

Report on survey of Western Hemlock PAWS

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Summary

Text in red provides a summary of the section which follows.

Western hemlock PAWS in south-east England were surveyed to record the amount of natural regeneration present and investigate relationships with site characteristics including canopy cover, parent trees and the ground flora.

All sites had some canopy cover with birch, oak, beech and western hemlock being the most common of the 25 species of overstorey tree recorded. Saplings were present at all sites, these were predominantly native species with hazel, birch and beech most common but the total number rarely exceeded 300 ha⁻¹. Shrubs were generally infrequent but holly was the most common. Across all sites 21 species of tree were regenerating with most sites having several thousand seedlings per hectare the majority being native broadleaves with birch, oak, ash and beech being most common. Western hemlock was regenerating on most sites being recorded as both saplings and seedlings, but numbers were usually much lower than for native species. Most seedlings were small with few exceeding 50 cm in height.

Estimates of stocking were made based on the sizes and numbers of seedlings and saplings. Most sites were partially stocked with regeneration of native species but this was usually less than 50 % of the area; the proportion of any site stocked with western hemlock was usually very low. Although seedlings and saplings of timber species including ash, beech and oak were present, less than 10 % of most sites was restocked with timber species.

The presence of nearby parent trees was the most important site character related to both the presence and abundance of seedlings.

A simple method to determine the percentage of a site which is stocked by naturally regenerating trees is described.

Introduction

1. The aim of this survey was to test a simple method to assess the amount and distribution of natural regeneration on western hemlock PAWS that would will give an indication of whether each site was suitably stocked and also help identify a general sampling method to assess the proportion of a site that is stocked.
2. The data collected also allowed investigation of relationships between some site characteristics and, the occurrence and abundance tree seedlings.
3. As the method only assessed tree seedlings and broad classes of vegetation, it cannot be used to evaluate whether the wider aspects of PAWS restoration have been achieved.

Methods

Twentyone western hemlock PAWS in south-east England forest district were surveyed.

Site selection

4. The sites were selected from western hemlock PAWS in south-east England using information from the sub-compartment database and the local knowledge of the beat forester.
5. Four main categories of western hemlock PAWS were identified: beech/hemlock (BE/WH), oak/hemlock (OK/WH), mixed broadleaf/hemlock (MB/WH) and pure hemlock stands (WH). Five or six sub-compartments of each type were selected, on about a third of these the western hemlock had not been felled.
6. These sites were classified into 3 stand types according to the current crop and are shaded differently in the tables:

Western hemlock felled

- Open sites were those derived by clearfelling of stands originally described as pure western hemlock.

- Broadleaved sites were those stands comprising a number of hardwood species that were originally mixtures of hardwoods and western hemlock from which the latter had been removed.

Western hemlock standing

- Hemlock sites – no recent felling had taken place at these sites which have a crop of western hemlock either pure or in mixture with hardwoods.

In all tables light grey shading indicates sites from which western hemlock has been felled but there is canopy cover from broadleaved trees; dark grey indicates sites where western hemlock remains standing; and unshaded areas indicate open clearfelled sites that were originally pure western hemlock.

7. All sites were ≥ 0.5 ha and in order to avoid edge effects larger compartments with a more uniform shape were favoured. Where sub-compartments of a similar species composition were in close proximity in the same forest, the largest sub-compartment was chosen. To allow comparison between felled and unfelled sites, those where western hemlock remained standing were matched as closely as possible to those from which it had been felled. The 21 sites surveyed are listed and briefly described in Table 1.

Table 1 Crops on site before and after felling, area and soil type of sites assessed.

Site	Sub-cpt	site no	Original Crop	Current crop	Age	Year felled	Area (ha)	Soil Type
Western hemlock felled								
Bushey Leaze	596e	1	BE / WH	BE	52	2006	2.3	Base rich brown earth
Bushey Leaze	596c	2	BE / WH	BE	52	2006	3	Base rich brown earth
West Wood	3517b	3	BE / WH	BE	47	2005	4.4	Rendzina
Chiddingfold	221b	4	MB / WH	MB	?	2005	2.5	Surface-water gley
Shabbington	4225a	5	MB / WH	MB	67	2005	5	Surface-water gley
Whitley Block	302h	6	MB / WH	MB	51	2005	0.5	Surface-water gley
Chiddingfold	227a	7	OK / WH	OK	38	2007	4	Surface-water gley
Micheldever	558a	8	OK / WH	OK	79	2003	7.4	Base rich brown earth
West Walk	3244b	9	OK / WH	OK	78	?	1.2	Surface-water gley
Ampfield	3401a	10	WH	Open	?	2005	3	Surface-water gley
Ampfield	3415a	11	WH	Open	?	2005	5	Surface-water gley
Micheldever	558d	12	WH	Open	?	2003	0.6	Base rich brown earth
Whitley Block	301a	13	WH	Open	?	2005	4.5	Surface-water gley
Western hemlock standing								
Home Hut	3630d	14	BE / WH	BE / WH	59/33	No felling	0.9	Surface-water gley
Stoke Park	3656a	15	BE / WH	BE / WH	49/49	No felling	3.3	Base rich brown earth
Ampfield	3403a	16	MB / WH	MB / WH	37/?	No felling	5	Surface-water gley
Ranmore	436b	17	MB / WH	MB / WH	39/?	No felling	3.7	Base rich brown earth
Chiddingfold	256a	18	OK / WH	OK / WH	97/47	No felling	2.2	Surface-water gley
Chiddingfold	218a	19	OK / WH	OK / WH	87/46	No felling	2.9	Surface-water gley
Alice Holt	68a	20	WH	WH	43	No felling	3	Surface-water gley
Redlands	426d	21	WH	WH	42	No felling	3.5	Typical podzol

Age = age of current crop; ? = unknown. Current crop – as described in the sub-compartment database.

Survey procedures

Assessments were made in a maximum of 50 temporary plots placed systematically across each site

8. During summer 2007 a systematic procedure based on that described in Kerr *et al*¹ was used to assess temporary 30 x 30 m plots and 2 x 2 m quadrats positioned at the centre of the plots. The plots and quadrats were placed at regular intervals on transects distributed evenly across the site (Figure 1).

Location of Quadrats

The distances between transects and quadrats was determined using the following formula:

$$S = 100 \times \sqrt{\frac{A}{n}}$$

S = spacing between plots on transects (m), and distance between transects (m) within each stratum. All distances were measured by pacing.

