	12	13	
459090	41	33	29	19	20	19	
459092	40	20	29	14	9	10	Recently thinned 1974, 1991; part clearfelled 2012
459094	25	18	11	12	18	19	
460071	32	19	16	18	21	17	
460073	26	8	1	10	21	9	Recently thinned c2010
460075	39	19	3	13	13	23	Recently thinned c2017
460077	36	12	26	14	11	7	Recently thinned in 1991
460079	43	25	18	14	29	7	Recently thinned 74
460081	18	7	5	5	9	5	

460085	23	8	18	16	12	12	Thinned/coppice c1990 waist high bramble
460087	18	14	13	11	10	9	
460089	35	22	24	19	12	12	Felled and replanted c1990; closed by 2012
460091	36	27	21	9	9	9	Sparse ash with hazel in 74
460093	39	12	19	24	26	19	Dense thicket
461072	9	4	1	7	1	1	
461074	15	4	10	6	8	7	
461076	37	21	14	13	19	16	
461078	41	21	16	16	14	13	
461084	23	5	8	11	15	17	
461086	37	21	25	22	20	16	
461088	24	19	16	18	15	17	
461090	31	13	23	16	18	16	Plot covered now in part by collapsed willow
461092	19	8	13	9	7	6	
461094	24	4	11	15	18	12	Dense thicket 1974, now more open
462071	59	33	37	37	30	26	
462073	32	14	8	21	17	10	
462075	23	9	9	10	15	13	Collapsing elm
462077	35	9	17	25	11	16	Oak thinned c2010
462085	23	9	16	14	12	12	
462087	21	6	11	18	12	10	Canopy gap formed pre-1991
462089	23	13	14	17	16	15	
462091	31	14	22	15	22	15	
462093	40	22	22	21	22	19	
462095	23	14	13	9	12	8	Collapsed maple pre-2018
463074	67	26	38	45	36	30	
463076	33	9	13	10	28	9	Thinned c2010
463078	26	14	15	16	11	3	
463082	37	17	18	23	23	14	Dead beech c1990
463084	14	10	5	5	6	5	
463086	28	15	13	16	11	10	
463088	24	20	13	11	11	9	
463090	50	21	37	28	23	21	
463092	20	9	15	13	17	14	Ash collapse c2010
464075	20	16	12	11	12	10	
464077	21	8	17	7	9	12	
464079	61	16	25	31	39	25	
464087	26	18	14	12	14	12	
464089	45	28	32	27	27	20	
464091	60	30	46	32	31	30	
464093	36	18	24	23	20	18	
465074	27	22	16	15	12	10	Fallen been c2010
465086	17	8	15	8	6	5	Fallen ash, c2010, bramble growth
465088	70	51	49	36	37	26	
465090	35	20	24	19	17	22	
465092	56	22	35	31	29	26	

466075	29	13	17	9	14	9	
466087	48	16	39	24	13	16	Part cleared at ride junction c1990; ash fallend c2000
466089	45	10	29	28	20	16	
466091	30	14	20	23	18	20	
467074	16	5	7	12	6	4	Windblow beech c1990
467087	26	17	16	16	15	15	
468075	21	15	14	5	4	3	
469074	17	5	5	5	12	7	
469076	23	12	12	12	16	11	
470073	25	8	18	11	11	11	
470075	50	31	27	7	0	2	Early thicket stage in 1974
471074	50	20	31	14	18	11	Thicket stage 1974, thinned c2010
471076	63	32	27	11	25	15	Early thicket 1974; thinned c2010
472073	29	17	9	13	16	14	
472075	26	12	15	12	14	13	
472077	32	12	20	12	12	9	Thinned c2010
473074	63	28	38	24	13	9	Recent thinning pre 74;
473076	14	9	3	6	6	5	
473078	19	4	9	10	13	11	
474073	22	16	9	7	11	11	
474075	39	16	24	12	16	8	Thinned c2010
474077	36	24	1	0	0	15	Early thicket 1974; thinned c2017
475074	54	29	29	22	29	39	Large tree to south fallen, c2017
475076	32	17	15	18	19	13	Fallen birch c1990
475078	20	12	6	9	11	7	
476075	38	17	24	22	19	16	
476077	29	12	22	20	20	14	Fallen birch c1990-2000
476079	40	22	26	14	22	9	
477074	13	5	5	10	8	10	
477076	82	62	41	29	33	34	
477078	52	35	23	18	23	25	
477080	21	12	16	8	11	13	
478075	29	17	15	16	14	13	
478077	26	6	18	18	14	8	Windblow c1990
478079	24	13	11	11	8	7	
479078	28	20	10	7	7	14	Field maple collapse c2017, opening stand to south

Appendix 10. The Wytham deer population

Osmaston (1959) noted the need for fallow deer control but estimated only one buck and five to seven does and young beasts. He was far more concerned about the effects of rabbits.

Elton (1966) identified the potential threat of deer irruption, perhaps because the deer got much of their food from the surrounding farmland. He also noted that muntjac were not far away (in a dairy entry he later records their arrival in the Woods in 1967). There are however far more comments about rabbit impacts.

Sheehan (1979) commented that there are about 60 fallow deer and a few muntjac. The deleterious effects of fallow were judged tolerable, provided that the herd remained at the current size; effects on adjacent farmland were minimal; muntjac might be encouraged on account of their amenity and scientific interest!

Wardell (1987) considered that deer were now at unacceptably high level; widespread damage occurred to regeneration and on neighbouring farms; there were about 200+/- 50 fallow, perhaps 300 muntjac, and roe also present. The numbers are based on estimates provided by Den Woods, the gamekeeper.

In 1989 the Woods were fenced with the deer inside. Control of deer within the fence initially undertaken on an *ad hoc* basis by Wood staff. This strategy proved ineffective and there was a buildup of the Fallow population inside the fence.

In 1998 a targeted culling programme was agreed: the population largely from the use of dung counting was: Fallow >375, Roe >20, Muntjac Unknown. An initial (ambitious) target was to reduce the population to 30 of each species.

The programme has been maintained over the last two decades and deer numbers much reduced: going into the 2019/20 cull year the estimates are Fallow <45, Roe <45, Muntjac >60.

Appendix 11. Change indices from other surveys for species in the Dawkins plots

Species abbr.	Change, 1971-2001 (Kirby et al 2005)		Change 1962- 2000	Change 1987- 2004,)	Ash Dieback effect?
	Site occurrences	Plot occurrences	Preston et al 2002	Braithwaite et al. 2006	Mitchell et al. 2016
Achil mil	no change	down	0.29	-4	
Aegop pod			-0.45	-2	
Agrim eup			-0.89	-11	
Agrop rep	no change	no change	-0.01	1	
Agros cap	no change	no change	1.28	4	
Agros gig	no change	no change	1.39	-11	
Agros sto	no change	no change	3.66	6	
Ajuga rep	no change	down	-0.56	-2	
Allia pet	up	up	0.03	-1	
Alliu urs	no change	no change	0.24	13	little change
Alope pra	no change	no change	0.09	0	
Anaga arv			-0.73	8	
Anemo nem	no change	no change	-0.70	-10	increase
Angel syl	down	down	0.12	-7	little change
Antho odo	no change	down	0.90	-6	
Anthr syl	no change	no change	-0.19	-2	
Arcti lap			0.51	6	
Arcti min	down	down	-0.41	0	
Arena ser			-0.76	-11	
Arrhe ela	no change	down	0.37	0	increase
Arum mac	no change	no change	-0.28	-1	
Astra gly			-0.36		
Athyr fil	no change	down	0.25	-2	decline
Belli per	no change	down	0.89	-2	
Beton off	no change	down	-0.62	-14	
Blech spi	no change	down	-0.39	-2	
Brach pin			0.15	3	
Brach syl	no change	no change	-0.17	3	increase
Bromu ere			-0.01	-38	
Bromu mol			-0.37		
Bromu ste	up	up	0.05	4	
Bryon dio			-0.50		
Calam epi			0.47	-8	
Calys sep			0.69	14	
Campa tra	down	down	0.14	1	
Carda fle	no change	down	1.06	7	
Carda pra			0.42	-3	
Carex acu			0.16	-2	
Carex fla	no change	no change	0.53	1	
Carex hir			0.17	17	
Carex otr			-0.14	2	
Carex pan	no change	no change	-0.31	-5	
Carex pen	no change	up	1.30	41	

Carex rem	no change	up	0.04	15	
Carex rip			0.18	4	
Carex syl	no change	down	0.05	17	
Centa ery	no change	no change	0.03	7	
Centa nig	down	down	-0.25	-1	
Ceras fon	no change	no change	1.40	-3	
Chame ang	no change	down	-0.01	-3	
Chrys leu	down	down	-1.14	2	
Circa lut	no change	down	-0.38	0	increase
Cirsi arv	up	up	0.47	-4	
Cirsi eri			-0.08	-27	
Cirsi pal	down	down	0.15	-6	
Cirsi vul	no change	up	0.80	-4	
Clema vit	no change	down	0.00	-1	
Clino vul			-0.67	-2	
Conop maj	no change	down	-0.19	-8	
Convo arv			-0.70	-3	
Crepi cap	no change	no change	-0.17	2	
Cynos cri	no change	no change	0.02	-4	
Dacty fuc	down	down	0.33	1	
Dacty glo	no change	down	-0.06	-3	
Daphn lau			0.10	13	
Daucu car			-0.59	-14	
Desch ces	no change	down	-0.09	-4	increase
Dipsa ful			0.82	22	
Dryop aff			2.44	22	
Dryop aus	no change	down	1.32	0	decline
Dryop fil	no change	down	0.03	-2	decline
Epilo hir	no change	no change	0.12	3	
Epilo mon	down	down	-0.39	2	
Epilo par	no change	no change	-0.41	33	
Epilo tet			1.66	41	
Epipa hel	down	down	0.08	2	
Epipa pur			-0.08		
Equis arv	down	down	0.39	-1	
Equis tel			0.41	-2	
Eupat can	no change	no change	-0.15	-5	
Eupho amy	no change	no change	-0.22	-25	
Festu aru			1.71	17	
Festu gig	down	down	0.46	-11	
Festu ovi	no change	down	-0.15	-6	
Festu pra			-0.16	19	
Festu rub	no change	down	2.96	1	
Filip ulm	no change	down	-0.10	0	increase
Fraga ves	down	down	-1.09	8	
Galeo lut	no change	no change	1.07	-17	
Galiu apa	no change	no change	-0.09	-3	increase
Galiu cru	down	down	-0.77	-5	

Galiu mol	no change	down	0.04	8	
Galiu odo	no change	down	-0.62	-11	
Galiu pal	no change	down	0.07	2	
Galiu uli			-0.14	-2	
Galiu ver			-0.85	5	
Geran dis	no change	no change	-0.09	9	
Geran mol			-0.46	-3	
Geran rob	no change	no change	-0.41	2	little change
Geum urb	no change	down	-0.53	3	little change
Glech hed	no change	no change	-0.56	-1	little change
Glyce flu	no change	down	0.89	-7	
Glyce pli					
Glyce spp					
Heder hel	no change	down	-0.65	-6	little change
Helia cha			-0.70	4	
Helic pub			0.35	-19	
Herac sph	no change	down	0.08	-4	
Hiera spp	down	down		-11	
Holcu lan	no change	down	1.34	-37	
Holcu mol	no change	down	0.80	6	increase
Horde sec			-0.19	12	
Humul lup			-0.09	7	
Hyaci non	no change	up	-0.41	-5	little change
Hyper hir	no change	no change	-0.18	-4	
Hyper mac			2.11	2	
Hyper per	down	down		6	
Hyper pul	no change	down	-0.32	-1	
Hyper tet	no change	no change	-0.41	12	
Hypoc rad			0.61	2	
Impat par			0.10	17	
Inula con			-0.15	-25	
Juncu eff	no change	no change	1.06	-2	little change
Juncu inf	no change	up	0.04	4	
Knaut arv			-0.88	-14	
Lapsa com			-0.47	1	
Lathy pra	no change	no change	-0.17	-1	
Leont his			-0.59	-14	
Linum cat			-0.44	-7	
Liste ova	no change	down	-0.54	-21	
Litho off			-0.59	8	
Loliu per	no change	up	-0.29	-2	
Lonic per	no change	down	-0.11	3	
Lotus cor	no change	down	1.09	1	
Lotus uli	down	down	-0.06	-6	
Luzul pil	down	down	-0.35	-7	
Lycop eur	no change	no change	-0.01	18	
Lysim nem	no change	down	-0.46	-5	
Lysim num	no change	no change	-0.02	18	

