Long-term monitoring at Heartwood Forest – an update

Tim Wright, on behalf of the Heartwood Monitoring Group

1. Introduction

It has been seven years since the very first tree was ceremoniously planted in November 2009 to mark the start of the creation of Heartwood Forest by the Woodland Trust. Since that time, over 540,000 saplings have been planted and the landscape is now markedly different – as the one-time arable fields are replaced by areas of newly planted woodland interspersed by grassland and wild flower meadows (Figure 1). All the planting has been done by volunteers including schoolchildren, corporate groups, religious groups, members of the public as well as Woodland Trust volunteers. The whole planting programme will have lasted nine years and will be complete by the end of winter of 2017-18 taking the total number of trees planted to over 600,000. From the start the impact of this transition on the flora and fauna has been closely monitored by a large team of observers, both expert and novice, and is continuing to yield important results. Three years into the programme, the methodology and early results of the monitoring were described (Smith *et al*, 2012). This paper updates and expands on those initial results.

2. Planting progress

The Woodland Trust acquired the land in 2008; 347

Figure 1*: 2009 (top) and 2016 photos of newly wooded area (photos Judith Parry).*

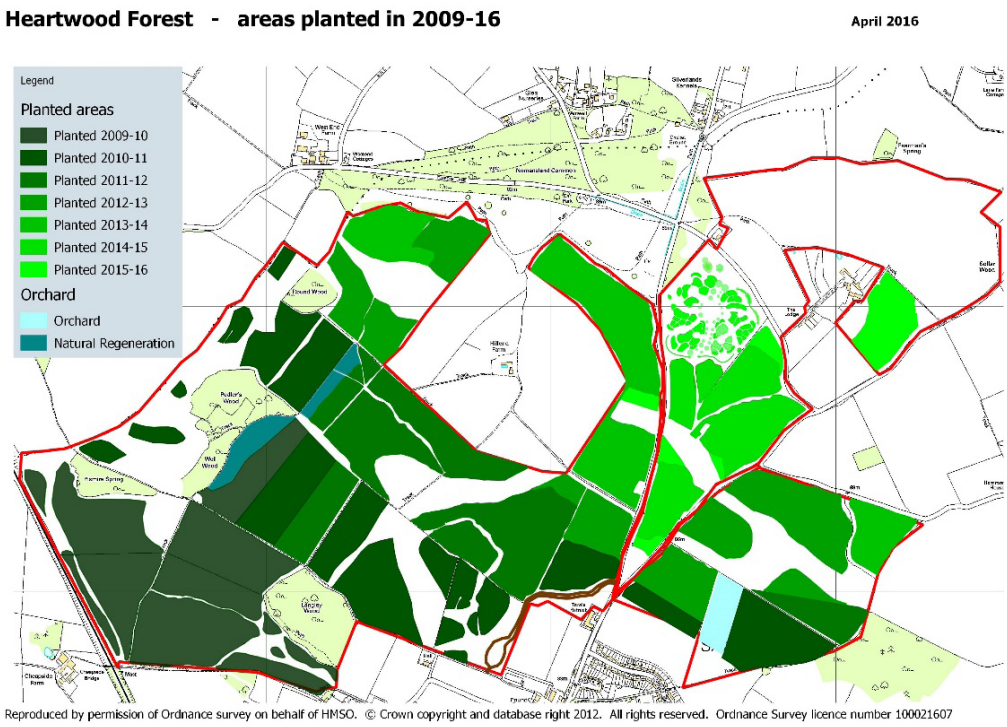

Figure 2*: Year-on-year tree planting at Heartwood Forest.*

hectares of mainly arable farmland which included four areas of ancient woodland totalling 17.8 hectares. Year-on-year, the arable fields were taken out of crop and planted with trees, or seeded with grasses or wildflowers. Figure 2 shows the areas planted year-on-year and Table 1 shows the numbers of the 26 main tree species planted (excluding arboretum and orchard – discussed later).

Given the advance westwards across the UK of Chalara (or Ash dieback) over the last several years, the planting of Ash saplings in Heartwood Forest ceased in 2012. From that time on, the number of Oak saplings planted was increased accordingly.

From the winter of 2012-13 onwards, the planting methodology was revised to differentiate the shrubby trees that typically form the perimeter of wooded areas and which provide a dense habitat suited to small birds and small mammals from the high canopy trees such as the oak and hornbeam that are often found in the more central parts of wooded areas. The revised methodology also promoted block planting of a single species (typically 25 to 40 trees in a block) to help minimise the risk of being overcome by more dominant species as the woodland matures. In some places, single-species copses were planted mainly to provide visual appeal.

In terms of pre and post planting treatment of the saplings, significant (although not total) use has continued to be made of rabbit fencing to enclose large areas of planting. Halo spraying using glyphosate has continued to be used around each sapling in the summer for the first three years to supress the growth of grasses and weeds that would otherwise take nutrients from the saplings. The first year's planting in the winter of 2009-10 made extensive use of individual tree guards or spirals to protect saplings against rabbit damage (particularly in the areas alongside the railway embankment that forms the north-west boundary of the site) and of straw bales to act as a mulch and weed suppressant to individual saplings. From winter of 2010-11 onwards, individual guards or spirals have been used to a very limited extent mainly to demarcate the boundary of a newly planted area. Mulching with straw was discontinued as it was labour-intensive to deploy, tended to get distributed by the wind, and seemed to be of limited benefit to the sapling survival.