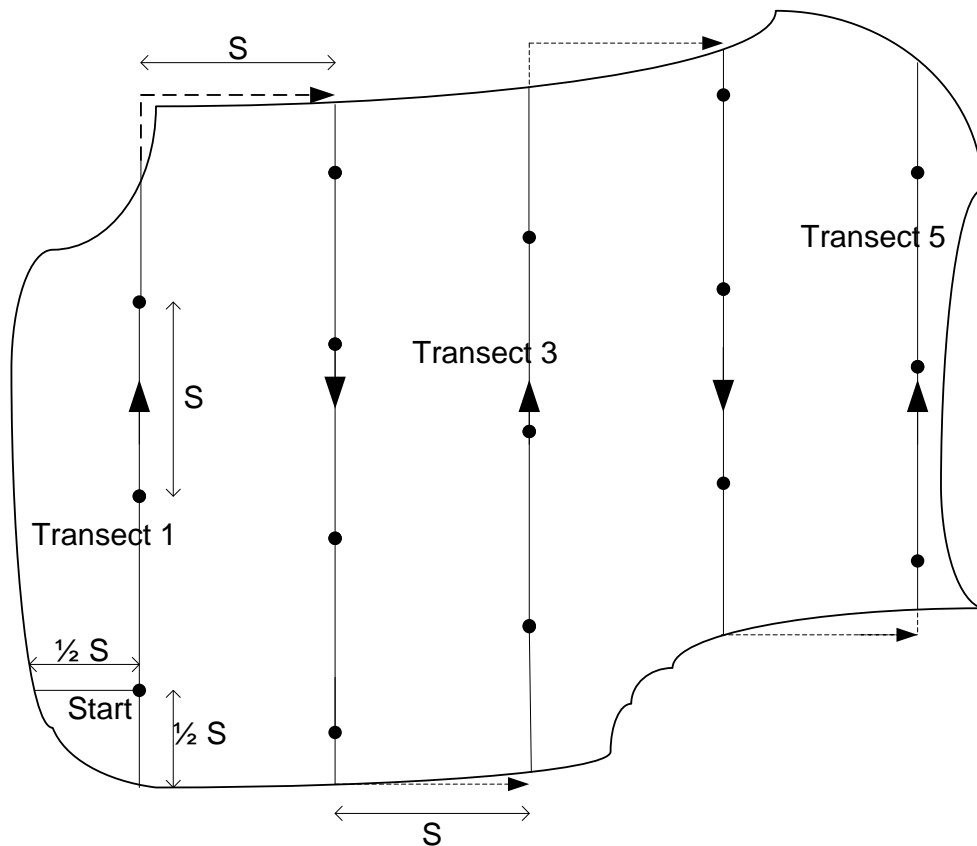
A = area of the site in hectares was taken from the sub-compartment database and adjusted at the site visit after studying the stock map.

n = the number of plots needed at each site.

9. The number of quadrats varied with site. The initial target number for assessment at each site was 50, but as this number could not always be achieved in the one day allowed for assessment of each site it was reduced to 35. However even this number could not be achieved on those sites with significant amounts of bramble and when weather conditions were poor.

¹ Kerr, G., Mason, B., Boswell, R. and Pommerening, A. (2002). Monitoring the transformation of even-aged stands to continuous cover management. FCIN 45, Forestry Commission, Edinburgh.

Figure 1 Positioning the transects and quadrats.



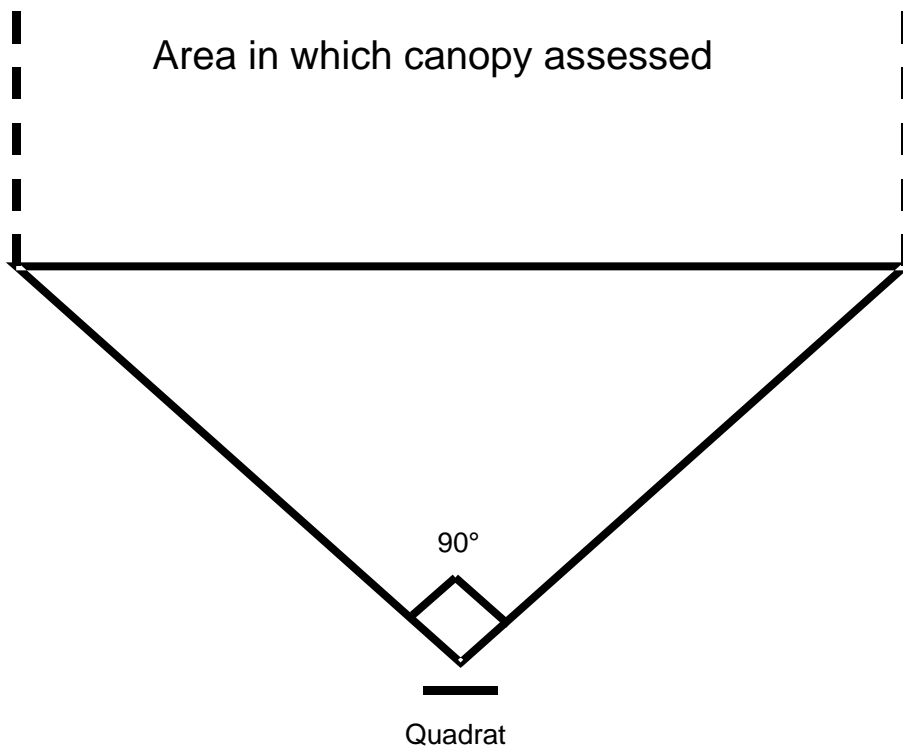
10. In order to allow greater accuracy in positioning, the transects were laid out across the shortest dimension of the site using a compass bearing which was taken from the map.
11. In order to exclude the scrub and vegetation outside the sub-compartment the edge of the site bordering a ride or path was defined as the boundary.
12. The first transect was not coincident with any edge of the site but ran along a bearing that was approximately parallel to the edge and between 10 and $S/2$ m away (to try to eliminate edge effects and avoid quadrats straddling the boundary). All subsequent transects were parallel to the first and were S m apart. The centre of the first quadrat was $S/2$ m along the first transect. Subsequent quadrats were separated by distances of S m along the transects. When the edge of the sub-compartment was reached, the distance from the last quadrat was recorded and carried over to the start of the next transect.

Assessments

Several characteristics of the stand, ground flora, and seedling and sapling regeneration were recorded including species present and percentage cover of the overstorey, cover and height of the ground flora vegetation, and species and heights of the seedlings regenerating.