Lysim vul			0.22	15	
Lythr sal			-0.08	12	
Medic lup			-0.43	4	
Medic sat			-0.56	-41	
Melic uni	no change	no change	-0.04	-6	
Menth aqu	no change	down	-0.11	3	
Menth arv			-1.30	-19	
Mercu per	no change	down	-0.65	-7	decline
Miliu eff	no change	up	0.31	-1	
Moehr tri	down	down	-0.40	-15	
Myoso arv	up	up	-0.34	-1	
Myoso ram			0.11	-14	
Narci hyb	no change	up		61	
Necta sco					
Odont ver	no change	no change	-0.46	3	
Ononi rep			-0.45	-8	
Ophio vul			0.72	-1	
Orchi sp	no change	no change		-22	
Origa vul			-0.10	-1	
Oxali ace	no change	down	-0.74	-5	increase
Paris qua	no change	down	-0.68		
Pasti sat			-0.39	-24	
Phleu pra	no change	no change	-0.33	-1	
Phyll sco	no change	up	0.45	21	
Pimpi maj	no change	down	-0.16	-23	
Plant maj	no change	down	0.09	-27	
Plata chl			-0.88	0	
Poa ann	down	down	0.83	-68	
Poa pra	no change	up	0.60	-28	
Poa tri	no change	down	1.10	-4	increase
Polyg avi	no change	no change		5	
Polyg vul	down	down	-1.14	7	
Polys set	up	up	1.47	13	
Poten ans	no change	no change	-0.23	-4	
Poten rep	no change	no change	-0.62	-3	
Poten ste	down	down	-0.30	-8	increase
Poter san			-0.16		
Primu vul	no change	down	0.16	4	increase
Prune vul	no change	down	0.60	1	
Pteri aqu	no change	down	-0.71	-6	increase
Pulic dys			-0.08	0	
Ranun acr	down	down	0.30	-3	
Ranun aur			-0.33	-20	
Ranun fic	up	up	0.16	-1	increase
Ranun rep	no change	no change	0.55	-3	little change
Ribes syl	no change	down	1.79	14	
Ribes uva	down	down	0.72	2	
Rosa spp	up	up		-3	

Rubus cae	up	up	-0.34	-4	
Rubus fru	no change	down	-0.29	-4	increase
Rubus ida	down	down	-0.09	-8	
Rumex ace	no change	no change	1.32	0	
Rumex cri	up	up	0.11	-2	
Rumex obt	no change	no change	0.66	-1	
Rumex san			0.66	13	
Sanic eur	down	down	-0.98	-18	
Scrop aqu	no change	no change	-0.21	11	
Scrop nod	no change	no change	-0.37	0	
Senec jac	up	no change	0.11	1	
Senec syl			0.09	8	
Senec vul	up	up	-1.08	-2	
Silen dio	down	down	-0.44	-1	
Solan dul	no change	down	-0.11	-5	
Sonch ole	no change	down	-0.42	6	
Stach syl	no change	down	-0.49	-4	
Stell als			-0.10		
Stell gra	no change	no change	-0.02	1	
Stell hol	down	down	-0.56	-4	
Stell med	no change	no change	0.03	-4	
Succi pra	down	down	-0.57	-4	
Symph off			0.34	92	
Tamus com	down	down	-0.41	-6	
Tarax off	no change	down	0.43	-3	
Toril jap	no change	no change	-0.48	-3	
Trifo pra	no change	no change	-0.18	-1	
Trifo rep	no change	no change	1.31	-4	
Trise fla			-0.13	1	
Tussi far	down	down	-0.65	-12	
Ulex eur	no change	no change	-0.34	2	
Urtic dio	no change	no change	0.28	2	increase
Verba tha			0.27	7	
Veron arv			0.48	9	
Veron bec	no change	no change	-0.31	-5	
Veron cha	no change	down	-0.50	1	
Veron hed			0.57	11	
Veron mon	no change	down	0.48	3	
Veron off	no change	down	-0.84	0	
Veron ser	up	up	0.80	7	
Vicia cra			-0.37	3	
Vicia sat			0.19	4	
Vicia sep	down	down	-0.43	8	
Vicia ten					
Viola hir	down	down	-0.46	-10	
Viola odo	down	down	-0.19	14	
Viola riv	no change	down	1.07	-4	increase
Zerna ram	no change	down	-0.18	-6	

Appendix 12. Brief descriptive notes for each plot

plot	crop age if known	1974	1991	1999	2012	2018
452077	cws	Willow and hazel scrub; straddles small stream (3,10; 2.5,0); former coppice with standards.	Glade amongst maple; <i>Urtica</i> , <i>Brachypodium sylvaticum</i> , flora. Collapsed <i>Salix</i> and maple stems.	Approximate position; post and markers not found.	Collapsed/leaning willow amongst old hazel; stream down west edge of plot; small glade, north-west corner..	Northern quadrant fairly impenetrable, collapsed willow and bramble
452079	cws	<i>Salix</i> , birch, hazel scrub; former coppice with standards.	Ash over mixed hazel, maple coppice; sparse ground flora; <i>Deschampsia cespitosa</i> .		Collapsing birch and willow; fallen birch across north-east half of plot.	birch collapsed across northern quadrant
452081	cws	Hazel and maple coppice; old birch/maple/hawthorn; mole activity.	Neglected maple-hazel coppice with birch over mercury- <i>Brachypodium</i>		Old maple coppice.	fallen birch in western half
452089	cws	Sparse ash poles and hazel amongst old oak; ash oak stand 1955-56; log pile.	Ash/oak over hazel coppice; mercury/bluebell flora.			ash in n.e. corner
453074	elm regrowth	Elms and low scrub at edge of wood; barbed wire fence (0,0.3; 4,0), ditch (0,1.4; 10,.6), shallow gully (0,6;10,5).	Not recorded	Approximate position based on ditch etc; markers not found.	Ditch and fence along southern edge; dead/dying elm poles; dense bramble clump in middle of plot.	most of plot impenetrable bramble; circlets done round edge of thicket
453076	ash hf	Blackthorn scrub under sparse old ash/oak.	Dense blackthorn thicket; small dead fallen wood.	Old stool in north-west corner only part in; tree just on edge at north-east corner.	Former blackthorn thicket, now starting to regrow.	thicket of bramble and blackthorn reforming; west side tape difficult to lay out!
453078	ride	Ride bordered by oak and ash plantation (1950-51); east edge of ride (7.2, 0;2.9,10)	Rideside and ash-maple; ride over south-west half of plot. 1st plot marker deep buried; second not found.	Oak-ash woodland; ride across south-west half of plot.	Mostly across ride; north-east corner in stand.	SW half mainly ride

453080	cws	Ash/birch under old oak; mole activity. Lords Copse. Birch generally dominant.	Oak, birch, ash canopy; open hazel coppice; sparse ground flora.		Mature oak-hazel; collapsing birch across centre point of plot.	big oak clost to southern edge; sparse flora; fallen birch in northern quadrant
453082	1952,recent windblow nearby	Oak/ash/larch plantation (1952) with oak, birch, sallow, elm etc.	Ash/spruce with hazel coppice; sparse ground flora; badger dung pits		Mixed plantation; windblown trees nearby; sparse flora.	mixed plantation
453084	1953 oak ash	Young ash/oak plantation (1953), with hazel and blackthorn scrub below	Pole stage ash over hawthorn.			mixed plantation over bluebell
453086	1953 beech	Young beech plantation (1953) with brushwood on floor; bramble in eastern half.	Beech and scattered mature oak over bluebell; north-east corner mostly bare litter.		Large fallen oak across north-east corner over marker.	recently thinned beech, over bluebell
453088	1955 ash-syc thinned	Tall herbs under sparse young ash; log pile. Ash/oak 1955.	Ash plantations and some sycamore; no understorey; Brachypodium-mercury flora.		Thinned ash-sycamore stand.	New access track through SW half of plot
453090	cws collapsed	Old hazel, hawthorn, maple scrub.	Oak, maple, hawthorn, hazel over mercury; big maple stool in south-west of plot	Maple/hazel/hawthorn; rich ground flora	Large maple collapsed; glade with hazel.	farily dense thicket in centrewere maple collapsed
454075	ash hf	Blackthorn thicket under ash poles. Oak birch ash stand generally.	Ash over sparse blackthorn thicket (partially collapsed in centre of plot).		Ash high forest; bramble thickets developing.	open ash stand; line of sight for shooting through plot
454077	edge 1950 ash plantn	Woodcroft Copse; loose scrub and bracken under giant ash; rest of stand 1950 ash/oak. Old lying branch (6,10; 4,5.5).	Blackthorn thicket and glade under ash.		Developing glade by veteran ash; blackthorn thickets; large ash (43cm) just on edge of plot.	Veteran ash by SE corner collapsed; much of eastern half bramble thicket
454079	1950 ash oak	Ashwood, fallen branches. General stand ash 1950.	Clearing with young ash under canopy of mature oak and ash; some dead wood; bracken.		Ash poles with scattered older trees; ditch along northern edge plus fallen branches; giant oak nearby (not in plot).	ash across plot in north east.

454081	1952 beech oak syc	Open sallow/hazel/sycamore scrub among planted beech (1950). Brushwood on floor.	Sycamore canopy, young crop, no shrub layer, sparse flora. Leaning birch.	Fallen birch across southern part of plot.	Mature high forest.	
454083	1953 chestnut	Oak/ash/chestnut plantation (1953) with old oak/birch.	Oak and ash over hazel coppice; sparse ground flora; uprooted tree in north-east corner.	Old plantation	Big chestnut; collapsing birch.	overlaps Louise Hill plot where ash girdled
454085	1954 beech	Beech plantation (1954), with cut poles on ground; old stumps (4,1)	Beech crop and occasional oak/sycamore; sparse bluebell flora.	Beech plantation; sparse flora, dense litter; occasional sycamore; south-west marker not found.		beech plantation; mainly ash seedlings in ground flora
454087	coppice sycamore	Sycamore, past coppice; moles; wire fence (1.3,10; 8.5,0)	Sycamore over sparse mercury.	Plot done on measurement only; markers not found.	Coppiced sycamore; small fallen wood.	dense sycamore stand
454089	1955 ash oak	Bracken among young ash and poplar (1955)	Poplar and sycamore over bracken.		Brachypodium lawn under mixed hardwoods.	Brachypodium lawn
454091	cws/scrub	Old hazel and blackthorn scrub; old fence (0,2.6;10,5.7).	Blackthorn, hawthorn, hazel thicket over mercury and nettle; bank along fence line; small path to south.	Neglected coppice of collapsed hazel, hawthorn; rich flora; bank running roughly east-west through middle.	Collapsed blackthorn scrub south-east/north-west; south-west/north-east running ditch.	collapsed logs across plot; blackthorn in north-east corner; difficult to access north-east plot marker
455074	1940s scrub	Old blackthorn thicket; clean floor; moles. Oak, ash, birch around.	Blackthorn thicket, particularly dense in south-west corner; south-west marker not found.		Southern part of plot impenetrable thicket.	most of plot rather inaccessible bramble thicket
455076	1950 ash birch	Dense birch poles, under ash, old fallen trees; mole activity. Ash/oak (1950).	Pole stage ash/birch.			birch ash poles
455078	1950 ash	Recently thinned pole stage ash plantation (1950) over bramble and bracken. Ride edge (0,10; 0,0).	Young ash at rideside; bracken-Brachypodium ground flora. Ride along west edge.		Recently thinned ash on slope; dense bramble/bracken; ride just to west of plot.	thinned ash.