In addition to the general planting of saplings, three other approaches to woodland creation were employed:

- **Natural regeneration** – an area of about 2.3 hectares on the leeward side of one of the areas of ancient woodland was left to regenerate naturally

Table 1: *Species and number of trees planted each year. (There are two more winters of planting to go).*

Common name	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
Common Oak	6000	14400	15600	20000	11700	7700	3300
Sessile Oak	5500	11000	12000	14000	7200	5600	2400
Ash	4500	8900	9600	0	0	0	0
Silver birch	4000	8900	9600	8000	7200	5600	2400
Hornbeam	3500	8900	9600	8000	7200	5600	2400
Rowan	3500	7700	8400	7000	6300	4900	2100
Wild cherry	3000	6600	7200	6000	5400	4200	1800
Aspen	3000	6600	7200	6000	5400	3500	1500
Hazel	3000	8900	9600	8000	7200	5600	2400
Field maple	2000	4300	4800	4000	3600	2800	1200
Goat willow	2000	3300	3600	3000	2700	2100	900
Small leaved lime	1500	3300	3600	0	2700	2100	900
White willow	1500	3300	3600	3000	2700	2100	900
Hawthorn	1500	3300	3600	3000	3600	2800	1200
Blackthorn	1000	2100	2400	2000	1800	1400	600
Guelder rose	1000	3300	3600	0	0	2100	900
Wayfaring tree	1000	2100	2400	2000	1800	1400	600
Dog rose	1000	1600	1800	1500	1800	1400	600
Holly	750	0	0	0	0	0	0
Spindle	250	500	600	500	900	700	300
Crab apple	250	500	600	500	900	700	300
Purging buckthorn	250	500	600	500	900	700	300
Dogwood	0	0	0	3000	3600	2800	1200
Alder	0	0	0	0	1800	1400	600
Grey sallow	0	0	0	0	1800	1400	600
Downy birch	0	0	0	0	1800	1400	600
Totals	**50000**	**110000**	**120000**	**100000**	**90000**	**70000**	**30000**

following the arable crop harvest in 2008. There is also evidence of natural regeneration elsewhere across the site.

- **Seeding** – a total of 3.2 hectares were seeded; some areas with a mix of tree seeds and other areas with acorns. Seeding was partly driven by a desire to engage with younger school children who would otherwise have been daunted by the prospect of digging into heavy ground.
- **Willow cuttings** – A few thousand willow cuttings were sourced from Rothamsted Research. Most of these were planted in the arboretum (described later), with a small number elsewhere across the site.
- **Beat-up** – In areas where the survival of saplings is low, new saplings have been planted (referred to as *beat-up*). Some 40,000 saplings have been planted as beat-up to date.

3. New features

As well as the general planting of woodland, grassland and wild flower meadows, the opportunity was taken to create other features at Heartwood Forest with the aim of increasing biodiversity and general interest:

- **Arboretum** – The UK's first native arboretum occupying 11 hectares will showcase all 60 native tree species (species list derived from the Royal Horticultural Society's classifications). 57 of the 60 species were planted during the winter of 2015-16 comprising 8,600 saplings (including approximately 2,250 in three hedges) and 3,400 willow cuttings (supplied by Rothamsted Research). As it matures, the arboretum will become a national resource that will contribute to the Woodland Trust's strategic initiatives of woodland culture and resilience and act as a focus for learning and engagement. The arrangement of the planting is intended to aid understanding of the historical use of tree products and timber with some species planted and maintained in ways that will illustrate traditional techniques (e.g. close spacing willows for basketwork; coppicing and pollarding, etc). In addition to the more common species, the mix includes Black Poplar, Arbutus, Wild Service, Scot's Pine from the Balmoral Estate, two Yews grown from cuttings from the Hambledon Yew, thought to be 950 years old, and three rare Whitebeam species.

Figure 3*: Heartwood Forest native tree arboretum. Planting being filmed for BBC Countryfile December 2015 (photo Judith Parry).*

- **Orchard** – The design for Heartwood Forest included a large community orchard covering about 2.5 hectares. Planting started in the winter of 2010-11 and will continue until winter 2016-17, when it will comprise nearly 600 apple trees (70 varieties) all grafted on MM106 medium-vigorous root-stock, 46 pear trees (8 varieties), and 136 stone and other fruit trees (9 varieties of plum/gage/damson and 18 varieties of species such as medlar, quince, peach, apricot, cherry). As well as the common varieties of apple, heritage and local varieties have also been sourced. Every tree has been individually guarded to a height of 1.2m to protect against rabbit and small deer damage. Once mature, as well as providing (hopefully) an abundance of fruit, the orchard should provide a habitat rich in biodiversity.

  Table 2 lists the fruit tree species and varieties planted, the year of planting and the quantity. The orchard location is relatively exposed to the prevailing winds and in parts is prone to waterlogging. A small number of trees were unable to survive these conditions, including the Fig trees.
- **Wetland area** – Although Heartwood Forest has no natural water courses or ponds, several areas are prone to waterlogging during the winter months. One area in particular, although largely flat, had been subject to a field drainage and ditch scheme whilst in arable use and, as such, potentially lent itself to the creation of a wetland wildlife reserve. The area was surveyed to determine the exact contours of the land and dip wells were installed in 2013 to determine the dependency of the water-table on time-of-year, rainfall and damming of the ditch. From these studies, plans have been prepared for a wetland area on both sides of the existing ditch covering about 1.1 hectare. The intention is to excavate some of this area to a depth of up to 1 metre to form a scrape into which water will seep. The spoil will be used to form a low water-retaining bund with the expectation that the scrape and much of the surrounding area will remain wet for much of the year.

Figure 4*: Heartwood Forest community orchard, spring 2016 (photo Judith Parry).*

Table 2: *List of fruit trees planted in the community orchard. Includes some trees to be planted in the winter of 2016-17.*