13. Once the location of the quadrat had been determined it was temporarily marked out using ranging rods; one was placed along the line of the transect with a second perpendicular to the transect with 1 m of the rod each side of the transect line.
14. The general characteristics of each stand was determined by an assessment of the 30 x 30 m plots; in order to describe the sites in greater detail more intensive assessments were made of the 2 x 2 m quadrats.
15. The following assessments were made in the 30 x 30 m plots:
 - Canopy trees – the dominant over and understorey species within the canopy.
 - Over and understorey stocking – the number of trees present was counted. This was not collected in quadrats < 10 metres from the edge of the site.
 - Sapling density – the number of saplings (stems > 1.3 m in height but less than 7 cm dbh) were estimated using the following class intervals: 0, 1, 2, 3, 4, 5...30, 31-40, 41-50...100. Native and non-native species were recorded separately. The species present were noted.
16. The following assessments were made in the 2 x 2 m quadrats:
 - Beneath a tree – Location of the quadrat, whether or not it was under a tree's canopy.
 - % Canopy Cover – visual assessment of canopy cover around the quadrat within an area determined by the base of an inverted imaginary cone with an apex of 90° in section (Figure 2). The following class intervals were used 0, 1-10, 11-30, 31-60, 61-90, > 90.
 - Nearest tree – the distance to the nearest tree (m) from the centre of the quadrat using the following class intervals: < 2, 2-5, 6-10, 11-30, 31-50, > 50.

Figure 2 Estimation of canopy cover.



- Percentage cover and height of each of the following categories of vegetation: shrubs, bramble, grasses/sedges, herbs, rushes, bracken. Shrub species included, broom, gorse, elder and holly despite its occasional presence as a substantial canopy tree. Hawthorn and hazel were recorded as trees. Herbs included ferns other than bracken. Cover was recorded in the following class intervals: 0, 1-10, 11-30, 31-60, 61-100 %. In order to exclude unusually tall emergent stems the height of vegetation was recorded as the height below which 80 % of the vegetation type grew. The following height class intervals were used: < 10, 10-25, 26-35, 36-50, 51-75, 76-100, 101-150, 151-200 cm.
- Saplings – the species and total number of saplings (stems > 1.3 m in height but less than 7 cm dbh) present were counted and their average height estimated in 50 cm class intervals.
- Seedlings – for each species the number of seedlings (\leq 130 cm tall and < 7 cm dbh) were counted and the height of the tallest measured. The number was

recorded as: 0, 1, 2, 3, 4, 5, 6+. Height (cm) was recorded using the following class intervals: 0-5, 6-10, 11-15, 16-20, 21-25, 26-35, 36-50, 51-75, 76-100, 101-130.

- Regeneration by coppice shoots – this was rare and was included in either seedling or sapling numbers. Separate clusters of shoots were counted as single individuals.

Data presentation and analysis

17. Data are presented in tables. Details of any statistics are kept to a minimum, but where it is thought necessary further information is provided in Appendix 6.

Results

Overview of site characteristics

There was great variation between sites

18. A total of 21 sites were assessed with areas that varied between 0.5 and 7.4 ha (Table 1). The age of the broadleaved trees varied between 37 and 97 years; the western hemlock was typically 40-50 years-old. The sites from which the western hemlock had been removed were felled a maximum of 4 years before the survey. Most of the sites have soils which are surface water gleys with the majority of the remainder being base rich brown earths.
19. The number of transects surveyed varied between 4 and 13, and the number of quadrats assessed between 19 and 50. On a majority of sites the target number of either 35 or 50 was not achieved, but on only one site were fewer than 20 assessed (Table 2).
20. There was great variation between sites, the most notable are summarized below:
 - The western hemlock at Sites 16 and 19 had suffered significant windthrow.

- Although the terrain on the majority of sites was flat, both Site 11 and Site 15 had a small stream or ditch running through the site and the ground sloped down towards these.
- The presence of stumps and seedling regeneration suggested that Lawson's Cypress had also been planted at Site 5.
- Site 6, a mixed broadleaf site at Whitley Block, had a high density of large birch saplings that were almost certainly present before the western hemlock was removed.
- The ground flora at Site 8 was dominated by a tall, dense thicket of bramble.
- Site 12 was unusual in comparison with others as the brash was stacked in several large piles rather than being distributed across the site.
- The western hemlock at Site 7 was felled only 2 weeks before surveying. The remaining tree canopy was sparse and there was little vegetation or regeneration, but a high cover of brash and deadwood.

Canopy trees

All sites had some canopy trees with canopy cover varying between 10 and 90 %. Birch, oak, beech and western hemlock were the most common of the 25 species recorded.

21. All sites, even those open sites which were clearfelled western hemlock, had some over/understorey trees remaining. Felled sites that had been pure western hemlock had about 10-100 stems ha⁻¹, the remainder had about 100-300 stems ha⁻¹ (Table 2).
22. Most stands had canopy covers of 60 % or more, but on the clearfelled sites it was 10-30 % (Table 2).
23. A total of 25 species of over and understorey trees were recorded during the survey, 7 of which were non-native conifers. However, only birch, oak, beech and western hemlock were seen on more than half of the 21 sites (Table 3).
24. The total number of canopy tree species recorded at any site varied between 1 in an unfelled stand of western hemlock, to 10 at a site that had been clearfelled.

There was no obvious simple relationship between the total number of species present, and the original and current crops (Tables 1 and 4). For both stands from which western hemlock had been thinned and those in which it remained, the most frequent canopy trees in the sub-compartment generally reflected the descriptions in the sub-compartment database (Tables 1 and 4).

Table 2 Number of transects and quadrats assessed at each site, stocking density of over and understorey trees and saplings on 30 x 30 m plots, canopy cover of trees, and proportion of quadrats beneath the canopy.