455080	part scrub part 1958 beech	Young beech/Thuja in east, mixed oak brackent in west. Coppiced sycamore on north edge. Fences (10,9.5; 3,5) (3,5;6.50). Fallen beech (4.6,4.6; 10,0)	Edge of Thuja plantation; remainder sycamore coppice and oak; sparse shrub and field layer.	On break of slope; old fence roughly along leading diagonal.	Part plantation; part old sycamore coppice on slope; fence along leading diagonal.	dense young stand; fence roughly along diagonal
455082	ash syc hf	Sparse sycamore amongst old oak and ash; stumps and log pile.	Mature and pole stage sycamore; no shrub layer; sparse ground flora; much bare soil; dead standing sycamore.		Ash/sycamore on slope	sycamore stand
455084	ash syc hf	Ash and sycamore saplings, dominated by old ash.	Under canopy of large sycamore with blackthorn/hawthorn scrub; badger sett; large dead fallen branches.	Oak/ash/sycamore.	On slope below giant ash.	Alliaria petiolata invasion
455086	1954 ash oak	Mixed older trees with some oak/ash/larch (some dead) (1954).	Oak/ash over nettle; deer track across north-west corner.		Dead oak; dense nettles.	quite open from thinning.
455088	ash syc hf	Sycamore with bracken floor, but dominated by huge ash; moles.	Ash/sycamore over sparse hawthorn understorey; bracken, mercury, nettle ground flora.		Former leading tree oak now collapsed; mercury/nettle flat by giant ash (just beyond north-east corner).	
455090	scrub/ride	Young oak plantation(1955), recently cleared; brushwood over whole plot; by ride; stump.	Open bracken under sycamore/oak; ride clips north-east corner.		Young ash/sycamore by ride under large oak	ride just beyond NE corner; sycamore poles
455092	cws /scrub	Sallow scrub. Channel (6,0; 0,6.5), with old oak.	Mixed coppice, hazel, willow, elder; bank and ditch across south-west corner.	Collapsed willow; ditch across south-west corner.	Old hazel coppice under oak standard collapsed willow;ditch across south-west corner..	collapsed willow;
456075	ride	Ash/hawthorn thicket bordering ride (9,0; 0,6.1)	Ash, hawthorn, maple at ride side; ride crosses south-west part of plot.	South-west marker not found; ride crosses south-west of plot.	Mostly ride with woodland fringe to north-east.	Ditch roughly along NW-SE diagonal
456077	1950 ash	Young ash/oak plantation (1950) heavily thinned, over Equisetum thickets.	Ash plantation, little understorey; mercury-Brachypodium flora.	South-west marker not found; post off-set.	Semi-mature high forest on slope.	SW half of plot mainly sedge; NW mainly bramble

456079	1950 beech thinned	Pole stage beech/ash/chestnut plantation (1950).	Beech plantation; no flora.	Small track across north-east corner.	Thinned beech stand; old ride across north-east corner; brash pile over north-east marker.	Brambly; thinned beech stand
456081	ash syc hf	Sycamore poles under oak and birch, next to path; fallen branch (6,0; 10,2).	Mature oak with sycamore understorey, over mercury; fallen birch in west of plot.	Markers not found; done on measured distance from post.	Sycamore poles with occasional mature oak; path across south-west corner.	mainly sycamore
456083	ash hf	Young ash and scrub amongst old ash; stumps. On steep slope.	Ash/sycamore over privet-ash understorey; next to badger sett.	North-east marker not found.	Steep slope.	Ash poles
456085	ash syc hf	Ash and sycamore saplings, among oak.	Oak/ash/sycamore over hazel coppice; sparse ground flora.	Ash, oak, sycamore, beech.	Young ash/sycamore high forest; new track clips south-west corner.	
456087	ash syc hf	Sparse oak/sycamore/poplar; moles.	Oak and poplar over nettle. Ride clips north-east corner.	Dead oak in north east of plot.	Large fallen oak (former leading tree); nettle patch; ride just beyond north-east corner.	fallen oak in western half of plot;
456089	ash syc hf	Sycamore poles under old ash. Stream (0,0; 5,0).	Sycamore over mercury; ditch from north-east to south-west; badger sett and path at north-east.	South-west marker not found.	Sycamore over mercury, either side of stream gulley.	ditch across western half of plot
456091	1962 oak thuya	Young oak/spruce plantation (1962) recently cleaned; edge of ride; bracken floor.	Oak/spruce plantation; bracken-mercury-Brachypodium flora.	Spruce/oak plantation.	Mixed plantation; ride just clips north-west corner; large maple just outside north-east corner.	collapsed salix in SE half of plot
456093	cws	Hazel coppice with oak standards.	Fallen dead maple, creating glade; hazel over mercury.	Neglected hazel coppice; very little canopy; oak/maple		hazel coppice
457072	cws	Ash/maple/hawthorn/blackthorn under large poplar at wood edge; moles; stump; ditch (9.7,0; 10,0.5).	Wood edge, elder/maple scrub under occasional ash and poplar; dead branches; ditch across south-east corner.	Plot on edge of wood; no post; found from trees.	Maple and thorn under ash in corner of ride; ditch across south-east corner; woodpile.	Now mostly pond! Southern pat of plot survives. Original post position outside wood

457074	scrub/ride	Thorn thicket in gap of fallen living poplar.	Tall herb clearing; log pile.	Clearing.	Grass and scrub around ride intersection.	rides cut so difficult to record grass species
457076	1948 plantn/ride	Spruce and oak (1950); track bordered by Thuja/Lawsons; some ash; some felling. South edge of ride (10,6.5; 0,7.7), old stumps.	Lawsons/spruce stand at ride side; ride across north-east corner.	Ride across north-east corner.	Ride across northern edge; fallen tree along southern ride edge.	NE corner a ride
457078	chestnut coppice cut 2013	Pole stage chestnut coppice; moles.	Sweet chestnut coppice with gorse along edge; path across north-west corner.		Mature chestnut coppice over bluebell; cut again in winter of 2012.	log pile halfway up western edge; log in western half; semi-mature coppice
457080	grass	Grassland with low scrub.	Mown rough grass; undulating ground.	Plot markers not found; done on measured distance from post. Rough grassland.	Grassland and low scrub.	rough grassland
457082	scrub	Grassland with hawthorn and hazel thicket in western half. Labelled open area.	Scrub in north-west half; more open grassland in south-east.	Open area in south-east, very limited.	Sparse flora under dense hazel; old pits; south-east corner only open.	only corner point open
457084	ash syc hf/ride	Mixed birch, sycamore, oak; ride in plot (0,1; 6.6,10)	Widened ride more-or-less along leading diagonal; open canopy either side.	Plot markers not found; measured in.	Plot across ride through northwest half (southern boundary along diagonal).	ride through north west half, roughly along diagonal
457086	ash syc hf	Ash saplings with one sycamore on brow of hill. Bank/outcrop (8,10; 10,9).	Sycamore-ash at top of steep slope over mercury.			dense ash poles
457088	ash syc hf	Sycamore poles over mercury.	Overstood sycamore coppice; no understorey, mercury ground flora.	On slope; small dead snag.	On steep bank, limestone outcrop; sycamore coppice; part fallen ash.	sycamore poles
457090	1962 plantn/ride	Pure sycamore over ride - four metres wide (0,0; 10,4.8)	Ride plot through oak, ash, sycamore; ride cuts through south-east half of plot.	Ride through southern part of plot.	Across ride and ride edge, through southern half of plot.	ride through southern half of plot

457092	scrub/lawn	Blackthorn thicket in south half of plot/bracken clearing; burnt.	Blackthorn and mown grass - 'Rambo' plot; south-west marker not found; only half circlets recordable.	Dense blackthorn in southern part of wood; circlets not recorded as inaccessible.	Part scrub (south), part mown grass (north).	collapsed salix and blackthorn thicket
458073	1962 ns/oak	Oak and spruce plantation (1962); thicket stage with rose, dogwood etc.	Oak/ash/spruce plantation.	Oak/spruce plantation	Plantation.	
458075	scrub by pond	Mixed scrub at edge of pond.	Edge of marsh (south-east corner); scrubby thicket going into young ash stand; earth mound in south-west corner.	Pond clips south-east corner of plot.	Pond and black mud in south-east corner.	just clipped edge of pond in south-east corner
458077	1948 ash thinned	Ash with DF (1948), some felling (DF). Ditch west edge (0,0; 0,10).	Ash/Douglas fir plantation; Brachypodium ground flora; ditch in south-west corner.	Ash/Douglas plantation; ditch along west edge.	Ditch along west edge.	ditch along west edge; open ash stand
458079	1948 beech/ride	Beech plantation (1948) and overgrown bank separated by ride,north edge (0,9; 10,5); fallen young beech.	Beech/oak plantation adjacent to ride; sparse ground flora.	Ride and bank across plot; north-east marker not found.	Edge of beech stand and across ride.	
458081	scrub/young hf	Mostly dense hawthorn scrub; edge of heath! Ride edge (0.2,10; 0,9)	Hawthorn scrub, very little flora.		Scrub on edge of Rough Common.	scrub
458083	beech hf	Beech and young sycamore.	Mature beech pollard and sycamore by chalet; very little flora.		Bare litter under old beech.	carpet of ash seedlings
458085	ash syc hf	Sycamore with oak; ?old coppice; path (10,2.3; 0.2,10)	Open thinned sycamore; bramble mercury flora.	Plot shaded; large oak, sycamore and young ash poles.	Mercury on slope.	
458087	ash syc hf	Ash thicket and poles, recently thinned in western half.	Ash/sycamore over mercury and bramble; sparse hawthorn.	Heavy shading from sycamore; young ash and older oak in canopy; hawthorn and hazel.		ash poles

458089	ash syc hf	Young sycamore poles; moles.	Mature oak and sycamore over young sycamore; flora mercury and nettles.	Markers not found; done on measured distance from post.	Sycamore and ash semi-mature high forest; dead oak in north-east corner; large sycamore on northern edge, may be just out.	sycamore poles, over mercury
458091	1962 beech thuya	Beech/Tsuga plantation (1962) recently thinned and brashed.	Beech/spruce plantation; recently thinned; poles left lying; some windthrow in north-east corner.	Beech plantation south of track; fallen beech in north of plot.		beech, little flora
458093	cws	Old oak/hazel coppice over nettles; moles	Oak standards over hazel coppice; nettles and bracken below.	Oak/hazel coppice; good ground flora.		large oak in plot
459072	1962 thinned beech	Thicket stage beech/larch plantation (1962); badger latrines	Larch/beech plantation.	Larch/beech plantation; little ground flora.	Thinned plantation	beech plantation
459074	1949 larch beech ride	Larch plantation 1949; across 3m wide ride (2.7,0; 4,10).	Straddles boundary of larch plantations; sycamore understorey.	Ride through middle of plot, north-south.	Ride through middle of plot; post and markers not found.	collapsed sycamore in south-east corner
459076	1949 ash thinned	Ash/oak plantation (1948), conifer nurses recently removed	Ash/birch plantation	Ash, birch, oak; some hawthorn/hazel; soft ground.	Carex pendula swamp through middle of plot (north-west to south-east).	sedge swamp
459078	1948 beech thinned, ash invasion	Ash/beech plantation (1948) pole stage, recent thinning.	Ash/beech stand, recently thinned.		Recently thinned beech-ash, stumps cut high for hurley sticks.	ash in plot in beech plantation

459080	nat regen glade in beech hf	Giant beech over clean floor; large hollow in eastern half.	Dead beech; clearing.	Beech clearing.	Dense regeneration in hollow under gap by giant beech.	SW corner mainly dell with dense young trees <5cm dbh; old beech in east half of plot
459082	syc beech hf	Young sycamore amongst oak..	Sycamore poles amid oak standards; solid mercury on shallow soil.			dense ash saplings
459084	road	Old ash and sycamore by road, north edge (4.2,0; 10,2.3).	Widened road side; grassy verge; piles of logs from clearancy; road occupies north-east corner.	Road, mown and unmown verges	Road and edge.	road through plot
459086	ash syc hf	Mixed; mole activity.	Occasional oak standard; thinned ash/sycamore; scrubby sycamore regrowth, much brash; ride clips north-east corner.		Ash pole flat.	ash-sycamore
459088	ash syc hf	Oak and sycamore with ash saplings; mercury floor.	Mature oak and sycamore over mercury; small dead branches.		Mercury/ash/sycamore.	seedlings of sycamore
459090	ash syc hf	Mostly sycamore, probably coppice shoots, by edge of ride (10,0; 8,10).	Sycamore coppice over mercury and nettle; ride clips north-east edge, more species-rich.	Ride clips north-east corner.	Sycamore/mercury/nettle on ride edge.	sycamore poles
459092	1962 oak conifer	Oak/spruce plantation (1962) recently brashed and thinned.	Oak plantation, recently thinned; brash along diagonal rack.	Plantation oak; shady.	part clearfell	oak plantation
459094	cws	Maple/hazel low canopy over nettle. 1.5m dry ditch (10,7.5; 0, 1.7).	Overstood hazel/maple coppice; wood bank through south-east half of plot.	Collapsed willow; bank roughly south-west to north-east.	Towards edge of wood across old boundary ditch, roughly along diagonal. Old maple stool.	collapsed salix (from outside plot) across northern edge
460071	ride	Bracken and grass among elder; old ride through plot (0,2; 10,3); large ash nearby.	Bluebell-bracken glade; neglected track through plot.	Bracken/bleubell/grass glade	Mostly old mown ride.	south-west half of plot a grassy ride, north- east bracken
460073	1949 thinned beech	Beech plantation (1949) next to planted ash; brushwood on floor; bramble in eastern half of plot.	Beech plantation.	Beech plantation.	Recently thinned beech over bluebell.	