Species	Variety	No.	Variety	No.	Variety	No.
Apple	Red Windsor	15	Allington Pippin	8	Gavin	8
	Lord Lambourne	7	Red Ellison's Orange	9	Greensleves	9
	Brownlee's Russett	7	St Edmund's Russet	8	James Grieve	15
	Lanes Prince Albert	10	Rajka	7	Tydman's Late Orange	10
	Peasgood Nonsuch	8	Katy	10	Ceeval	10
	Jonagold	10	Egremont Russet	8	Kidd's Orange red	10
	Winston	10	Topaz	10	Flanders Cox	8
	Laxton's Reward	10	Rivers Nonsuch	10	Rivers St Martin	10
	Fairie Queen	10	Adam's Pearmain	10	D'Arcy Spice	10
	Scrumptious	10	Crispin	10	Sturmer Pipin	10
	Hitchin Pippin	10	Fiesta	8	Red Devil	8
	Red Windsor	8	Ribston Pippin	8	Crimson Newton	6
	Edward VII	7	Newton Wonder	8	Sunset	9
	Bramley	8	Laxton's Fortune	10	Laxton's Favorite	10
	Herring's Pippin	10	Cheddar Cross	10	Discovery	10
	Laxton's Epicure	10	Blenheim Orange	9	Ashmead's Kernel	9
	Rivers Early Peach	10	Encore	5	Golden Noble	4
	Claygate Pairmain	9	Howgate Wonder	4	New Hawthornden	5
	Hormead Pairmain	5	Warner's King	4	Bushy Grove	8
	Lord Derby	4	Reverend W Wilks	6	Red Victoria	5
	Bountiful	7	Emneth Early	6	Beauty of Bath	9
	Grenadier	4	George Cave	10	Laxton's Superb	9
	Irish Peach	10	Falstaff	9	Sunburn	8
	Pitmaston Pinapple	9				
Cherry	Morello	7	Stella	9	Merton Glory	9
	Early Rivers	6				
Pear	Cornice	6	Conference	6	Williams Bon Chretien	6
	Beth	4	Laxton's Satisfaction	7	Laxton's Foremost	5
	Summer Beurre	6	Concorde	6		
Plum/	Rivers Early Prolific	5	Stella Star	5	Early Transparent	5
Gage/	Cambridge	5	Reine Claude de Bavay	5	Ouillins	5
Damson	Denniston's Superb	5	Merryweather	5	Majorie Seedling	5
Medlar	Macrocarpa	5	Nottingham	5	Westerveld	4
Quince	Vranja	5	Meeche's Prolific	5	Smyrna	4
Nectarine	Madame Blanchett	5				
Peach	Peregrine	5				
Apricot	Flavorcot	4	Moorpark	4	Golden Glow	5
	Tomcot	5				
Mulberry	Morris Nigra Wellington	2				
Fig	Brown Turkey	2				

- **Hedgerows** – Heartwood Forest has about 17km of hedgerows around the arable fields that previously comprised the site and along the public roads and bridleways that intersect the site. Many stretches of hedgerow will be absorbed totally within, or form the shrubby boundary of, the newly created wooded areas. However, some stretches will remain as hedgerow visible from both sides and will need a management regime that maintains their biodiversity as well as their utility. Part of this regime includes traditional hedge-laying according to the South of England style in which brush is left on both sides. Originally intended to provide a stock-proof barrier, hedges are laid these days mainly for aesthetic appeal but the resulting thick low growth provides a good habitat for small birds and mammals. Every winter since 2012-13, some 40m of hedgerow has been laid by volunteers and

Figure 5*: Before (left) and after of the hedge alongside Pismire Spring wood at Heartwood Forest being laid by volunteers February 2016 (photos Albert Callewaert).*

now totals about 350m (this includes a hedge-laying competition in February 2015 when over 200m was laid in one day). Many of the stakes and binders required for hedge-laying were harvested from Heartwood Forest. In some parts the existing hedgerows have fallen into disrepair and significant gaps have appeared. A programme of planting these gaps with hedgerow species is ongoing.

4. Managing footfall

One of the Woodland Trust's intentions for a flagship forest is that it should demonstrate woodland culture and the value of woodland preservation and creation to as wide a number of people as possible. It was important therefore that the site chosen should be easily accessible by large numbers of people and hence be in a relatively densely populated part of the UK. Heartwood Forest fulfils that criteria; some 270,000 people live within 10km and 2 million are within 25km.

The Hertfordshire Way forms much of the southern boundary and there are two public bridleways that intersect the site. From these rights of way and other public roads, 21 kissing gates give pedestrian access to the forest, six of which include a horse-step to allow equestrian access to the site's permissive bridleways. The site itself is criss-crossed with over 17km of permissive bridleways and footpaths including a 2km all-ability route. A car park with 55 spaces was opened in 2012.

Visitor numbers have exceeded expectations but now seem to be plateauing at about 180,000 person visits per year accompanied by about 50,000 dog visits per year (extrapolated from visitor number surveys conducted two or three times a year). This number of visitors brings its own issues most notably (a) the erosion and widening of the footpaths that run through the ancient woods to the detriment of the native bluebells and (b) the disturbance of birds and mammals (including badgers) by dogs particularly in ground cover of the recently planted woodland. Steps are being taken to mitigate the bluebell damage by clearly marking the preferred routes through those woods and by an education campaign of interpretation boards, leaflets and volunteer engagement. The impact of dogs has been mitigated to some extent by engaging with dog owners by signage, leaflets, awareness days, volunteer campaigning and by retaining the rabbit fencing that was originally erected around some of the newly planted areas.

5. Photo-points

The transition from mainly arable to mainly woodland and the growth of the trees is being captured visually by taking several photos at each of 32 photo-points (marked with wooden posts) resulting in a total of 126 photos 4 times a year. Effectively a time-lapse record is being established. In addition, photos are taken at each of the 114 sapling survival monitoring points and the 24 long-term monitoring plots described in Smith *et al.* 2012.

6. Monitoring Group

The Heartwood Monitoring Group described earlier (Smith *et al*, 2012) has continued to meet twice a year as a forum for sharing the monitoring plans and results and co-ordinating activities. Several members of the Monitoring Group also participate in the Heartwood volunteer work parties that are engaged in planting during the winter months and other more general activities during the summer months. These work parties provide another opportunity to co-ordinate the monitoring activity and to identify volunteer resources to help with the monitoring.

The detailed results of all monitoring activities are shown on the Hertfordshire Natural History Society web site.

7. Tree monitoring

Sapling growth and survival

Ever since the first saplings were planted in the winter of 2009-10, an annual programme has been carried out to monitor the growth and survival of a sample of each year's plantings. The methods are described in Smith *et al.* (2012) but, in essence, within each year's planted area, 20 randomly selected points are set up and permanently marked and all saplings within a 5m radius circular plot are identified to species and their height measured. For the first five years all points were re-measured annually but in recent years those that have been planted for more than five years are being measured only every three years.

For many of the plots it is still too early to draw conclusions but, for those planted in the early years, clear patterns are starting to emerge. The survival of planted saplings through their first year has in general been good, averaging 82.8% overall. However, there has been significant variation in survival between species and between years. In particular, saplings measured in 2011 having been planted over winter 2010-11 suffered particularly badly (Figure 6). Spring 2011 was exceptionally warm and dry with rainfall 6 miles north of Heartwood Forest in March, April and May recorded as 7, 5 and 11mm respectively compared with the 15-year average of 42, 42 and 55mm. Many of the newly planted saplings succumbed to the dry conditions.

In addition, there is weak evidence that some species have survived less well than others with Ash, Birch and White Willow apparently having lower survival (Figure 7).