Site	subcpt	site no	Tran	Quad	Beneath	Trees		Saplings	
						Canopy	Stems	Native	Non-native
Western hemlock felled									
Bushey Leaze	596e	1	8	34**	0.91	90	234	8	<1
Bushey Leaze	596c	2	6	42	0.93	90	207	6	<1
West Wood	3517b	3	9	50	0.76	60	205	47	0
Chiddingfold	221b	4	4	29**	0.41	30	100	118	19
Shabbington	4225a	5	6	29**	0.48	60	310	105	43
Whitley Block	302h	6	5	19**	0.89	90	97	907	0
Chiddingfold	227a	7	8	33**	0.64	60	145	23	4
Micheldever	558a	8	5	24*	0.63	60	94	32	176
West Walk	3244b	9	7	30**	0.63	60	71	619	1
Ampfield	3401a	10	11	50	0.34	30	87	29	7
Ampfield	3415a	11	5	35	0.06	10	7	340	42
Micheldever	558d	12	8	50	0.18	30	17	12	36
Whitley Block	301a	13	5	30**	0.07	10	23	261	4
Western hemlock standing									
Home, Hut,	3630d	14	13	38	0.79	60	134	41	0
Stoke Park	3656a	15	13	35	1.00	90	292	18	18
Ampfield	3403a	16	7	34**	0.85	90	110	30	11
Ranmore	436b	17	12	35	0.97	90	199	22	6
Chiddingfold	256a	18	6	29**	0.93	90	179	110	10
Chiddingfold	218a	19	3	21**	0.76	60	202	221	149
Alice Holt	68a	20	7	34**	0.94	90	177	19	215
Redlands	426d	21	7	30**	0.93	90	281	4	17

Tran = number of transects; Quad = number of quadrats; Beneath = proportion of quadrats located beneath the canopy of a tree; Canopy = median % canopy cover; Stems, Native and Non-native = mean number of stems / ha. * = less than target of 50; ** = less than target of 35.

Saplings in 30 x 30 m plots

Saplings were present at all sites and there were generally more native than non-native species, 23 species were seen with hazel, western hemlock, birch and beech being most common. In many cases the most frequent species differed from those in the canopy.

25. Saplings were present at all sites and there were usually greater numbers of native than non-native species. The mean number of native and non-native saplings varied from 4-907 and 0-215 respectively (Table 2). The percentage of non-native saplings varied between 0 and 90 %.
26. A total of 23 different species of sapling were recorded, 6 of which were non-native conifers. The only species seen on 10 or more of the 21 sites were hazel, western hemlock, birch and beech (Table 3).
27. The total number of species recorded as saplings at any site, either native or non-native, varied between 1 and 10 for site numbers 12 and 20 respectively (Table 4). Western hemlock was always the most frequent non-native species of sapling found and, in general, birch was the most frequent native sapling species.
28. At many sites the most frequent native species of saplings regenerating differed from the most frequent species found in the canopy (Table 4).

Shrubs

Shrubs were infrequent with holly being most common.

29. The presence of shrubs was only recorded in the 2 x 2 quadrats: they were generally uncommon.
30. Only 8 species of shrubs were seen, this included laurel and rhododendron which are non-native species, and holly which was also seen as a canopy tree and a sapling. Holly, broom and gorse were recorded at the most sites (Table 3).
31. Only 2 sites had more than 3 shrub species. Holly was usually the most frequent species (Table 4).

Table 3 Number of sites where native and non-native species were present as trees, saplings and shrubs, and total numbers of species recorded.

Native species	Canopy trees	Saplings	Shrubs
Trees			
Apple	1	1	
Ash	9	9	
Aspen		3	
Beech	13	10	
Birch	15	16	
Common alder	2	2	
Hawthorn	2	6	
Hazel	9	18	
Hornbeam	1	1	
Oak	14	5	
Poplar	2	3	
Rowan	1	7	
Sweet chestnut	6	4	
Sycamore	2	5	
Unidentified	1		
Wild Cherry	2		
Wild service tree	2		
Yew	2	1	
Shrubs			
Blackthorn			1
Broom			8
Elder			1
Gorse			4
Holly	2	3	14
Viburnum			1
Total number of native species	19	17	6
Non-native species			
Trees			
Corsican pine	2		
Douglas fir	3	1	
Fir	1	1	
Lawson's cypress		1	
Norway spruce	2	1	
Pine	1		
Scots pine	2		
Western hemlock	11	18	
Western red cedar		1	
Shrubs			
LAU			1
RHO			1
Total number of non-native species	7	6	2

Poplar, Sweet chestnut and Sycamore are considered to be native; Pine was not identified to species; shrubs were recorded in 2 x 2 m quadrats; canopy trees and saplings in 30 x 30 m plots.

Table 4 Total number of over/understorey, sapling and shrub species seen and the most frequent species recorded in the 30 x 30 m plots at each site.

Site	Sub-cpt	No.	Over/Understorey		Native saplings		Non-native saplings		Shrubs	
			Total	Freq spp	Total	Freq spp	Total	Freq spp	Total	Freq spp
Western hemlock felled										
Bushey Leaze	596e	1	2	BE	4	-	1	-	0	-
Bushey Leaze	596c	2	3	BE	6	-	1	-	1	-
West Wood	3517b	3	4	BE	7	SYC, BE	0	-	0	-
Chiddingfold	221b	4	5	OK, BI	5	HZL, BI	1	WH	2	BRM, HOL
Shabbington	4225a	5	9	BI, OK, AH	4	HZL, BI, AH	2	WH	0	-
Whitley Block	302h	6	6	BI, HZL	2	BI	0	-	0	HOL
Chiddingfold	227a	7	8	OK, WH	6	BI, HZL	2	WH	0	-
Micheldever	558a	8	2	OK	3	-	1	WH	1	HOL
West Walk	3244b	9	3	OK	7	BI, HZL, ROW, HOL	1	-	3	HOL
Ampfield	3401a	10	6	BI, OK	5	BI	2	WH	2	HOL
Ampfield	3415a	11	6	BE, SC	5	BI, ROW	1	WH	3	GOR, BRM, HOL
Micheldever	558d	12	1	OK	0	-	1	-	1	-
Whitley Block	301a	13	10	BI, AH, OK	7	BI, FM	1	WH	1	HOL
Western Hemlock standing										
Home Hut	3630d	14	7	BE, OK, WH, BI	7	HZL, BI, BE, WL	0	-	2	-
Stoke Park	3656a	15	7	WH, BE, SC	4	BE, HZL	2	WH	1	HOL
Ampfield	3403a	16	8	WH, AH, BE, OK	6	BI, WL, HZL	1	WH	2	HOL
Ranmore	436b	17	7	WH, OK, BE	6	BI	1	WH	1	HOL
Chiddingfold	256a	18	8	WH, HBM, HZL, AH	4	BI, HZL	1	WH	1	HOL
Chiddingfold	218a	19	6	WH, OK, HAW	5	HZL, BI	1	WH	2	HOL
Alice Holt	68a	20	5	WH	8	HZL	2	WH	1	HOL
Redlands	426d	21	1	WH	2	-	1	WH	2	-

No. = Site number; Total = total number of species seen at each site; Freq spp = species that were seen on > 10 % of plots in decreasing order; - = no species > 10 %.