460075	1946 ash	Ash plantation (1946) with mole activity. Ride, south-east corner (8,0; 10,0.5)	Ash plantation; sycamore/hazel/hawthorn understorey; little ground flora; north-west marker not found.	Ride clips south-east corner.	Bare soil and bramble in different parts of plot. Ride clips south-east corner; gulley by north-west corner.	Heavily thinned, only 1 oak left in plot.
460077	1947 spruce oak, now mainly oak	Oak/spruce plantation (1947); pole stage, bramble floor; ride through corner (9,0; 10, 2).	Oak/spruce plantation; recently thinned; ride clips south-east corner.	Mature spruce/oak; beech nearby; well-spaced trees, but shady.	Oak high forest occasional spruce; mainly bracken. Second plot marker not found, so may be slightly offset.	bramble bracken stand
460079	1956 thinned/coppiced	Young planted ash/oak (?1956); larch removed. Part open.	Oak/ash plantation; some hawthorn understorey; bank roughly along north-west/south-east diagonal.	Young ash and hornbeam poles; a few oaks nearby; hawthorn understorey		bramble thicket
460081	beech hf	Gap thicket by giant beech.	Old beech pollard (south-west corner) amid regeneration; mercury carpet.	Massive beech in corner of plot.		sycamore ash; large beech by sw corner
460085	ash syc hf	Closed sycamore poles over pure mercury.	Waist high bramble under sparse sycamore; ride across northern edge; badger path along western edge; some sycamore stump regrowth.		Brachypodium lawn; large sycamore on edge of plot (may be just out).	
460087	remnant oak stds over syc cop	Young sycamore under oak.	Pole stage sycamore and mature oak/ash; deer tracks; small fallen branches.	Young mature stand; just below bank to south-west; ash-sycamore in canopy.	Remnant large oaks and sycamore poles.	oak over sycamore poles
460089	former df 1933, now oak c1991	Old Douglas/larch (1933) over bracken.	New planted oak; former Douglas/larch plantation; felling brash.	Very open young oak plantation.	Young oak plantation.	young oak plantation
460091	1933 ash	Sparse ash (1933) with hazel.	Ash over hazel coppice.	Heavy shade from hazel; ash in canopy.		ash over hazel and thorn

460093	cws/scrub	Dense thicket under birch; path (2,0; 6.9,0)	Blackthorn thicket; fallen tree across north-west corner.	Plot markers not found; done on measured distance from post.	Blackthorn thicket.	collapsed blackthorn thickets
461072	1948 oak beech	Beech/oak plantation (1948) with clean floor. Dead fallen beech.	Beech/oak/ash plantation; little ground flora; large fallen branch.			dense bluebell
461074	1946 oak	Larch/oak mixture (1946); pole stage plantation with dense bracken.	Oak plantation with sycamore understorey; sparse bracken flora; shaded track roughly along north-west/south-east diagonal.	No markers found for post or plot.	Bracken bramble slope under oak. Plot markers not found. Possibly plot slightly offset.	oak-sycamore over bluebell; larch all gone
461076	scrub ash	Hawthorn under giant ash; mole activity; ditch (0,7.3; 10,9.3).	Hawthorn scrub under large ash pollard.	Ditch across northern part of plot	Stream across north edge; giant ash in plot.	Stream across north edge; giant ash about halfway along;
461078	1955 spruce	Spruce strip beside oak/larch plantation (?1955)	Boundary between spruce and oak plantation; ditch across south-east corner.	Avenue of spruce through plot; beech-oak plantation.	Spans ditch and spruce strip; bramble on west slope.	spruce stand
461084	bracken hollow	Bracken, no trees or shrubs.	Bracken.; brash pile in middle of plot.	Bracken	Bracken hollow.	bracken hollow
461086	ash oak syc hf	Ash poles in western half; mole activity	Young ash pole with sparse understorey; old oak pollards nearby; deer path across south-west corner.	Young ash poles with sycamore; old oak and ash in vicinity.	Flat ground, old common.	Glade created by fall of ash to the south; dense ash poles
461088	ash syc hf	Young sycamore at ride edge (8,10; 10,9.5); very mixed around with willow, sycamore, birch, oak.	Sycamore and oak; elder over mercury and nettles; old stumps; deer path through centre of plot.	North-east corner by ride; stump; ash just outside plot to south.	Ride clips north-east edge.	
461090	scrub glade	Herbs only; dense mercury.	Glade edge; bracken dominated.	Bracken glade; post and markers not found; a few metres off correct position.	North-west corner of glade; south-west collapsed willow; north east hazel; central area bracken.	collapses willow more or less along western edge; eastern half of plot a bracken glade

461092	cws	Blackthorn thicket under birch with some oak.	Ash sycamore hazel; fallen blackthorn; sparse ground flora, much bare soil and litter.	Litter covered slope; neglected former coppice.		birch oak, sparse flora
461094	cws scrub	Dense blackthorn thicket.	Hazel, field maple, blackthorn coppice; overstood.	Remnant blackthorn thicket; sparse ground flora.	Oak nest box 34.	sparse blackthorn only; scrubby area
462071	ride	Old hawthorn and elder with 3m ride(0,8.7; 10,2); power line (0,9; 1,10); planted elm in north; mole activity.	Ride at wood edge; south-east corner just outside gate; elm in north-east corner; power lines cross north-west corner.	Dense bramble across northern third; ride through middle; south-east corner just outside fence.	Across ride, under power line (north-west corner); dense bramble in northeast corner.	Across ride through bracken glade
462073	scrub	Elder scrub at edge of larch beech plantation. Old logs. Fence remains (1.5,10; 2,0).	Elder scrub on edge of larch plantation. Ditch at south-east corner and along east edge.		Between plantation and trenches.	trenches run along eastern edge
462075	scrub	Old elm over elder scrub on steep bank.	Elder thicket at ride side; plot on slope; badger sett; elder and elm collapsing; dead large elm stems.	Elm and elder; lots of dead wood; on steep slope; stand collapsed in middle of plot.	Steep bank with elm poles and elder scrub..	collapse elm in north of plot; badger sett
462077	1956 oak thinned	Pole stage oak plantation (1956) over bramble; just clips pine plantation (2.5, 10; 0,7.8).	Edge of oak plantation; adjacent to pine; nettles; log piles	Oak and pine; one pine fallen; open canopy; nettles.	Thinned oak and edge of pine stand.	bramble nettles
462085	ash oak syc hf	Open bracken amongst sparse oak and ash.	Ash at ride side (southern edge); sparse understorey; mercury bracken ground flora.		Bramble-nettle glade.	Nettle glade
462087	ash oak syc hf	Pure sycamore, mercury floor.	Glade on rideside; bramble dominated; ash-oak canopy; large fallen branch	Canopy gap by north-west corner; fallen wood by north-east corner.	Eastern edge; trees cleared; ride by eastern edge	sycamore, ash, maple

462089	ash-syc hf edge of 1933plantn	Old ash/oak and young sycamore. Charcoal pit (4,10); Ditch end (7,0)	Mature ash, sycamore understorey; bank running roughly north-west to south east; dead ash fallen.	Mature ash, Douglas, larch, sycamore; open and grassy.	Edge of plantation/mixed broadleaves; pit in northeast corner; shallow bank/gulley through middle of plot; giant ash just to north outside plot.	Bank runs roughly along NW-SE diagonal; sycamore over mercury
462091	cws	Old oak/ash over dense bramble.	Oak/ash; sparse ash understorey; bramble/mercury/Brachypodium flora; small fallen branches.			Bramble, mercury, Brachypodium
462093	cws	Dense maple/hawthorn. Stream (9.4,0; 8.4,10).	Hazel/hawthorn dominated glade; nettle flora; dry ditch along east edge.	Ditch across north-east edge; fallen hawthorn; oak, hawthorn, hazel; collapsed maple in middle of plot.		Stream across north-east corner; hazel, hawthorn, maple; mercury flora
462095	cws	Hazel/maple with old oak.	Overstood hazel/maple coppice; mercury flora; wind blown maple in south-west part of plot.	Fallen field maple in western part of plot; otherwise hawthorn, hazel, oak.	Derelict coppice	collapsed maple across plot just south of middle; mercury flora
463074	grass	Grassland with small hawthorn bushes. 2m ride (2,0; 2.5,10).	Sundays hill; close cut grass.	Sundays Hill grassland.	Sunday's hill grassland.	most of plot bracken, with remnant grassland along eastern edge
463076	1956mixed bl thinned	Colonising woodland on forest/common edge; fallen birch. Forest edge bank (5.5,10; 3,0).	Ash standards over hazle coppice; sparse flora.		Thinned mixed broadleaves; ditch/bank across north-west corner; treefall into plot from east.	mixed vegetation
463078	1962 beech	Planted beech saplings, under old beech and sycamore at track edge (10,0; 10,10); mercury floor.	Beech plantation at rideside (along east edge); much small dead wood from thinning.	Ride on edge.	Beech stand in ride angle; ride along east edge.	ride along east edge

463082	beech hf	Bramble and bare patch under hole in old beech; fallen beech debris.	Elder bramble glade over fallen dead beech (central area windblow debris).	Collapsed beech through plot	Gap from old beech fall; dense bramble thicket in south of plot; rotting trunk across north-west corner.	bramble thicket in south-west of plot; collapsed beech across NW corner
463084	mixed hf	Loose elder and young sycamore under chestnut; moles.	Sycamore regrowth/saplings under sweet chestnut; large fallen branch.	Large chestnuts; litter dominant; sparse bracken.	Hollow amongst chestnuts; fallen wood.	bramble/brachypodium in slight hollow
463086	ash syc hf	Young sycamore.	Sparse ash/sycamore; thin hawthorn over mercury; old stumps; deer track.		Young-mature ash-sycamore high forest	sycamore ash poles over bramble
463088	oak ash hf	Oak and young sycamore.	Widely spaced open grown oak (with nestbox); ash/sycamore saplings; large fallen branch	Mature oak/ash/sycamore.		old oak with ash poles
463090	oak ash hf	Ash and sycamore poles under old oak; ride (0,2; 2,0).	Young ash and mature oak along rideside. Big oak just outside plot (south-east corner); ride clips south-west edge.	Ride across south-west corner; large oak just to south-east		ride through south-west of plot;
463092	larch ash hf (no larch)	Pure old ash coppice.	Old coppice ash with larch; big old stool in north-west corner.	Ash, Brachypodium. Slightly off as post missing and markers not found (stool in middle should have been in corner).	Outgrown and collapsing ash coppice; markers refund. Bird box 148 in plot (8,7). Leaning larch outside plot.	giant ash stool in northwest corner; bramble mercury
464075	syc hf	Birch and sycamore; old logs in plot. Small path (0,4.5; 10,4.5).	Birch/sycamore clearing; birch dying; one fallen but alive in southeast half.	Closed canopy of young sycamore with occasional birch and hawthorn; fallen birch across centre of plot.	Semi-mature sycamore; fallen birch in plot in south-east hlaf.	Fallen birch across south-east of plot; sycamore poles