Most of the planted stock is growing well. As to be expected, Aspen and Goat Willow have put on more height than the other species with the forest species (Ash, Oak and Hornbeam) growing more slowly (Figure 8).

Although the majority of the woodland creation on the site has been by means of planting saplings there are also small areas of natural regeneration and two areas where establishment was by seed planting. These two treatments have produced very different outcomes compared with the planted areas (Figure 9). Both the natural regeneration and seed-sown areas have much higher stem density than the planted areas and in both the stem density has increased over time; both the effects of area and year are highly significant with $p<0.001$. This is probably the result of very small seedlings being missed in the early years and some seeds not germinating immediately. All these plots are getting to the stage that competition will result in self-thinning. The stem densities in the planted areas are much lower than in the other two but they too are increasing over time. This is the result of some natural regeneration within the planted areas but also to a small amount of replanting (beat-up) to replace dead saplings.

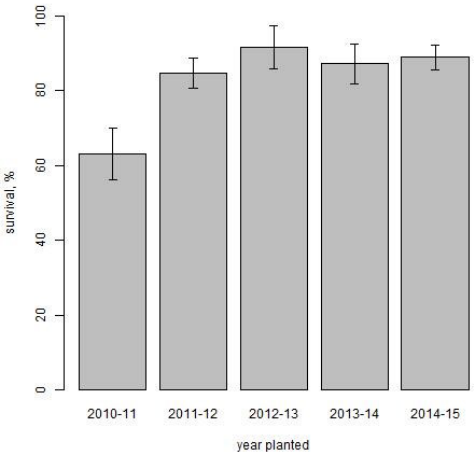

Figure 6: *Annual variation of the first year survival of planted saplings for all species combined. The effect of the year is highly significant with saplings measured in 2011 (planted 2010-11) having significantly lower survival than every other year (Tukey Honest Significant Differences $p<0.05$). The error bars represent the standard error of the mean.*

In terms of wildlife habitat there is a big contrast between the planted and other areas. The planted areas still have widely spaced trees with grass and herbs growing in the spaces between them whereas, in the natural regeneration and seeded areas, the vegetation is dominated by the woody species with shaded bare ground beneath.

Hedgerows

A decision was taken in 2012 to suspend detailed monitoring of hedgerows because the hedges were fairly mature and not particularly affected by the transition from arable farming to woodland. This decision will be reviewed with the possibility of resuming a monitoring regime on a less frequent basis. The monitoring undertaken in 2011 and 2012 (see Smith *et al*, 2012) has provided a baseline.

8. Bird monitoring

Heartwood Forest has become a well-known birdwatching site in the county for farmland birds, birds of prey and owls.

Breeding birds

Systematic counts of the breeding birds have been carried out over the whole site each year since 2009,

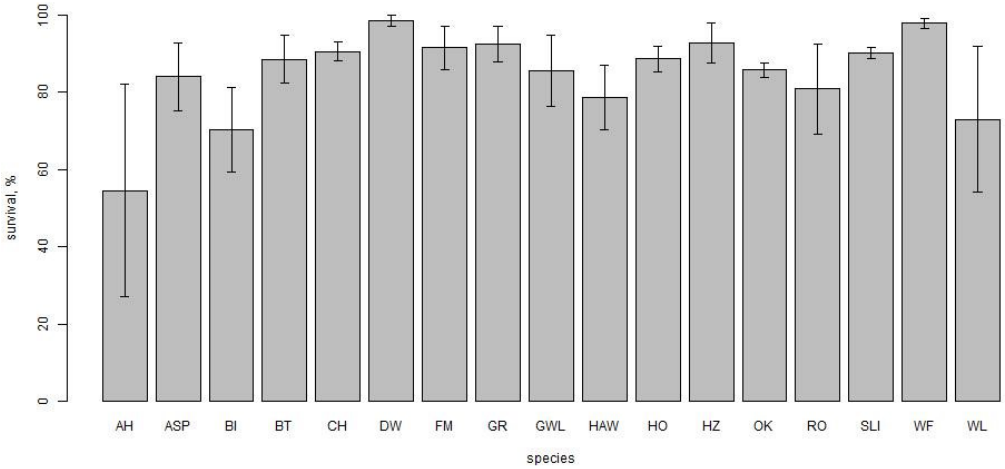

Figure 7*: The overall first year survival of saplings by species. The species codes are as follows: AH, Ash; ASP, Aspen; BI, Birch; BT, Blackthorn; CH, Cherry; DW, Dogwood; FM, Field Maple; GR; Guelder Rose; GWL, Goat Willow; HAW, Hawthorn; HO; Hornbeam; HZ, Hazel; OK, Oak; RO, Rowan; SLI, Small-leaved Lime; WF, Wayfarer Tree; WL, White Willow.*

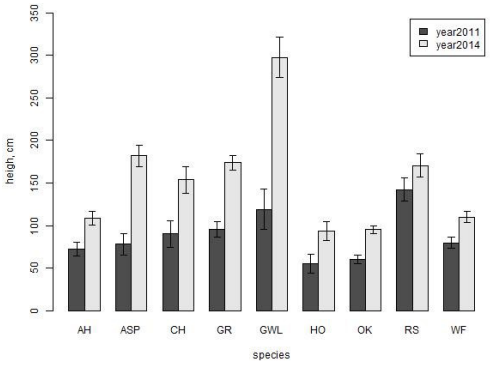

Figure 8: *The growth for selected species between 2011 and 2014. Species codes are given in Figure 7.*