Saplings in 2 x 2 m quadrats

The number of species seen was similar to that for the large plots with birch, western hemlock and hazel being most common. Average height was 150-200 cm.

32. These data are more accurate than those for the 30 x 30 m plots as all saplings were counted rather than the numbers being estimated when sapling numbers were high.
33. The number of species present at any site varied between 0 and 7, and overall there were similar numbers of species at sites where western hemlock had been felled and where it remained standing (Table 5).

Table 5 Total number of species present as saplings and the most frequent species seen in 2 x 2 m quadrats.

Site	Site no.	No. species	Native	Non-native
Western hemlock felled				
Bushey leaze	1	0		
Bushey leaze	2	2		
West Wood	3	2		
Chiddingfold	4	4		WH
Shabbington	5	2		
Whitley Block	6	2	BI, HZL	
Chiddingfold	7	1		
Micheldever	8	1		WH
West Walk	9	2	BI	
Ampfield	10	1		
Ampfield	11	3	BI	
Micheldever	12	1		
Whitley Block	13	7	BI	
Western hemlock standing				
Home Hut	14	1		
Stoke Park	15	0		
Ampfield	16	3		
Ranmore	17	2		
Chiddingfold	18	5	BI	
Chiddingfold	19	4	BI	
Alice Holt	20	2		WH
Redlands	21	0		

Native and non-native are the species that were seen on > 10 % of quadrats at each site in decreasing order.

34. Over all sites saplings of 10 species were seen. Birch and western hemlock were recorded on 9 sites, but beech and hornbeam on only 1. The most common species of saplings were birch, western hemlock and hazel which were found at 8 or more sites. However their overall frequencies was < 10 % (Table 6).
35. The average height of saplings of most species was 150-200 cm, the only species for which this was exceeded was hornbeam that occurred at one site where it was 500 cm tall and probably of coppice origin.

Table 6 Total number of sites on which saplings of each species was recorded, the overall percentage of quadrats with the species and the median height (cm).

Species	Sites	Frequency	Height
ASP	4	0.4	150
BE	1	0.1	200
BI	9	9.0	150
HAW	3	0.3	150
HB	1	0.1	500
HZL	8	1.6	200
MA	3	0.4	150
SYC	2	0.7	200
WH	9	3.1	150
WIL	4	0.1	150

Sites = no. sites on which species was present; Frequency = percentage of all 2 x 2 quadrats observed on which the species occurred.

Seedlings in 2 x 2 m quadrats

Birch, oak, ash, beech and western hemlock seedlings were the most common of the 21 species recorded. Most seedlings were small with few exceeding 50 cm in height.

36. The number of species recorded as seedlings at any site varied between 3 and 11, and there were generally similar numbers of species present as seedlings across all site types (Table 7). The most common native species were birch, ash, and oak with most others occurring at frequencies of less than 10 %. There were few non-native seedlings other than western hemlock.

Table 7 Total number of species present as seedlings and the most frequent species recorded on 2 x 2 m quadrats at each site.

Site	Site no.	No. species	Native	Non-native
Western hemlock felled				
Bushey leaze	1	3	AH, BE, SYC	
Bushey leaze	2	8	AH, BE, SYC, BI	
West Wood	3	4	AH, BE	
Chiddingfold	4	9	BI, OK, AH	
Shabbington	5	9	BI, AH, OK	WH, LC
Whitley Block	6	3	BI, AH	
Chiddingfold	7	7	BI, OK	WH
Micheldever	8	6	OK	
West Walk	9	6	BI, OK	
Ampfield	10	11	BI, OK	Pine, DF, WH
Ampfield	11	9	BI, OK	
Micheldever	12	4	BI, OK	WH
Whitley Block	13	6	BI, OK	WH
Western hemlock standing				
Home Hut	14	9	BI, OK, BE, HZL	
Stoke Park	15	7	BI, AH	WH
Ampfield	16	9	AH, BI, OK	WH
Ranmore	17	8	AH, BI	WH
Chiddingfold	18	6	AH, OK, HB, BI	WH
Chiddingfold	19	7	OK, AH, HZL, BI,HN	WH
Alice Holt	20	11	OK, BI, AH	WH
Redlands	21	4		WH

Native and non-native are the species that were seen on > 10 % of quadrats in decreasing order.

37. Of the 21 species recorded as seedlings only 5 – birch, oak, ash, beech and western hemlock – occurred on more than half of the sites. These species were seen on 39 %, 17 %, 22 %, 10 % and 16 % of the quadrats respectively (Table 8).
38. The same 5 species tended to be most abundant with greater numbers of seedlings being found; for some quadrats the number was ≥ 6 . However for most species the average number of seedlings present on quadrats on which the species occurred was < 2 (Table 8).
39. Many of the seedlings were small and the tallest seedlings of most species were less than 50 cm in height. Birch was a notable exception as the average height of

the tallest seedlings was > 50 cm on about half of the sites and they were taller on sites from which western hemlock had been felled (Appendix 1).

Table 8 Number of sites with seedlings of each species and number of 2 x 2 m quadrats with different numbers of seedlings.

Species	Sites	%Q	Number of seedlings						Average
			1	2	3	4	5	≥ 6	
Native									
BI	20	39	54	20	23	13	14	152	*
OAK	17	17	75	18	12	3	2	12	1
AH	16	22	41	24	12	9	9	64	4
BE	12	10	46	11	2	5	0	6	1
HZL	9	3	15	3	2	0	0	1	1
WIL	9	2	12	0	2	2	0	1	1
SYC	7	2	10	3	1	2	1	0	1
POP	5	1	1	1	1	0	1	4	5.5
HAW	4	<1	5	0	1	0	0	0	1
HBM	4	2	3	3	0	2	0	5	4
SC	4	<1	5	1	0	0	0	0	1
YEW	4	<1	4	0	0	0	0	0	1
ROW	3	<1	4	0	1	0	0	0	1
FM	2	<1	1	0	0	0	0	1	3.5
BLKTH	1	<1	0	1	0	0	0	0	2
WC	1	<1	0	1	0	0	0	0	2
Non-Native									
WH	17	16	50	21	8	7	4	22	2
PINE	5	2	12	1	0	0	1	0	1
FIR	3	<1	1	1	0	0	1	1	3.5
DF	1	<1	4	2	0	1	0	0	1
LC	1	<1	1	1	1	0	0	0	2

% Q = percentage of all 2 x 2 quadrats observed on which the species occurred; Number of seedlings = the number of seedlings present on each 2 x 2 quadrat; Average = median number of seedlings on quadrats on which the species was present; * = could not be calculated due to the large number of quadrats with ≥ 6 seedlings.