464077	syc hf former copp?	Sycamore (coppiced in past) rather broken. Fallen log and stump.	Much bare ground and litter under dense sycamore.	Sycamore canopy; little flora; fallen tree along north-west south-east diagonal.		sycamore poles; fallen logs in north-east of plot
464079	grass	Grassland at edge of elder scrub.	Long grass at edge of elder scrub in north-east corner.	Grassy field	Within fenced areas apart from south-west corner and west edge (just out);	mostly grassland; difficult to fully record as recently cut.
464087	ash syc hf	Sparse sycamore and oak. Bramble in east of plot.	Sycamore and oak; understorey sycamore, hazel, hawthorn.	Oak/sycamore over Brachypodium.	Sycamore poles; large oak in south-west corner (just out).	sycamore-ash
464089	ash syc hf	Ash poles; felling stumps. Gully (10,4.7; 0,5).	Ride edge, ditch, young ash crop. Ride across south-west corner; dry ditch in eastern half.	Pole ash/sycamore; ride edge and ditch across south-west corner; mercury flora.	Ride clips south-west corner; gulley through middle (east-west)	path cuts SW corner; ash
464091	ride	Blackthorn and Viburnum thicket under oak. Stream (4.6,0; 10,5). 3m ride (0,6; 6.8,10).	Oak-ash on wood edge; half plot now ride (north-west half); ditch from south-west to north-east.	Ride to north-west of plot; stream, ditch to south-east; tall ash; grassy flora.	Ride cutting across north-west of plot; second plot marker in south edge of ride; stream across south-east of plot.	mostly ride
464093	cws	Hawthorn/maple/ash thicket.	Mixed maple/hawthorn understorey under ash; deer tracks.	Ash, oak, hawthorn; tall canopy.		ash poles
465074	beech hf	Pure old beech with clean floor by very large hollow.	Hollow between several mature beeches; bramble and Brachypodium flora.	Mature beech; very open; maple and sycamore; large beech just outside plot.	Dense ash regeneration in hollow; fallen beech across north-east corner.	mass of ash, beech saplings to 2 m high in east side of plot

465086	ash syc hf	Mixed, mostly sycamore old trees about; giant ash in plot; old branches on ground.	Mixed shrubs unde canopy of old ash and oak; sycamore and elder; Brachypodium, mercury.	Approximate position; markers not found, but giant ash in centre of plot.- may be wrong position	Below giant ash on slope; sparse ground flora: may have been in wrong position.	sycamore over bramble; giant ash now a stump
465088	ride	Mixed with old oak; ride through plot (6,0; 0,7).	Most of plot occupied by wide ride; small areas of fringing vegetation in north-east and south-west corners.	Spans ride with bracken edges.	Most of plot covered by ride.	Across First Turn
465090	ash syc hf	Ash/sycamore poles over bramble; shallow ditch (0,0; 7,10); wet area in west edge.	Ash/sycamore over maple/hazel; compartment edge; bank roughly along the leading diagonal.	Bank/ditch through plot, roughly leading diagonal; young-mature ash/sycamore. Large ash on western edge just out.	Bank/ditch roughly along leading diagonal; swamp in south-west corner.	Partly marshy ground to north-west; ash sycamore
465092	ride	Ash over blackthorn at edge; ride (6.4,0; 10,5).	Rideside canopy gap; bramble/nettle; brash pile in north west half.	Ride makes up south-east half; north west scallop with planted trees; nettles.	Ride edge roughly along diagonal; open to south-east; bramble scallop to north-west.	half in ride; edge roughly along diagonal
466075	beech hf	Ash and sycamore saplings under giant beech and ash at ride edge (8,0; 10,1.5).	Wood edge; pollard beech; some hawthorn understorey; mercury and Brachypodium flora. Windblown oak across south-east corner.	Approximate position, via large beech as markers not found; a few metres off.	Poles under giant beech which is just outside plot.	beech sycamore canopy; dense ash sycamore regeneration
466087	glade in ash-syc hf	Young sycamore.	Clearing edge of ride junction;	Glade half covered by 1.5m bramble; close to veteran ash.	1-2m bramble patch; large fallen ash through plot.	Part bramble glade; remains of large fallen ash

466089	ride	Mostly bracken, some elder; dead ash tree (3,7.6)	Mown glade; recently cut.	Large open grass glade; mown ride intersection.	Grassy glade/wide ride.	grassy glade, track in eastern half
466091	ash oak hf	Mature ash and oak; moles.	Hawthorn/hazel under ash/oak.	Ash-oak high forest; sparse shrub layer; large ash just to north- east.		collapsed hawthorn in south east quadrant
467074	mixed hf	Ash and sycamore saplings under old ash, sycamore, beech; old stumps.	Windblown fallen beech top along diagonal; mercury.	Collapsed beech through plot, south- east to north-west	Mixed hardwoods amongst old lime, beech.	mixed hardwoods, fairly sparse flora
467087	ash syc hf	Pure sycamore.	No markers. Sycamore.		Small path roughly north- south through plot.	sycamore stand
468075	syc cop 1960?	Larch, spruce, beech and Thuja (1960), plus sycamore and ash. Thicket stage.	Ash/beech plantation, sycamore; nettle round flora.	Signals near post and first marker, but may be wrong. Rack across south-west corner.		ash beech poles; sparse flora
469074	mixed hf	Old lime, elm, ash high forest; mercury floor.	Two large hybrid limes and mercury ground flora; large rotten branches in south-west corner.	Large limes.	Under giant limes	lime over mercury
469076	oak ash hf	Mixed hardwood with mercury floor; mole activity.	Overstood sycamore coppice;oak standards; wood edge; mercury ground flora.			ash saplings
470073	mixed hf	Beech regeneration under old beech.	Mature beech over beech/sycamore regeneration; hornbeam plantation; sparse ground flora.	Marker at base of giant beech	Under big beech.	beech hornbeam poles
470075	1960 beech thuya	Thicket stage beech/Thuja plantation (1960); grassy ride edge (7.3,0; 10,8)	Thuja/beech plantaiton, recently thinned; brash pile in north-east corner; rideside.	Thuya/Beech plantation.	Bare litter; shaded ride clips south-east edge.	thuya beech, sparse flora

471074	1959 larch oak beech thinned	Thicket stage ash/oak/beeh plantation (1960) with larch nurse.	Ash/beech/oak; widely spaced, grassy flora.	Dead standing oaks.	Thinned mixed broadleaves; birch in centre of plot.	bramble, recent thinning
471076	1959 beech ash thinned	Thicket stage oak/beech/spruce plantation (1960); north edge grassy track (2,0; 0,1).	Beech/spruce plantation; rideside	Young mature beech/spruce; fallen spruce also.	Recently thinned; ride across south-west corner.	ash saplings common
472073	mixed hf	Sycamore saplings under large elm.	Sycamore thicket over mercury; wood-edge; old stump.	Closed canopy young sycamore; elm and ash.	Sycamore pole stand; ride and large ash a metre or so to north.	sycamore poles with some elm
472075	mixed hf	Mixed high forest with sycamore pole understorey; stumps and log piles.	Oak/pine/sycamore over hazel at wood-edge. Nettle /Brachypodium ground flora.	Young sycamore, hazel, hawthorn; mature oak, ash, pine nearby; fallen birch in north-west quadrant.		sycamore poles
472077	1959 beech oak thinned	Strip of planted beech/oak, thicket stage (1959); clean floor.	Oak/beech/spruce plantation over nettles.	Beech-spruce plantation.	Thinned hardwoods; brash pile in middle of plot.	ash beech; brachypodium lawn
473074	1958 thinned syc ash	Thicket stage larch/hardwood plantation (1958); recently cleaned.	Beech/sycamore clearing.	Open grassy glade; mown; Brachypodium, sedges; approximate as plot markers not found.	Mostly bramble glade	mostly bramble/nettle glade
473076	mixed hf	Lime/sycamore high forest; extraction track (3,0; 6,10); some lying logs.	Lime over mercury		Large lime.	lime over mercury

473078	mixed hf	Broken elder, old hawthorn under big oaks; near wood edge.	Elder scrub at wood-edge; occasional large oak.	Oak, elder, hawthorn; nettles; elder scrub to north-west.	1-2m bramble patch; steep bank in north-west; large fallen branch.	mostly bramble glade
474073	mixed hf	Tall ash over hawthorn; grass/nettle floor.	Ash/elm over hawthorn scrub.	Closed canopy ash and elm. Plot markers not found.	Gap in ash; nettles.	gap in ash over nettles
474075	1959 oak beech thinned	Thicket stage oak/beech plantation (1958); hawthorn, stumps.	Pole stage oak/beech plantation	Young mature beech plantation with oak.	Thinned.	beech oak plantation; over bramble
474077	1958 beech con	Planted Thuja/spruce/oak (1958), thicket stage.	Thuja/beech/spruce plantation		No ground flora.	large brash pile through west of plot; conifers removed
475074	ride	Old hazel coppice with elder; 2m ride (5.7,0; 7,10)	Straddles minor north-south ride; nettle, bramble, elder, hazel; log pile on east side.	Ride north-south through plot	Hazel coppice to east; ride through middle; bracken glade to west.	open; large ash nearby recently cleared
475076	cws	Old hazel coppice ; large fallen living hazel.	Fallen birch across diagonal, filling centre of plot; hazel coppice; mercury flora.	Hazel and fallen birch west to centre; maple, oak, ash nearby.	Remnant fallen birch in north-west of plot.	fallen birch almost disappeared
475078	ash-syc hf edge of 1933 plantn	Old hawthorn and loose elder under elm and sycamore poles.	Hazel/hawthorn/sycamore scrub; occasional mature oak		Old collapsed branches.	Scrubby sycamore; dense nettles and mercury
476075	cws	Hazel coppice between old oak/ash. Hazel part collapsed.	Bracken glade under large canopy gap; oak, birch, hazel, maple.	Fallen birch; north-east marker not found.	Bramble gap in north east half of plot.	hazel coppice

476077	cws	Clump of birch in east part; bracken and bramble floor.	Bracken glade in windblown birch in centre of plot.	Bracken dominated; lots of fallen birch; partially fallen ash.	Open bracken bramble in south-west corner; rotten branch across middle.	bracken bramble under sycamore/ash
476079	cws	Bracken and crab apple; moles; fence (0,5; 8,10); old ride (10,8.5; 8.5,10).	Bracken glade at edge of wood. North-west corner outside fence, not recorded.		Fence across north-west corner.	bracken bramble glade by apple tree
477074	cws	Old oak/ash over elder and nettles.	Oak/ash over hazel, elder nettles; deer track.	North-east marker not found. Nettles.	Mainly nettles; both markers found.	large oak in nettle glade
477076	cws	10m ride between ash and birch; west edge (3.5,0; .5,10); east edge (10,9; 9.5, 10).	Ash over ride (roughly north-west to south-east); hazel bracken, nettle ground flora.	Largely ride; dead willow.	Mostly ride.	Mostly grassy ride;
477078	cws	Open hazel with birch poles; 2m ride (5,0; 10,6).	Birch/hazel over mercury at ride edge; path cuts across south east corner of plot.	Ride across south-east corner of plot; north-east marker not found.	By ride	mostly ride
477080	cws	Old hazel with hawthorn; moles.	Hazel/hawthorn coppice over ground ivy and nettle; wood-edge.			western half mostly dense bramble thicket; east more scrubby; path roughly through middle, north-south
478075	cws	Old oak/ash over elder shrubbery.	Small dead branches;oak/ash over hazel/elder, bluebell.		Second marker not found	bluebell, ash, oak;bramble encroaching from NW
478077	cws	Old birch with bramble and bracken floor; many birch fallen.	Bracken clearing under birch,ash; much windblow in centre of plot.	Very open ; old windblow site.		open ash over dense bramble
478079	cws	Loose hawthorn scrub under birch poles.	Birch over hazel/hawthorn scrub; ground ivy/Brachypodium; small dead wood, old stump.	Some fallen birch.		birch over bramble