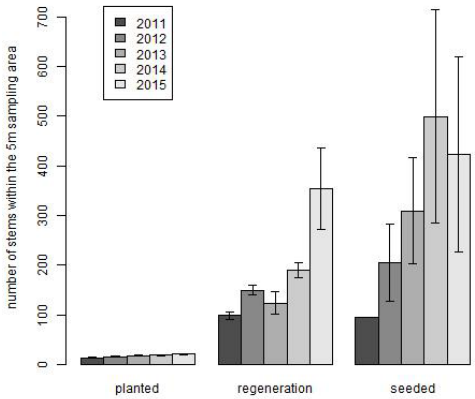

Figure 9: *The numbers of woody stems within the 5m radius recording plot in areas of natural regeneration, seed sowing and sapling planting.*

and have included the planted areas as well as the land still under arable cultivation. BTO/JNCC/ RSPB Breeding Bird Survey methods have been used (Harris *et al.* 2014) to allow comparisons with other sites within the county. The transect routes used have been described previously (Smith *et al.* 2012) but are over 6km in length. The number of species recorded on these transects has increased from 35 in 2009 to between 40 and 46 between 2012 and 2015. The cumulative total of species recorded has now reached 63 (the full table of results can be found on the Hertfordshire Natural History Society website). Although there are only seven years of data, the trends in numbers are starting to emerge; it is already clear that species normally thought of as farmland birds have so far benefited. Species such as Skylark, Linnet, Yellowhammer, Goldfinch and Reed Bunting have all done well (see Figure 10). All these species except the Goldfinch are either stable or decreasing elsewhere in Hertfordshire. Between 2012 and 2014 Corn Buntings, now a rare bird in central Hertfordshire, bred but sadly they were not present in 2015 although there are still occasional reports. The total numbers of birds recorded during the breeding bird survey, excluding pigeons (doubled since 2009) are shown in Table 3.

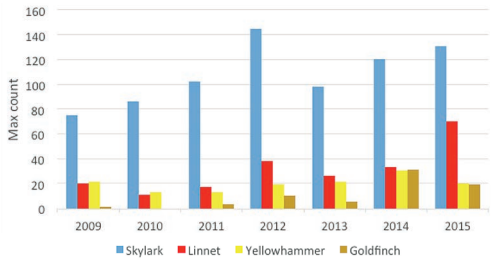

Figure 10: *Trends in the numbers of Skylark, Linnet, Yellowhammer and Goldfinch recorded in standard breeding bird surveys at Heartwood Forest 2009 to 2015.*

Table 3*: Total numbers of birds recorded during the breeding bird survey, excluding pigeons.*

Year	2009	2010	2011	2012	2013	2014	2015
Total birds	360	351	408	476	469	745	689

An owl nest box was installed in spring 2012 near Langley Wood and was occupied by a Barn Owl which raised six chicks. Six more boxes have subsequently been placed around the site and monitored each year. Occupants have included Barn Owl, Tawny Owl, Kestrel, Jackdaw and Stock Dove.

Winter birds

To complement the breeding season work, bird surveys through the winter have been conducted using BTO BirdTrack methods. These have shown that the high numbers of farmland birds have been maintained through the winter including flocks of Skylarks, Linnets, Goldfinch and Yellowhammers plus Fieldfares and Redwings. Of great interest have been the birds of prey and owls presumably attracted by the high numbers of small mammal prey in the grasslands. For instance, through the winter of 2015-16 up to five Short-eared Owls were present and provided a fine spectacle (see Figure 11).

9. Invertebrate monitoring

Butterflies

Butterflies have been monitored at Heartwood Forest since August 2010 as part of the UK Butterfly Monitoring Scheme (Butterfly Conservation, 2016). The transect route on the western side of Heartwood Forest has been walked weekly from April to October (Smith *et al.* 2012). The full results are published by Butterfly Conservation and summarised on the Heartwood website. Over the five years the number of butterflies counted each year has increased significantly from a total of 1255 in 2011 to 3038 in 2015. An illustration of the counts for species that have shown notable change is shown in Figure 12.

In particular, species which tend to favour grassland, including Small Skipper, Large Skipper, Marbled White, Meadow Brown, Gatekeeper and Small Heath, have increased substantially, whereas they have remained relatively stable in the rest of Hertfordshire. The only group to show a decline are the Large White, Small White and Green-veined White. This may be linked to the cessation of cultivation of oil-seed rape as they have increased elsewhere in the county (Wood, 2016). The number of species recorded has increased to 28, with Clouded Yellow seen for the first time in

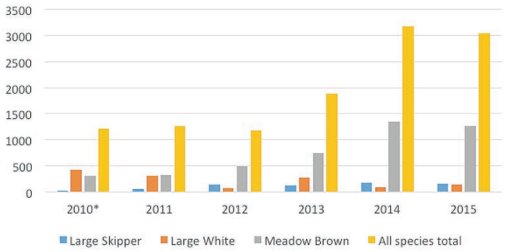

Figure 12: *Counts for butterfly species that have shown notable change each year on the Heartwood Forest western transect.*

Figure 11*: Short Eared Owl over Heartwood Forest in late autumn 2015 (photo Prashant Meswani).*

Figure 13*: Marbled White butterfly at Heartwood Forest (photo Andrew Steele).*

2013 and Small Blue in 2014. The Small Blue was recorded in the meadow area of the transect which has been specifically managed by the Woodland Trust to encourage butterflies.

In 2015 a second butterfly transect was established on the eastern side of Heartwood Forest incorporating the new arboretum.

Other invertebrates

There is nothing further to report on other insects, mainly due to shortage of resource. It is hoped to conduct a survey of moths.

10. Mammal monitoring

Small mammals

Small mammal trapping is part of the extensive wildlife monitoring being undertaken by volunteers on the site, presenting an opportunity to assess any changes in species composition and occurrence in specific habitats during the transition from arable to grassland to scrub to woodland.

Trapping is performed using Longworth traps which are the standard trap used to humanely live-capture mice, voles and shrews. The traps are initially deployed for a few days in 'pre-bait' mode whereby animals can enter and leave the trap without being caught. This enables them to find the traps, sample the food, overcome any wariness and hopefully return in good numbers when the traps are eventually primed.

The traps are baited with a range of foodstuffs: mixed seed, peanuts, casters (blowfly larvae) for shrews, chopped apple and carrot, as well as dry hay for bedding. The traps are normally initially primed late in the evening, checked and reset in the early morning, checked and reset midday and possibly again later in the afternoon/evening. The overnight session tends to catch mainly the nocturnal species such as wood mice, whereas the morning session tends to catch the crepuscular and diurnal species, although there is some overlap. The welfare of the mammals is paramount and the time any animals are kept in the traps must be kept to a minimum. Shrews in particular have a very high metabolism and are susceptible to stress, so as a result the surveyor needs to be licensed in order to use these traps. When an individual is caught in a trap it is identified to species, sexed, aged (if possible), and weighed.