Amount of regeneration

The number of saplings of native species rarely exceeded 300 ha⁻¹ and there were very few of timber species. Most sites had several thousand seedlings of native or timber species per hectare. All non-native saplings were western hemlock.

40. This was estimated from the number of saplings and seedlings present on the 2 x 2 m quadrats for both native and non-native species. A group of valuable timber producing native species – ash, beech, oak, sweet chestnut and sycamore – was also identified.

Native species

41. Most sites had saplings of some native species, but the total number only exceeded 1000 ha⁻¹ at 6 sites and only 3 sites had any saplings of timber producing species (Table 9). Seedling numbers were usually much greater than those for saplings with about 30 % of sites having more than 10,000 ha⁻¹ of all species: the smallest number was recorded at Redlands. With the exception of one site at Bushey Leaze, the number of seedlings of timber species was lower than the total for all species and varied between c. 100 and c. 12000 ha⁻¹ (Table 9). For both saplings and seedlings the differences between numbers of timber and all seedlings was due to the large numbers of regenerating birch. Felling of western hemlock had a variable effect on the number of seedlings. Sites without western hemlock had greater numbers of birch and beech seedlings whereas there were fewer of western hemlock (Figure 3).

Non-native species

42. The non-native saplings present were all western hemlock; they were recorded on most sites with a maximum of 2500 ha⁻¹. At sites where western hemlock saplings were present there were usually fewer than those of native species (Table 9).

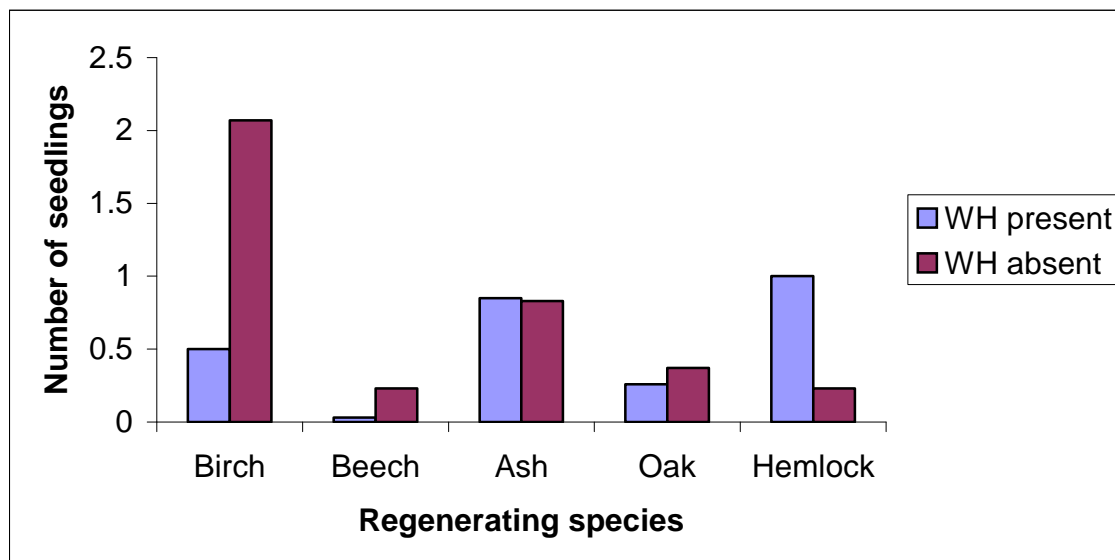
Similarly with the exception of sites at Alice Holt and Redlands, there were fewer seedlings of non-native species than there were of native species.

Table 9 Numbers (ha^{-1}) of saplings or seedlings of native or non-native species.

Site	No.	Native species				Non-native species	
		Saplings		Seedlings		Sapling	Seedling
		Timber	All	Timber	All		
Western hemlock felled							
Bushey leaze	1	0	0	12206	12206	0	0
Bushey leaze	2	60	119	6369	10060	0	119
West Wood	3	200	250	5650	5800	0	0
Chiddingfold	4	0	345	4655	15862	259	0
Shabbington	5	0	259	5000	16293	172	1897
Whitley Block	6	0	13158	658	7105	0	0
Chiddingfold	7	0	76	1288	4545	0	1364
Micheldever	8	0	0	1146	1771	729	313
West Walk	9	0	5583	2750	7667	0	250
Ampfield	10	0	50	1150	11950	0	2000
Ampfield	11	0	5786	929	9000	0	286
Micheldever	12	0	0	1100	12600	100	700
Whitley Block	13	0	6000	417	13917	83	3750
Western hemlock standing							
Home Hut	14	0	66	1974	6382	0	197
Stoke Park	15	0	0	3000	3571	0	1071
Ampfield	16	0	147	6912	9779	74	2794
Ranmore	17	71	143	2000	3071	0	1929
Chiddingfold	18	0	1121	10517	14052	86	690
Chiddingfold	19	0	1310	4762	7857	476	1310
Alice Holt	20	0	147	1397	4265	2500	5441
Redlands	21	0	0	83	167	0	1833

No. = site number.

Figure 3 Mean number of seedlings in quadrats on sites with or without western hemlock.



Percentage of each site stocked by natural regeneration

Most sites were partially stocked with regeneration of native species, but this was typically < 50 % of the area. The proportion of all sites stocked with regenerating timber species or western hemlock was low.

43. Estimates of stocking were calculated for seedlings or saplings either separately or combined, the group of timber species was also identified. The percentage of the site stocked is equivalent to the percentage of 2 x 2 m quadrats which were stocked, these were defined as follows:
- Saplings – 1 sapling / quadrat.
 - Seedlings – either 2 seedlings where the seedling height was > 100 cm or 4 seedlings where the seedling height was > 40 cm.
 - Combined – either a. or b.