479078		Loose hazel scrub with maple and hawthorn; track (1.5, 10; 0,1.0).	Oak/hazel with sparse ground flora.	Very shady, beneath mature oak, hazel, hawthorn; little ground flora.		
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References

- ADAMSON, R. S. 1912. An Ecological Study of a Cambridgeshire Woodland. *Journal of the Linnean Society of London, Botany*, 40, 339-387.
- AL-MUFTI, M., SYDES, C., FURNESS, S., GRIME, J. & BAND, S. 1977. A quantitative analysis of shoot phenology and dominance in herbaceous vegetation. *The Journal of Ecology*, 759-791.
- ANON 1950. *Working plan for 1949/50-1959/60 for the Woods of Hazel, Wytham, Berkshire*, Oxford, Unpublished MS.
- ARCHAUX, F., GOSSELIN, F., BERGÈS, L. & CHEVALIER, R. 2006. Effects of sampling time, species richness and observer on the exhaustiveness of plant censuses. *Journal of Vegetation Science*, 17, 299-306.
- BACKMEROFF, C. E. & PETERKEN, G. F. 1988. Long-term changes in the woodlands of Clairinsh. *Transactions of the Botanical Society of Edinburgh*, 45, 253-297.
- BAETEN, L., BAUWENS, B., DE SCHRIJVER, A., DE KEERSMAEKER, L., VAN CALSTER, H., VANDEKERKHOVE, K., ROELANDT, B., BEECKMAN, H. & VERHEYEN, K. 2009. Herb layer changes (1954-2000) related to the conversion of coppice-with-standards forest and soil acidification. *Applied Vegetation Science*, 12, 187-197.
- BAETEN, L., VANGANSBEKE, P., HERMY, M., PETERKEN, G., VANHUYSE, K. & VERHEYEN, K. 2012. Distinguishing between turnover and nestedness in the quantification of biotic homogenization. *Biodiversity and Conservation*, 21, 1399-1409.
- BAKKER, J. P., OLFF, H., WILLEMS, J. H. & ZOBEL, M. 1996. Why do we need permanent plots in the study of long-term vegetation dynamics? *Journal of Vegetation Science*, 7, 147-156.
- BARKER-PLOTKIN, A. & FOSTER, D. 2006. Sustaining long-term research through changing times at the Harvard Forest. In: CAMP, A. E., IRLAND, L. C. & CARROLL, C. J. W. (eds.) *Long-term silvicultural and ecological studies: Results for science and management*. New Haven, Connecticut: Yale University, School of Forestry and Environmental Studies.
- BERNHARDT-RÖMERMANN, M., BAETEN, L., CRAVEN, D., DE FRENNE, P., HÉDL, R., LENOIR, J., BERT, D., BRUNET, J., CHUDOMELOVÁ, M., DECOCQ, G., DIERSCHKE, H., DIRNBÖCK, T., DÖRFLER, I., HEINKEN, T., HERMY, M., HOMMEL, P., JAROSZEWICZ, B., KECZYŃSKI, A., KELLY, D. L., KIRBY, K. J., KOPECKÝ, M., MACEK, M., MÁLIŠ, F., MIRTL, M., MITCHELL, F. J. G., NAAF, T., NEWMAN, M., PETERKEN, G., PETŘÍK, P., SCHMIDT, W., STANDOVÁR, T., TÓTH, Z., CALSTER, H. V., VERSTRAETEN, G., VLADOVIČ, J., VILD, O., WULF, M. & VERHEYEN, K. 2015. Drivers of temporal changes in temperate forest plant diversity vary across spatial scales. *Global Change Biology*, 21, 3726-3737.
- BITTERLICH, W. 1984. *The relascope idea. Relative measurements in forestry*, Wallingford, CABI
- BLONDEEL, H., PERRING, M. P., BERGÈS, L., BRUNET, J., DECOCQ, G., DEPAUW, L., DIEKMANN, M., LANDUYT, D., LIIRA, J. & MAES, S. L. 2018. Context-Dependency of Agricultural Legacies in Temperate Forest Soils. *Ecosystems*, 1-15.
- BOBBINK, R., HORNUNG, M. & ROELOFS, J. G. 1998. The effects of air-borne nitrogen pollutants on species diversity in natural and semi-natural European vegetation. *Journal of Ecology*, 86, 717-738.
- BOLTE, A., LAMBERTZ, B., STEINMEYER, A., KALLWEIT, R. & MEESENBURG, H. 2004. Zur Funktion der Bodenvegetation im Nährstoffhaushalt von Wäldern – Studien auf Dauerbeobachtungsflächen des EU Level II-Programms in Norddeutschland *Forstarchiv*, 75, 207-220.
- BRAITHWAITE, M. E., ELLIS, R. W. & PRESTON, C. D. 2006. *Change in the British Flora 1987-2004*, London, Botanical Society of the British Isles.
- BRUNET, J., DIEKMANN, M. & FALKENGREN-GRERUP, U. 1998. Effects of nitrogen deposition on field layer vegetation in south Swedish oak forests. *Environmental Pollution*, 102, 35-40.

- BUESCHING, C., CLARKE, J., ELLWOOD, S., KING, C., NEWMAN, C. & MACDONALD, D. 2010. The mammals of Wytham woods. In: SAVILL, P., PERRINS, C., KIRBY, K. & FISHER, N. (eds.) *Wytham Woods: Oxford's Ecological Laboratory*. Oxford University Press, Oxford.
- BUTT, N., CAMPBELL, G., MALHI, Y., MORECROFT, M., FENN, K. & THOMAS, M. 2009. Initial results from establishment of a long-term broadleaf monitoring plot at Wytham Woods, Oxford, UK. Oxford, UK: University of Oxford.
- CHOLEWIŃSKA, O., ADAMOWSKI, W. & JAROSZEWICZ, B. 2020. Homogenization of Temperate Mixed Deciduous Forests in Białowieża Forest: Similar Communities Are Becoming More Similar. *Forests*, 11, 545.
- CHYTRÝ, M. & DANIHELKA, J. 1993. Long-term changes in the field layer of oak and oak-hornbeam forests under the impact of deer and mouflon. *Folia Geobotanica et Phytotaxonomica*, 28, 225-245.
- CORNEY, P., KIRBY, K., LE DUC, M., SMART, S., MCALLISTER, H. & MARRS, R. 2008. Changes in the field-layer of Wytham Woods-assessment of the impacts of a range of environmental factors controlling change. *Journal of Vegetation Science*, 19, 287-298.
- CRAMPTON, A., STUTTER, O., KIRBY, K. & WELCH, R. 1998. Changes in the composition of Monks Wood National Nature Reserve (Cambridgeshire, UK) 1964–1996. *Arboricultural Journal*, 22, 229-245.
- DAWKINS, H. C. D. & FIELD, D. R. B. 1978. A long-term surveillance system for British woodland vegetation. *Commonwealth Forestry Institute Occasional Paper 1*. Oxford: Commonwealth Forestry Institute.
- DE FRENNE, P., RODRÍGUEZ-SÁNCHEZ, F., COOMES, D. A., BAETEN, L., VERSTRAETEN, G., VELLEND, M., BERNHARDT-RÖMERMANN, M., BROWN, C. D., BRUNET, J., CORNELIS, J., DECOCQ, G. M., DIERSCHKE, H., ERIKSSON, O., GILLIAM, F. S., HÉDL, R., HEINKEN, T., HERMY, M., HOMMEL, P., JENKINS, M. A., KELLY, D. L., KIRBY, K. J., MITCHELL, F. J. G., NAAF, T., NEWMAN, M., PETERKEN, G., PETŘÍK, P., SCHULTZ, J., SONNIER, G., VAN CALSTER, H., WALLER, D. M., WALTHER, G.-R., WHITE, P. S., WOODS, K. D., WULF, M., GRAAE, B. J. & VERHEYEN, K. 2013. Microclimate moderates plant responses to macroclimate warming. *Proceedings of the National Academy of Sciences*, 110, 18561-18565.
- DEPAUW, L., PERRING, M. P., LANDUYT, D., MAES, S. L., BLONDEEL, H., DE LOMBAERDE, E., BRÜMELIS, G., BRUNET, J., CLOSSET-KOPP, D., CZEREPO, J., DECOCQ, G., DEN OUDEN, J., GAWRYŚ, R., HÄRDTLE, W., HÉDL, R., HEINKEN, T., HEINRICHS, S., JAROSZEWICZ, B., KOPECKÝ, M., LIEPIŃA, I., MACEK, M., MÁLIŠ, F., SCHMIDT, W., SMART, S. M., UJHÁZY, K., WULF, M. & VERHEYEN, K. 2020. Light availability and land-use history drive biodiversity and functional changes in forest herb layer communities. *Journal of Ecology*, 108, 1411-1425.
- ELLENBERG, H. 1988. *The vegetation ecology of central Europe.*, Cambridge, Cambridge University Press.
- ELTON, C. S. 1942-1965. *Elton Archive: notes on the Wytham Area 1942-1965* [Online]. Available: <http://ora.ox.ac.uk/objects/uuid:89c5e479-6003-45ba-bd78-8a8a12858bf1>.
- ELTON, C. S. 1966. *The pattern of animal communities*, London, Chapman & Hall.
- FALKENGREN-GRERUP, U. & DIEKMANN, M. 2003. Use of a gradient of N-deposition to calculate effect-related soil and vegetation measures in deciduous forests. *Forest Ecology and Management*, 180, 113-124.
- FARMER, A. M. 1994. Changes in soil chemistry at Wytham Wood (Oxfordshire) 1974-1991. *English Nature Research Reports*. Peterborough: English Nature.
- FARMER, A. M. 1995. Soil chemistry change in a lowland english deciduous Woodland 1974–1991. *Water, Air, and Soil Pollution*, 85, 677-682.
- FISCHER, C., PARTH, A. & SCHMIDT, W. 2009. Vegetation dynamics in beech-dominated strict forest reserves. A comparison study from southern Lower-Saxony (Germany). *Hercynia*, 42, 45-68.