Trapping has been performed at Heartwood Forest annually, since October 2012, with ten traps positioned in six different habitats across the site over one night and morning in September or October each year. This is the time of year when small mammal populations are at their peak. The six locations were chosen to represent the diversity of habitats found at Heartwood Forest and included woodland, woodland edge, hedgerow, naturally regenerating scrub, rough grassland with saplings planted in 2009 (Figure 14). Although assessing the population size of small mammals is impossible using the current sampling design, it may still be possible to identify changes in the species composition and occurrence in specific habitats across the site between years using the data collected. Additional trapping sessions were undertaken in a smaller number of habitats, including Car Park 2 shown in Figure 14, in November 2013, August 2014 and December 2015 but this data has not been included here.

Overall, across all habitats and over all four years, the percentage capture rate was 50% overnight and 24% over the morning. The overnight capture rate increasing from 43% in 2012 to 67% in 2015 indicating a small increase in the numbers of nocturnal small mammals (specifically Wood Mice) over time. In 2015 the number of species caught was at an all-time high (Figure 15), indicating an increase in species richness across the site over time.

To date, seven species have been caught: Wood Mouse, Yellow-necked Mouse, Harvest Mouse, Bank Vole, Field Vole, Common Shrew and Pygmy Shrew. The numbers initially caught in the existing woodlands and hedgerows were generally higher than in the new meadows and natural regeneration area and it has been interesting to see if numbers in the latter would catch up over time. In the longer term, we will continue with the trapping in our six reference locations but will also continue to explore other parts of the site on an occasional basis. As trapping is a very time-consuming exercise, we also plan to obtain data using less labour-intensive methods such as the positioning around the site of 'reptile tiles' or baited tubes to obtain hair samples and maybe additional Harvest Mouse nest searches.

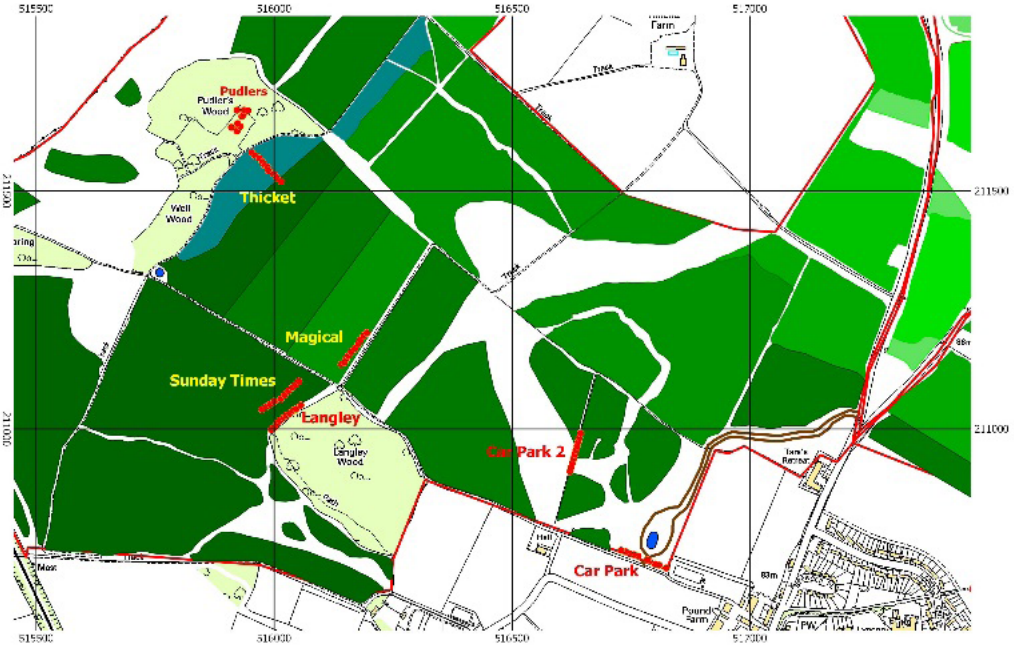

Figure 14: *Small mammal trapping locations at Heartwood Forest. The section labelled 'Car Park 2' no longer plays a part in the monitoring.*

Other mammals

There is evidence of the presence of many other mammal species at Heartwood Forest (Badgers, bats, Foxes, Stoats, Muntjac and Fallow Deer, Hares and Rabbits). However, given resource constraints, it has not been possible to systematically monitor any changes in their abundance.

Some checks have been made of Badger activities by noting active setts. The indications are that badger numbers are holding up but that old setts are being vacated and new setts established, possibly to avoid proximity with routes used by people and dogs.

A number of bat surveys were undertaken in 2013 across the site but have been suspended due to resource constraints. The numbers detected were low, with Common Pipistrelle giving the most frequent registrations (85%) but Soprano Pipistrelle, Noctule and Brown Long-eared Bats were also detected. The lack of water on site is again a constraint for bat populations. Bat surveys have had to stop due to lack of resources but it has been proposed that static bat detectors be purchased and placed around the site so that bat populations can be monitored remotely at frequent intervals.

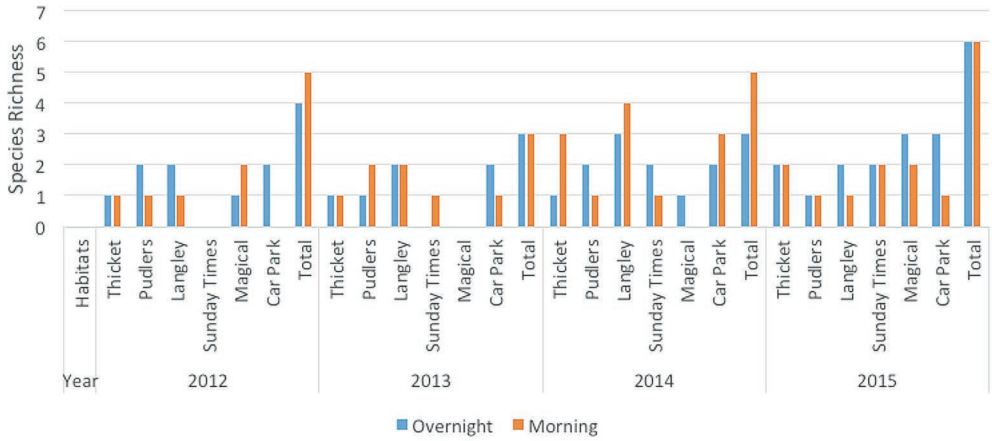

Figure 15: *Total number of small mammal species caught in each area between 2012 and 2015.*

Figure 16*: Harvest Mouse caught in a Longworth trap at Heartwood Forest before being photographed and released (photo Brian Legg).*

11. Other fauna monitoring

Reptiles and amphibians

No regular monitoring has yet been performed at Heartwood Forest. The only species currently known to be present is the Common Frog: spawn was found in the car park pond and a Common Frog was found in another small pond, heavily utilised by dogs. The utilisation of this pond by dogs will most likely prevent successful breeding. More ponds would be needed across the site for amphibians to become regular visitors and it is hoped that the wetland area planned for another part of Heartwood Forest will help in this respect.