Native species

44. In general < 10 % of any site was stocked with saplings of any native species although sapling regeneration exceeded 50 % at both sites in Whitley Block. The percentage of the sites stocked by saplings was very variable with no obvious relationship to the presence of western hemlock in the canopy (Table 10).
45. Only 4 sites had any of their area stocked with saplings of timber species and the amount was always < 10 %.
46. Most sites were at least partly stocked with seedlings of any species, but this was frequently \leq 10 % of the area. The percentage stocked with any seedlings was variable but open sites were all \geq 40 %. Overall those with western hemlock standing had a generally lower percentage of the area stocked.
47. Fewer than half of the sites had any of their area stocked with seedlings of timber species and for all except West Wood the area was < 10 %.

Non-native species

48. Many sites had no parts of their area stocked with either seedling or saplings of non-native species. In general the percentage of a site's area stocked was smaller than that for native species (Table 10).

Table 10 Percentage of the area of each site stocked with either saplings or seedlings of native and non-native species.

Site	No.	Native species				Non-native species	
		Saplings		Seedlings		Saplings	Seedlings
		Timber	All	Timber	All	Timber	All
Western hemlock felled							
Bushey leaze	1	0	0	6	6	0	0
Bushey leaze	2	2	5	7	7	0	0
West Wood	3	8	10	20	20	0	0
Chiddingfold	4	0	10	0	41	10	0
Shabbington	5	0	3	3	7	3	7
Whitley Block	6	0	79	0	21	0	0
Chiddingfold	7	0	3	0	3	0	0
Micheldever	8	0	0	0	0	21	0
West Walk	9	0	43	0	40	0	0
Ampfield	10	0	2	4	40	0	6
Ampfield	11	0	51	0	43	0	0
Micheldever	12	0	0	0	72	4	2
Whitley Block	13	0	53	0	87	3	17
Western hemlock standing							
Home Hut	14	0	3	3	8	0	0
Stoke Park	15	0	0	6	9	0	3
Ampfield	16	0	6	0	3	3	0
Ranmore	17	3	6	0	0	0	3
Chiddingfold	18	0	34	0	10	3	0
Chiddingfold	19	5	38	0	10	10	0
Alice Holt	20	0	3	3	9	29	9
Redlands	21	0	0	0	0	0	3

No. = site number.

Combined data for seedlings and saplings

49. Combining data for native saplings and seedlings increased the estimated areas of each site stocked by only small amounts relative to the largest value for either saplings or seedlings recorded at the same site (Tables 10 and 11). This suggests that in many cases the larger sizes of seedling regeneration and saplings are occurring on the same plot. The greater parts of most sites were not stocked.

Nineteen of the sites were partially stocked with some native species but only 9 had parts of their area stocked with timber species. In general open sites had the greatest areas stocked (Table 11).

50. For non-native species combining seedlings and saplings increased the number of sites with at least part of the area stocked but for most sites this remained < 10 % (Table 11).

Table 11 Total percentage of the area of each site stocked by native or non-native species calculated by combining data for saplings and seedlings.

Site	No.	Native		Non-native
		Timber	All	
Western hemlock felled				
Bushey leaze	1	6	6	0
Bushey leaze	2	7	10	0
West Wood	3	24	26	0
Chiddingfold	4	0	45	10
Shabbington	5	3	7	10
Whitley Block	6	0	79	0
Chiddingfold	7	0	6	0
Micheldever	8	0	0	21
West Walk	9	0	60	0
Ampfield	10	4	40	6
Ampfield	11	0	63	0
Micheldever	12	0	72	6
Whitley Block	13	0	93	20
Western hemlock standing				
Home Hut	14	3	11	0
Stoke Park	15	6	9	3
Ampfield	16	0	6	3
Ranmore	17	3	6	3
Chiddingfold	18	0	34	3
Chiddingfold	19	0	43	10
Alice Holt	20	3	9	29
Redlands	21	0	0	3

No. = site number.

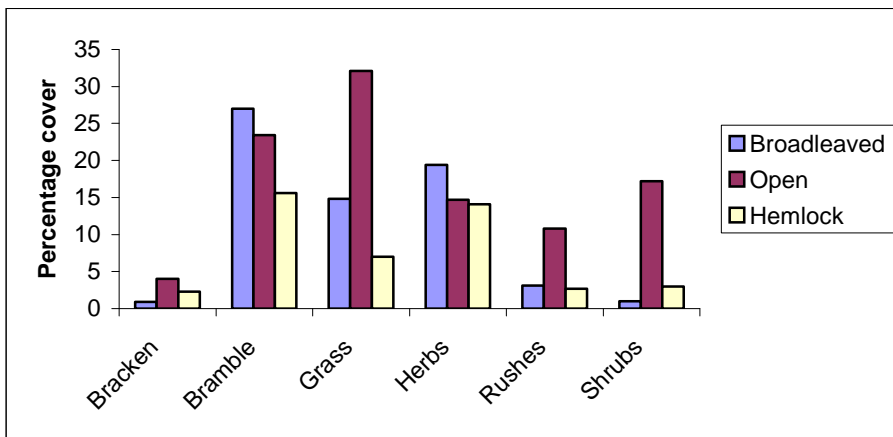
Ground flora vegetation

Most types of vegetation occurred on most of the sites – bracken was least common and bramble most common.

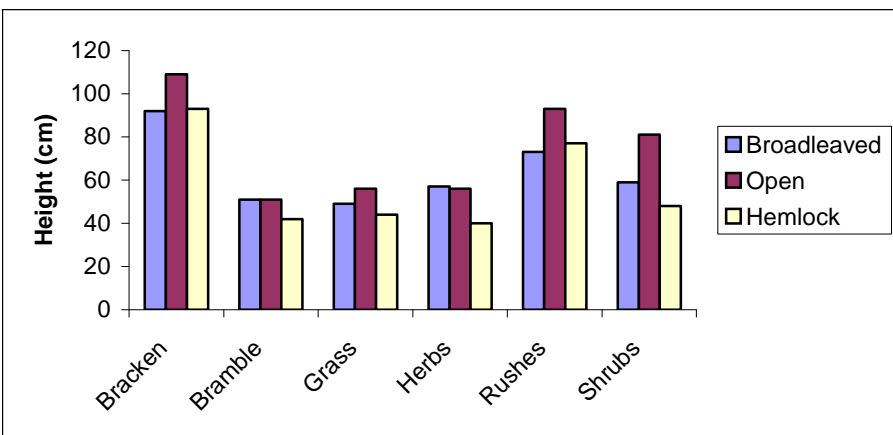
51. There was considerable variation in the frequency, percentage cover and height of the types of vegetation observed; data over all sites are summarised below with more detailed information for individual sites presented in Appendices 2-5.
52. The ground flora at all sites was generally species poor. Excluding bracken, bramble, grasses, sedges and rushes, most sites had an average of two other species in the ground flora of each quadrat. However, at almost all sites there were some quadrats with no other species. The maximum number of additional species present on a quadrat varied between 1 and 13 depending on site. There were no obvious differences between sites with or without western hemlock standing (Appendix 5).
53. Bracken was the least common vegetation type occurring on fewest sites at the lowest frequency. Bramble, grasses and herbs were found on all sites at generally the highest frequencies.
54. Overall bramble was the predominant vegetation type with mean percentage cover scores varying between 15 and 27 %, but there was no significant difference between sites either with or without western hemlock (Figure 4a). In contrast grasses, rushes and shrubs were significantly more abundant on the open sites.
55. The heights of the different types of vegetation did not differ between the different classes of site (Figure 4b). Where bracken was present it was usually the tallest plant exceeding 100 cm at most sites. Although other types of vegetation were occasionally recorded at this height, their mean heights were typically < 60 cm.