- FORD, E. D. & NEWBOULD, P. J. 1977. The Biomass and Production of Ground Vegetation and Its Relation to Tree Cover Through a Deciduous Woodland Cycle. *Journal of Ecology*, 65, 201-212.
- FÖRSTER, A., BECKER, T., GERLACH, A., MEESENBURG, H. & LEUSCHNER, C. 2017. Long-term change in understorey plant communities of conventionally managed temperate deciduous forests: effects of nitrogen deposition and forest management. *Journal of Vegetation Science*, 28, 747-761.
- FULLER, R. J. 1995. *Birdlife of woodlands and forest*, Cambridge, Cambridge University Press.
- GIBSON, C. W. D. 1986. Management history in relation to changes in the flora of different habitats on an Oxfordshire Estate, England. *Biological Conservation*, 38, 217-232.
- GOLDSMITH, F. B. 2012. *Monitoring for conservation and ecology*, Springer Science & Business Media.
- GRAYSON, A. J. & JONES, E. W. 1955. *Notes on the history of the Wytham Estate with special reference to the woodlands*, Oxford, Imperial Forestry Institute.
- GRIME, J. P., HODGSON, J. G. & HUNT, R. 2007. *Comparative plant ecology (revised edition)*, Dalbeattie, Castlepoint Press.
- HARMER, R., PETERKEN, G., KERR, G. & POULTON, P. 2001. Vegetation changes during 100 years of development of two secondary woodlands on abandoned arable land. *Biological Conservation*, 101, 291-304.
- HEDL, R. & CHUDOMELOVÁ, M. 2020. Understanding the dynamics of forest understorey vegetation: combination of monitoring and legacy reveals patterns across temporal scales. *Journal of Vegetation Science*.
- HEDL, R., KOPECKY, M. & KOMAREK, J. 2010. Half a century of succession in a temperate oakwood: from species-rich community to mesic forest. *Diversity and Distributions*, 16, 267-276.
- HEDWALL, P. O., GUSTAFSSON, L., BRUNET, J., LINDBLADH, M., AXELSSON, A. L. & STRENGBOM, J. 2019. Half a century of multiple anthropogenic stressors has altered northern forest understory plant communities. *Ecological Applications*, e01874.
- HESTER, A. J., BRITTON, A. J., HEWISON, R. L., ROSS, L. C. & POTTS, J. M. 2019. Long-term vegetation change in Scotland's native forests. *Biological Conservation*, 235, 136-146.
- HILL, M. O., PRESTON, C. D. & ROY, D. B. 2004. *PLANTATT: attributes of British and Irish plants.*, Cambridge, Biological Records Centre (NERC).
- HOPKINS, J. J. & KIRBY, K. J. 2007. Ecological change in British broadleaved woodland since 1947. *Ibis*, 149, 29-40.
- HORSFALL, A. S. & KIRBY, K. J. 1985. The use of permanent plots to record changes in the structure and composition of Wytham Woods. *Research and Survey in Nature Conservation 1*. Peterborough: Nature Conservancy Council.
- HÜLBER, K., DIRNBÖCK, T., KLEINBAUER, I., WILLNER, W., DULLINGER, S., KARRER, G. & MIRTIL, M. 2008. Long-term impacts of nitrogen and sulphur deposition on forest floor vegetation in the Northern limestone Alps, Austria. *Applied Vegetation Science*, 11, 395-404.
- HUTCHINGS, M. J. 1978. Standing Crop and Pattern in Pure Stands of *Mercurialis Perennis* and *Rubus fruticosus* in Mixed Deciduous Woodland. *Oikos*, 31, 351-357.
- KÄFER, J. & WITTE, J.-P. M. 2004. Cover-weighted averaging of indicator values in vegetation analyses. *Journal of Vegetation science*, 15, 647-652.
- KEITH, S. A., NEWTON, A. C., MORECROFT, M. D., BEALEY, C. E. & BULLOCK, J. M. 2009. Taxonomic homogenization of woodland plant communities over 70 years. *Proceedings of the Royal Society B: Biological Sciences*, 276, 3539-3544.
- KIMBERLEY, A., BLACKBURN, G. A., WHYATT, J. D., KIRBY, K. & SMART, S. M. 2013. Identifying the trait syndromes of conservation indicator species: how distinct are British ancient woodland indicator plants from other woodland species? *Applied Vegetation Science*, 16, 667-675.
- KIRBY, K. J. 1980. Experiments on Vegetative Reproduction in Bramble (*Rubus Vestitus*). *Journal of Ecology*, 68, 513-520.

- KIRBY, K. J. 1988. A woodland survey handbook. *Research and survey in natural conservation*. Peterborough: Nature Conservancy Council.
- KIRBY, K. J. 2001. The impact of deer on the ground flora of British broadleaved woodland. *Forestry*, 74, 219-229.
- KIRBY, K.J 2004. Changes in the composition of Wytham Woods (southern England), 1974–2002, in stands of different origins and past treatment. In: HONNAY, O., VERHEYEN, K. & BOSSUYT, B. (eds.) *Forest Biodiversity: Lesson from History for Conservation*. Wallingford, UK: CABI.
- KIRBY, K. J. 2010a. The flowers of the forest. In: SAVILL, P. S., PERRINS, C., KIRBY, K. J. & FISHER, N. (eds.) *Wytham Woods, Oxford's Ecological Laboratory*. Oxford: Oxford University Press.
- KIRBY, K. J. 2010b. The trees in the Woods 1945–2007. In: SAVILL, P. S., PERRINS, C., KIRBY, K. J. & FISHER, N. (eds.) *Wytham Woods, Oxford's Ecological Laboratory*. Oxford: Oxford University Press.
- KIRBY, K. J. 2016. The transition of Wytham Woods from a working estate to unique research site (1943–1965). *Landscape History*, 37, 79-92.
- KIRBY, K. J. 2020. The ash population in Wytham Woods. *Fritillary*, 8, 98-106.
- KIRBY, K. J., BAZELY, D. R., GOLDBERG, E. A., HALL, J. E., ISTED, R., PERRY, S. C. & THOMAS, R. C. 2014. Changes in the tree and shrub layer of Wytham Woods (Southern England) 1974–2012: local and national trends compared. *Forestry*, 87, 663-673.
- KIRBY, K. J., BAZELY, D. R., GOLDBERG, E. A., HALL, J. E., ISTED, R., PERRY, S. C. & THOMAS, R. C. 2022. Five decades of ground flora changes in a temperate forest: The good, the bad and the ambiguous in biodiversity terms. *Forest Ecology and Management*, 505, 119896.
- KIRBY, K. J., BINES, T., BURN, A., MACKINTOSH, J., PITKIN, P. & SMITH, I. 1986. Seasonal and Observer Differences in Vascular Plant Records from British Woodlands. *Journal of Ecology*, 74, 123-131.
- KIRBY, K. J., GOLDBERG, E. A., ISTED, R., PERRY, S. C. & THOMAS, R. C. 2016. Long-term changes in the tree and shrub layers of a British nature reserve and their relevance for woodland conservation management. *Journal for Nature Conservation*, 31, 51-60.
- KIRBY, K. J., PYATT, D. G. & RODWELL, J. S. 2012. Characterization of the woodland flora and woodland communities in Britain using Ellenberg Values and Functional Analysis. In: ROTHERHAM, I. D., JONES, M. & HANDLEY, C. (eds.) *Working and Walking in the Footsteps of Ghosts: volume 1 the wooded landscape*. Sheffield: Wildtrack Publishing.
- KIRBY, K. J., SMART, S. M., BLACK, H. J., BUNCE, R. G. H., CORNEY, P. M. & SMITHERS, R. J. 2005. Long-term ecological changes in British woodland (1971–2001). *English Nature Research Report 653*. Sheffield.
- KIRBY, K.J. & THOMAS, R. 2000a. Changes in the ground flora in Wytham Woods, southern England from 1974 to 1991–implications for nature conservation. *Journal of Vegetation Science*, 11, 871-880.
- KIRBY, K. J. & THOMAS, R. C. 2000b. A comparison of the structure and composition of the Warburg Reserve between 1973 and 1992. *English Nature Research Report*. Peterborough: English Nature.
- KIRBY, K. J., THOMAS, R. C. & DAWKINS, H. C. D. 1996. Monitoring of changes in tree and shrub layers in Wytham Woods (Oxfordshire), 1974–1991. *Forestry*, 69, 319-334.
- KIRBY, K. J. & WOODDELL, S. R. J. 1998. The distribution and growth of bramble (*Rubus fruticosus*) in British semi-natural woodland and the implications for nature conservation. *Journal of Practical Ecology and Conservation*, 2, 31-41.
- KLYNGE, D., SVENNING, J.-C. & SKOV, F. 2020. Floristic changes in the understory vegetation of a managed forest in Denmark over a period of 23 years – Possible drivers of change and implications for nature and biodiversity conservation. *Forest Ecology and Management*, 466, 118128.
- KORB, J. E. & FULE, P. Z. 2008. Intra-and Interannual Vegetation Change: Implications for Long-Term Research. *Restoration ecology*, 16, 5-11.

- LANDUYT, D., MAES, S. L., DEPAUW, L., AMPOORTER, E., BLONDEEL, H., PERRING, M. P., BRŪMELIS, G., BRUNET, J., DECOCQ, G. & DEN OUDEN, J. 2019. Drivers of above-ground understorey biomass and nutrient stocks in temperate deciduous forests. *Journal of Ecology*.
- LING, K. A. 2003. Using environmental and growth characteristics of plants to detect long-term changes in response to atmospheric pollution: some examples from British beechwoods. *Science of The Total Environment*, 310, 203-210.
- MAES, S. L., BLONDEEL, H., PERRING, M. P., DEPAUW, L., BRŪMELIS, G., BRUNET, J., DECOCQ, G., DEN OUDEN, J., HÄRDTLE, W., HÉDL, R., HEINKEN, T., HEINRICHS, S., JAROSZEWICZ, B., KIRBY, K., KOPECKÝ, M., MÁLIŠ, F., WULF, M. & VERHEYEN, K. 2019a. Litter quality, land-use history, and nitrogen deposition effects on topsoil conditions across European temperate deciduous forests. *Forest Ecology and Management*, 433, 405-418.
- MAES, S. L., PERRING, M. P., DEPAUW, L., BERNHARDT-RÖMERMAN, M., BLONDEEL, H., BRŪMELIS, G., BRUNET, J., DECOCQ, G., DEN OUDEN, J., GOVAERT, S., HÄRDTLE, W., HÉDL, R., HEINKEN, T., HEINRICHS, S., HERTZOG, L., JAROSZEWICZ, B., KIRBY, K. J., KOPECKÝ, M., LANDUYT, D., MÁLIŠ, F., VANNESTE, T., WULF, M. & VERHEYEN, K. 2019b. Plant functional trait response to environmental drivers across European temperate forest understorey communities. *Plant Biology*.
- MARRS, R. H., KIRBY, K. J., LE DUC, M. G., MCALLISTER, H. A., SMART, S. M., OKSANEN, J., BUNCE, R. G. H. & CORNEY, P. M. 2013. Native dominants in British woodland - a potential cause of reduced species-richness. *New Journal of Botany*, 3.
- MASKELL, L. C., SMART, S. M., BULLOCK, J. M., THOMPSON, K. & STEVENS, C. J. 2010. Nitrogen deposition causes widespread loss of species richness in British habitats. *Global Change Biology*, 16, 671-679.
- MIHÓK, B., KENDERES, K., KIRBY, K. J., PAVIOUR-SMITH, K. & ELBOURN, C. A. 2009. Forty-year changes in the canopy and the understorey in Wytham Woods. *Forestry*, 82, 515-527.
- MILBERG, P., BERGSTEDT, J., FRIDMAN, J., ODELL, G. & WESTERBERG, L. 2008. Observer bias and random variation in vegetation monitoring data. *Journal of Vegetation Science*, 19, 633-644.
- MITCHELL, R. J., HEWISON, R. L., HESTER, A. J., BROOME, A. & KIRBY, K. J. 2016. Potential impacts of the loss of *Fraxinus excelsior* (Oleaceae) due to ash dieback on woodland vegetation in Great Britain. *New Journal of Botany*, 6, 2-15.
- MORECROFT, M. D. & TAYLOR, M. E. 2010. Wytham in a changing world. In: SAVILL, P. S., PERRINS, C., KIRBY, K. J. & FISHER, N. (eds.) *Wytham Woods: Oxford's ecological laboratory*. Oxford: Oxford University Press.
- MORECROFT, M. D., TAYLOR, M. E., ELLWOOD, S. A. & QUINN, S. A. 2001. Impacts of deer herbivory on ground vegetation at Wytham Woods, central England. *Forestry*, 74, 251-257.
- MOUNTFORD, E. P. 2001. Long-term changes in the vegetation of Denny wood, an ancient wood-pasture in the New Forest. *English Nature Research Report*. Peterborough: English Nature.
- MOUNTFORD, E. P. & PETERKEN, G. F. 1998. Monitoring natural change in Monks Wood National Nature Reserve. *English Nature Research Report*. Peterborough: English Nature.
- MOUNTFORD, E. P. & PETERKEN, G. F. 2000. Natural developments at Scords Wood, Toy's Hill, Kent, since the Great Storm of October 1987. *English Nature Research Report*. Peterborough: English Nature.
- MOUNTFORD, E. P., PETERKEN, G. F. & BURTON, D. 1998. Long-term monitoring and management of Langley Wood: a minimum intervention National Nature Reserve. *English Nature Research Report*. Peterborough: English Nature.
- MOUNTFORD, E. P., PETERKEN, G. F., EDWARDS, P. J. & MANNERS, J. G. 1999. Long-term change in growth, mortality and regeneration of trees in Denny Wood, an old-growth wood-pasture in the New Forest (UK). *Perspectives in Plant Ecology, Evolution and Systematics*, 2, 223-272.
- NAAF, T. & WULF, M. 2010. Habitat specialists and generalists drive homogenization and differentiation of temperate forest plant communities at the regional scale. *Biological Conservation*, 143, 848-855.