No records of reptiles have been received either. A few reptile tiles were positioned in an area bordering Nomansland Common in 2015, but these have produced no records other than small mammals. In the next couple of years it is planned to put out a large number of reptile refugia around the site to investigate further. Given the lack of water on site, grass snakes are relatively unlikely, but slow worms may still be present. Perhaps Heartwood Forest could act as a reptile translocation site where reptiles that have to be moved from development sites can be provided for. This could reintroduce a number of reptiles that may have become extinct due to the previous use of the land, assuming suitable habitat can be maintained.

12. Flora

In 2012 transects were established to examine the flowering plants and ferns in the existing woodland and extending into the former arable land before tree planting (Smith *et al*, 2012). These were the focus for surveys in May and August 2015 which used a revised methodology to reflect the developing woodland. The abundance of plant species in sixteen 10x10m plots along the four 50m transects was recorded using the DAFOR scale. Two transects run from Langley Wood into newly planted areas; two run from Well and Pudler's woods into the natural regeneration area. Two notable finds this year are shown in Figures 17 and 18. The 2016 surveys in June and August will endeavour to list all plant species across Heartwood Forest, including the areas with existing transects, with a view to establishing some additional areas for monitoring (for example in the grasslands). We anticipate transect monitoring to continue every two years in the initial stages of tree establishment but this will be kept under review.

In 2014 mosses and liverworts were surveyed and we are grateful to Dr Mark Hill and Prof. Jeff Duckett who led a small group to record the bryophytes chiefly in the old woodlands. The number of species in these varied between 19 (Pismire Springs) and 27 (Round Wood). This provides a baseline for monitoring future colonisation of trees and the woodland floor in the new woodlands over time. The records have been submitted to the Hertfordshire Environmental Records Centre and to the National Biodiversity Network via the British Bryological Society.

Lichens

Lichens were surveyed at Heartwood Forest during 2012, in April and June. Sixty-one species were recorded, the vast majority being corticolous (found

Figure 17*: Rough Hawksbeard* Crepis biennis *– scarce in Hertfordshire generally but locally common in rough grassland at Heartwood Forest.*

Figure 18*: Southern Marsh-Orchid* Dactylorhiza praetermissa *– found for the first time at Heartwood Forest in 2016.*

on bark). For the purposes of the survey, species were listed for three main habitats where lichens occur; hedgerows (four lengths) and woodland edge and woodland interior at Round Wood, Pudler's Wood, Well Wood, Pismire Spring and Langley Wood. The woodland edge was defined as the outer line of trees or coppice stools, or the marginal zone of scrub where this was present e.g. on the north-west side of Pudler's Wood. As this was primarily a baseline survey, sample size was dictated by the length of the section of hedgerow, or the area and circumference of the woodlands. Hence samples were not standardised but still make an interesting comparison.

Lichens were recorded roughly up to a height of 2 to 2.5m for most species. A few fallen branches with their epiphytes still in reasonable condition made it possible to record some lichens originating from higher up, but foliose species typical of tree boughs such as *Parmelia sulcata* and the overall species richness of several of the woodlands is likely to have been under-recorded due to the inaccessibility of the canopy. The tree species on which the lichens were found was also recorded with the habitat details.

A brief investigation of the natural regeneration areas was made with the intention of charting the succession of lichens on the young trees. The saplings in the newly planted areas were too recent to have been colonised by lichens.

A simple method of recording relative abundance using the DAFOR scale was used. Hedgerows were dominated by species of eutrophic bark particularly *Xanthoria parietina* and *Physcia adscendens* which overall were also the most abundant species in Heartwood Forest. However a reasonable variety of lichens (38) had colonised the hedges including some which have only become widespread in Hertfordshire in recent years such as *Lecanora carpinea*, *Physcia aipolia* and *Ramalina fastigiata*.

The margins of the woodlands were similar to the hedgerows and had typical lichen assemblages of nutrient-enriched and smooth bark, the latter with the characteristic species *Lecanora chlarotera* and *Lecidella elaeochroma* which also achieved a high score on the frequency calculation. Large coppice stools on the edge sometimes had lichens favouring stable woodland environments such as *Cliostomum griffithii*.

The woodland interior generally had a lower coverage of lichens particularly in the dark areas of relic Hornbeam and Lime coppice. Overall, however, the number of species recorded for the woodland edge (48) and interior (45) were very similar. There was an absence of several more obligate acidophilus species such as *Parmelia saxatilis*. Of those species typifying lignum, only *Cladonia coniocraea* was recorded on tree stumps.

The tree species which hosted the greatest variety of lichens was Ash. The 45 species found on its bark accounted for 69% of the total of 61 recorded at Heartwood Forest and it had 50% more lichen species than the next richest tree Oak with 30. Other significant species were Hawthorn (25), Field Maple (22) and Elder (21). The richness of lichens on Ash

Figure 19*: Low-growing Pedunculate Oak bough supporting several species of lichen (photo Andrew Harris).*

emphasises the potential impact of the Ash die-back fungus *Chalara fraxinea* on the wider ecosystem and the importance of records for assessing this. Oak, with the next highest number (and probably under-recorded due to inaccessibility of the canopy), was mainly a woodland standard, where it would benefit from humidity from transpiration from the surrounding trees.

Heartwood Forest is generally an exposed site and the remnant areas of ancient woodland are rather small in area, so it has been open to the effects of environmental factors such as sulphur dioxide pollution in the past and enrichment from nitrogen from farming etc. This is probably the reason why no indicators of ecological continuity were found. Lichens in this category are often tolerant of more shade than other species but are sensitive to pollution. An absence of some species associated with acidic bark such as *Parmelia saxatilis* may be due to eutrophication.