- NATURAL ENGLAND 2012. Environmental Monitoring in Natural England 2012. *Natural England Research Report*. Peterborough: Natural England.
- NEEDHAM, J., MEROW, C., BUTT, N., MALHI, Y., MARTHEWS, T. R., MORECROFT, M. & MCMAHON, S. M. 2016. Forest community response to invasive pathogens: the case of ash dieback in a British woodland. *Journal of Ecology*, 104, 315-330.
- NUTTLE, T., RISTAU, T. E. & ROYO, A. A. 2014. Long-term biological legacies of herbivore density in a landscape-scale experiment: forest understoreys reflect past deer density treatments for at least 20 years. *Journal of Ecology*, 102, 221-228.
- OGLE, K., BARBER, J. J., BARRON-GAFFORD, G. A., BENTLEY, L. P., YOUNG, J. M., HUXMAN, T. E., LOIK, M. E. & TISSUE, D. T. 2015. Quantifying ecological memory in plant and ecosystem processes. *Ecology letters*, 18, 221-235.
- OREDSSON, A. 2000. Choice of surveyor is vital to the reliability of floristic change studies. *Watsonia*, 23, 287-292.
- OSMASTON, F. C. 1959. *The revised working plan for the Wytham Woods 1959/60-1968/69*, Oxford, Unpublished MS.
- OVINGTON, J. D. 1955. Studies of the Development of Woodland Conditions Under Different Trees: III. The Ground Flora. *Journal of Ecology*, 43, 1-21.
- PERRIN, P. M., KELLY, D. L. & MITCHELL, F. J. G. 2006. Long-term deer exclusion in yewwood and oakwood habitats in south-west Ireland: natural regeneration and stand dynamics. *Forest Ecology and Management*, 236, 356-367.
- PERRING, F. H. & WALTERS, S. M. 1976. *Atlas of the British Flora (second edition)*, Wakefield, Botanical Society of the British Isles.
- PERRING, M. P., BERNHARDT-RÖRMERMANN, M., BAETEN, L., MIDOLO, G., BLONDEEL, H., DEPAUW, L., LANDUYT, D., MAES, S. L., DE LOMBAERDE, E., CARÓN, M. M., VELLEND, M., BRUNET, J., CHUDOMELOVÁ, M., DECOCQ, G., DIEKMANN, M., DIRNBÖCK, T., DÖRFLER, I., DURAK, T., DE FRENNE, P., GILLIAM, F. S., HÉDL, R., HEINKEN, T., HOMMEL, P., JAROSZEWICZ, B., KIRBY, K. J., KOPECKÝ, M., LENOIR, J., LI, D., MÁLIŠ, F., MITCHELL, F. J. G., NAAF, T., NEWMAN, M., PETŘÍK, P., RECZYŃSKA, K., SCHMIDT, W., STANDOVÁR, T., ŚWIERKOSZ, K., VAN CALSTER, H., VILD, O., WAGNER, E. R., WULF, M. & VERHEYEN, K. 2018. Global environmental change effects on plant community composition trajectories depend upon management legacies. *Global Change Biology*, 24, 1722-1740.
- PERRINS, C. M. 2010. Introduction. In: SAVILL, P. S., PERRIN, C. M., K.J., K. & FISHER, N. (eds.) *Wytham Woods: Oxford's ecological laboratory*. Oxford: Oxford University Press.
- PERSSON, S., MALMER, N. & WALLÉN, B. 1987. Leaf litter fall and soil acidity during half a century of secondary succession in a temperate deciduous forest. *Vegetatio*, 73, 31-45.
- PETERKEN, G. & GAME, M. 1984. Historical factors affecting the number and distribution of vascular plant species in the woodlands of central Lincolnshire. *The Journal of Ecology*, 72, 155-182.
- PETERKEN, G. F. 1977. Habitat conservation priorities in British and European woodlands. *Biological Conservation*, 11, 223-236.
- PETERKEN, G. F. & BACKMEROFF, C. 1988. Long-term monitoring in unmanaged nature reserves. *Research and Survey in Nature Conservation 9*. Peterborough: Nature Conservancy Council.
- PETERKEN, G. F. & FRANCIS, J. L. 1999. Open spaces as habitats for vascular ground flora species in the woods of central Lincolnshire, UK. *Biological Conservation*, 91, 55-72.
- PETERKEN, G. F. & JONES, E. W. 1987. Forty Years of Change in Lady Park Wood: The Old-Growth Stands. *Journal of Ecology*, 75, 477-512.
- PETERKEN, G. F. & JONES, E. W. 1989. Forty years of change in Lady Park Wood: the young growth stands. *Journal of Ecology*, 77, 401-429.
- PETERKEN, G. F. & MOUNTFORD, E. P. 2017. *Woodland development: a long-term study of Lady Park Wood*, Wallingford, UK, CABI.
- PETERKEN, G. F. & STACE, H. 1987. Stand development in the Black Wood of Rannock. *Scottish Forestry*, 41, 29-44.

- PIGOTT, C. D. & TAYLOR, K. 1964. The distribution of some woodland herbs in relations to the supply of nitrogen and phosphorus in the soil. *Journal of Ecology*, 52 (supplement), 175-185.
- PITCAIRN, C. E. R., LEITH, I. D., SHEPPARD, L. J., SUTTON, M. A., FOWLER, D., MUNRO, R. C., TANG, S. & WILSON, D. 1998. The relationship between nitrogen deposition, species composition and foliar nitrogen concentrations in woodland flora in the vicinity of livestock farms. *Environmental Pollution*, 102, 41-48.
- PRESTON, C. D., PEARMAN, D. A. & DINES, T. D. 2002. *New Atlas of the British and Irish Flora: An Atlas of the Vascular Plants of Britain, Ireland, The Isle of Man and the Channel Islands* Oxford, Oxford University Press.
- PUTMAN, R. J. 1986. *Grazing in temperate ecosystems: large herbivores and the ecology of the New Forest*, Beckenham, Kent, Croom Helm.
- RACKHAM, O. 2003. *Ancient woodland: its history, vegetation and uses in England (revised edition)*, Dalbeattie, Scotland, Castlepoint Press.
- RATCLIFFE, D. A. 1977. *A nature conservation review*, Cambridge, Cambridge University Press.
- REINECKE, J., KLEMM, G. & HEINKEN, T. 2014. Vegetation change and homogenization of species composition in temperate nutrient deficient Scots pine forests after 45 yr. *Journal of Vegetation Science*, 25, 113-121.
- RODWELL, J. S. 1991. *British plant communities: 1 woodlands and scrub*, Cambridge, Cambridge University Press.
- SAVILL, P. S., PERRINS, C., KIRBY, K. J. & FISHER, N. 2010. *Wytham Woods, Oxford's Ecological Laboratory*, Oxford, Oxford University Press
- SCHULZE, I.-M., BOLTE, A., SCHMIDT, W. & EICHHORN, J. 2009. Phytomass, litter and net primary production of herbaceous layer. *Functioning and Management of European Beech Ecosystems*. Springer.
- SHEEHAN, P. 1979. *Management plan for Wytham Woods 1980-85*. Forestry and Land Management MSc, University of Oxford.
- SMART, S., BUNCE, R., MARRS, R., LEDUC, M., FIRBANK, L., MASKELL, L., SCOTT, W., THOMPSON, K. & WALKER, K. 2005. Large-scale changes in the abundance of common higher plant species across Britain between 1978, 1990 and 1998 as a consequence of human activity: tests of hypothesised changes in trait representation. *Biological Conservation*, 124, 355-371.
- STRUBELT, I., DIEKMANN, M., PEPLER-LISBACH, C., GERKEN, A. & ZACHARIAS, D. 2019. Vegetation changes in the Hasbruch forest nature reserve (NW Germany) depend on management and habitat type. *Forest ecology and management*, 444, 78-88.
- STRUBELT, I., DIEKMANN, M. & ZACHARIAS, D. 2017. Changes in species composition and richness in an alluvial hardwood forest over 52 yrs. *Journal of Vegetation Science*, 28, 401-412.
- TANENTZAP, A., KIRBY, K. J. & GOLDBERG, E. A. 2012. Slow responses of ecosystems to reductions in wild ungulates and strategies for achieving recovery. *Forest Ecology and Management*, 264, 159-166.
- TAYLOR, M. E., MORECROFT, M. D. & OLIVER, H. R. 2010. The physical environment. In: SAVILL, P. S., PERRINS, C., KIRBY, K. J. & FISHER, N. (eds.) *Wytham Woods: Oxford's ecological laboratory*. Oxford: Oxford University Press.
- THIMONIER, A., DUPOUEY, J., BOST, F. & BECKER, M. 1994. Simultaneous eutrophication and acidification of a forest ecosystem in North-East France. *New Phytologist*, 126, 533-539.
- TITTENSOR, R. 2002. Report on the vegetation of the The Mens woodland reserve, West Sussex. *English Nature Research Report*. Peterborough: English Nature.
- VAN DEN BERGE, S., TESSENS, S., BAETEN, L., VANDERSCHAEVE, C. & VERHEYEN, K. 2019. Contrasting vegetation change (1974-2015) in hedgerows and forests in an intensively used agricultural landscape. *Applied Vegetation Science*.
- VERHEYEN, K., BAETEN, L., DE FRENNE, P., BERNHARD-ROMERMANN, M., BRUNET, J., CORNELIS, J., DECOQ, G., DIERSCHKE, H., ERIKSSON, O., HEDL, R., HEINKEN, T., HERMY, M., HOMMEL, P., KIRBY, K. J., NAAF, T., PETERKEN, G. F., PETRIK, P., PFADENHAUER, J., VAN CALSTER, H.,

- WALTHER, G.-R., WULF, M. & VERSTRAETEN, G. 2012. Driving factors behind the eutrophication signal in understorey plant communities of deciduous temperate forests. *Journal of Ecology*, 100, 352-365.
- VERHEYEN, K., DE FRENNE, P., BAETEN, L., WALLER, D. M., HEDL, R., PERRING, M. P., BLONDEEL, H., BRUNET, J., CHUDOMELOVÁ, M., DECOCQ, G., DE LOMBAERDE, E., DEPAUW, L., DIRNBOCK, T., DURAK, T., ERIKSSON, O., GILLIAM, F. S., HEINKEN, T., HEINRICHS, S., HERMY, M., JAROSZEWICZ, B., JENKINS, M. A., JOHNSON, S. E., KIRBY, K. J., KOPECKY, M., LANDUYT, D., LENOIR, J., LI, D., MACEK, M., MAES, S., MALIS, F., MITCHELL, F. J. G., NAAF, T., PETERKEN, G. F., PETRIK, P., RECYNSKA, K., ROGER, D. A., SCHEI, F. H., SCHMIDT, W., STANDOVAR, T., SWIERKOSZ, K., UJHAZY, K., VAN CALSTER, H., VELLEND, M., VILD, O., WOODS, K. D., WULF, M. & BERNHARD-ROMERMANN, M. 2017. Combining community resurvey data to advance global change research. *Bioscience*, 67, 73-83.
- VILD, O., HÉDL, R., KOPECKÝ, M., SZABÓ, P., SUCHÁNKOVÁ, S. & ZOUHAR, V. 2017. The paradox of long-term ungulate impact: increase of plant species richness in a temperate forest. *Applied Vegetation Science*, 20, 282-292.
- WALTHER, G. & GRUNDMANN, A. 2001. Trends of vegetation change in colline and submontane climax forests in Switzerland. *Bulletin of the Geobotanical Institute ETH*, 67, 3-12.
- WARD, A. I. 2005. Expanding ranges of wild and feral deer in Great Britain. *Mammal Review*, 35, 165-173.
- WARDELL. 1987. *Management plan for Wytham Woods 1987-1991*. Forestry and Land Management MSc, University of Oxford.