The non-standard size of the samples and qualitative nature of the frequency calculations lack the scientific rigour of a quantitative method necessary for monitoring. The focus of this survey was however to provide baseline data and to give a general impression of the lichen composition at Heartwood Forest. A more precise sampling method of a few key species could be repeated say every 5-10 years to monitor changes.

Though no rarities were found, Heartwood Forest is of interest precisely because its lichens are unremarkable. They are typical of many woodlands and hedgerows in Hertfordshire. So it is a good example of the current state of woodland lichens in Hertfordshire against which future changes, such as an increase in woodland cover, can be compared.

Fungi

Fungi forays were held in Langley and Well and Pudlers woods in autumn 2013, 2014 and 2015 by the Hertfordshire and Bedfordshire Fungus Group. The 94 species found on 15 November 2015 are listed on the HNHS website. One of interest was *Clitocybe houghtonii* which, from above, looks like one of those fairly nondescript off-white *Clitocybes*. It has pale pink gills and is supposed to smell of tomatoes. It is nationally uncommon but turns up quite often in Hertfordshire.

13. Soil and worms

In 2012-2013, soil acidity, soil carbon and earthworm counts were taken and published (Lydiate & Helm 2014). This study provided a baseline assessment of a number of soil quality variables across three different habitats. The habitats were selected to provide a basic understanding of how the land was prior to the study (unplanted post-agricultural land – habitat *U*), how the majority of the site is currently (recently planted woodland – habitat *P*) and the possible eventual climax habitat of the site (Ancient Semi-Natural Woodland (ASNW) – habitat *W*). Prior to sample collection and analysis and earthworm surveys, desk study and personal communications with the previous land manager provided contextual knowledge on past land management practices. This showed extensive agro-chemical and fertiliser applications typical of an arable farm of this type in the UK for at least the last 10 years.

Analyses of soil samples showed that, overall, soil quality appears to be developing and improving from post-agricultural land to woodland, with electrical conductivity levels seen to show a closer relation between recently planted woodland and ASNW. Currently, however, the recently planted soils were still quite different from the ASNW soils. Soil pH (acidity/alkalinity) was found to be marginally higher in habitat P than U, but still significantly different from W. Whether this is a successional response to increased grass cover, higher abundance of earthworms, anomalous outliers in samples collected, or possibly several other factors cannot be said for certain without further monitoring. Earthworm abundance was higher in habitat *P* (see Table 4), showing that soil conditions for this habitat are presently more favourable than the unplanted ex-agricultural habitat. A possible link can be seen here with the higher levels of soil organic matter, a factor likely to increase as the woodland develops over time.

Earthworm counts were also taken in May 2013 from five sites at 5m intervals in the Orchard in accordance with the OPAL technique using a mustard soak.

Future plans are to expand on the 2012-2013 study in two ways:

1. Look for long term soil variations using the previous study (Lydiate & Helm 2014) as a baseline and using samples taken at the same locations. Earthworm

Table 4*: Summary of earthworm counts in the three habitat types.*

Worms	Overall abundance (per 20cm^3)		
	Woodland (W)	Planted (P)	Unplanted (U)
Total immatures	0	91	21
Total adults	0	10	28
Total worms	0	101	49

counts were planned for 14 May 2016. Soil Carbon monitoring currently seems too expensive and time-consuming but may become cheaper if soil colour-based spiking monitors are developed.

2. Build a map of soil acidity across the site by sampling at some or all of the locations used for sapling survival measurements. This should enable correlation of growth rates with soil acidity. It might be interesting to confirm or otherwise the suggestion in the Rothamsted long term carbon sequestration studies that major differences in rates are due to the different acidities of the Broadbalk and Geesecroft sites. It might also enable correlation with which species prevail.

Soil samples taken in 2011 and stored at Rothamsted, have not been investigated further.

14. Acknowledgements

The Monitoring Group would like to express its appreciation to Louise Neicho, Woodland Trust Site Manager (Central England), for her continued support and enthusiasm for this work. Thanks also to John Hunter for his support and wise counsel on many matters.

Monitoring co-ordination: Brian Legg, Ken Smith and Agneta Burton.

Sapling survival: Brian Legg, Ken Smith and Linda Smith with support from Alla Mashanova who processed the data, and Agneta Burton, Albert Callewaert, Edric Williams, Ian Flack, Jay Wilson, Jim Paterson, Katie Gallagher, Linda McArdell, Pete Cutforth, and Tim Wright.

Birds: Survey work by Ken and Linda Smith and Barn Owls, etc. by Colin Shawyer.

Butterflies: Andrew Steele with support from Geoff Horn, Ian Flack, Jim Paterson and Malcolm Hull.

Small mammals: Chantal Helm and Ian Flack with support from Bob Carter, Brian Legg, Geoff Horn, Jane Everett, Jay Wilson, Pete Cutforth and Veronica Carnell.

Bats: Chantal Helm and Tanya Dickson.

Flora: Agneta Burton and Ian Denholm with support from Alla Mashanova, Andrew Harris, Claudia Harflett, Jean Williamson, Jenny Spurgeon, Linda McArdell, Ruth Graham and Laura Gravestock who led the initial flora survey.

Lichens: Andrew Harris and Paula Shipway.

Fungi: Kerry Robinson.

Worms and soils: Agneta Burton with support from Ashley Lydiate, Chantal Helm, Elise and Pete Cutforth, Ian Flack, Ken and Linda Smith and Tanya Dickson.

Many other volunteers, too many to name here, have assisted with one or more of the monitoring activities.

15. References

Smith, L., *et al.* (2012) Long-term monitoring at Heartwood *Transactions of the Hertfordshire Natural History Society* 44(1) 56-67.

Butterfly Conservation, UK Butterfly Monitoring Scheme website http://butterfly-conservation.org/

Wood, A. (2016). *Hertfordshire & Middlesex Butterflies for the year 2015*. Hertfordshire and Middlesex Branch of Butterfly Conservation.

Smith, C., *et al.* (2009). The Lichens of Great Britain and Ireland, London: British Lichen Society.

British Lichens Website species gallery: http://www.britishlichens.co.uk/speciesgallery.html

Lydiate, A. & Helm, C. (2014). A soil quality comparison from agriculture to afforestation in Heartwood Forest *Transactions of the Hertfordshire Natural History Society* 46(2) 141-149.