Figure 4 Vegetation in each type of stand.

(a) Percentage cover



(b) Height



Relationships between tree seedlings and site characteristics

Data were very variable both within and between sites, and the characteristics that are significantly related to the number and size of seedlings can vary with the precise method of analysis.

56. When interpreting this information it is important to remember that these data represent the state of each site on one day, often several years after felling

operations. Nothing is known about the state of each site prior to felling or the subsequent pattern of development that created the sites assessed.

57. A summary of the results of statistical analysis is presented, a more detailed description of the methods is provided in Appendix 6.
58. Relationships between site characteristics and the presence and abundance of seedling regeneration were investigated separately for ash, beech, birch, oak and western hemlock. All other species were found too infrequently for any analyses to be carried-out.

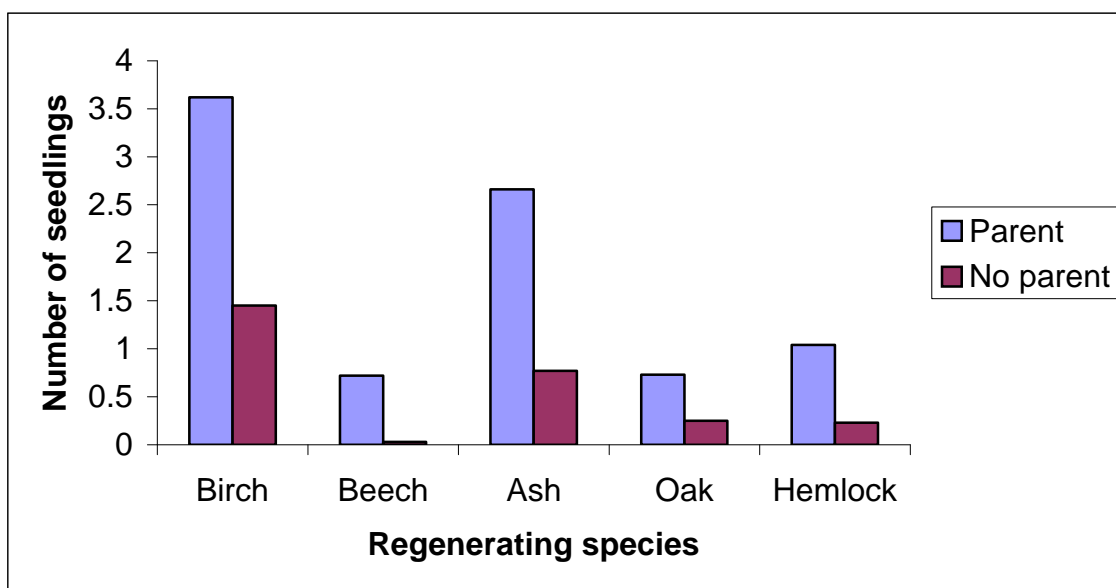
Number of seedlings

Overall the most important relationships were those associated with tree cover, the presence of nearby parent trees being of particular importance being positively related to both the presence and abundance of seedlings.

59. Although the range of significant characters varied with species there were some obvious trends and some were significant for all species. However the importance of some characters was influenced by site (Table 12).
 - Parent in plot – significant and positive for all species which indicates that nearby parent trees is an important site character for regeneration. Mean seedling numbers were between 2- and 20-fold greater in quadrats when parent trees were within the 30 x 30 m plot (Figure 5).
 - Canopy cover – a significant character for four species but with varying effect (Table 12). It had an adverse effect on the number of birch seedlings which may be related to birch's light demanding nature. Conversely the positive effect of canopy cover on ash and beech may be due to their ability to withstand shade.
 - Percentage bramble cover – where the effect is significant it is usually negative indicating that it has an adverse effect on seedling number (Table 12).
 - Overall bramble, bracken and grass had no effect on presence of seedlings but affected their abundance (Table 12).

60. In general the most important site characters relating to seedling number were the presence of parent trees, canopy cover and % bramble cover. Data suggest that seedling numbers are likely to be low at sites with few parent trees and where % bramble cover is high, and that the effect of a tree canopy varies with species.

Figure 5 Mean number of seedlings in quadrats with or without parent trees in the 30 x 30 m plot.



Conclusions

61. Investigation of relationships between site characteristics and seedlings demonstrated that the presence of parent trees nearby (within *c.* 15 m) was an important factor related to the abundance of seedlings for all species analysed. This suggests that natural regeneration at any site is likely to be less successful if there are few parent trees present or those present are not well distributed over the area. Conversely natural regeneration of a site is likely to be more successful if there are many parent trees evenly distributed across a site.

62. A simple systematic survey of a site which assesses small plots can be used to determine the proportion of an area that is stocked.
63. At sites where western hemlock had not been felled there were greater numbers of western hemlock seedlings reflecting the reproductive potential of the species. This indicates that clearfelling could be a good option for restoring western hemlock PAWS as it will reduce both the probability of the species re-establishing on and around the site, and the costs of remedial work to remove unwanted natural regeneration.
64. Although there were more than 10,000 seedlings ha⁻¹ at some sites they were usually small: birch was the most common species with desirable timber species being less abundant. The number of saplings was usually lower than that for seedlings, with saplings of timber species being absent at most sites. Few sites had more than half of their area restocked with native species and estimates of the area stocked with timber species were very low. This will partly reflect both the time since any felling or thinning and the species composition of the stand. It indicates that natural regeneration, especially of timber species, may be failing and that planting may be necessary to produce well-stocked stands of valuable timber species.

Table 12 Significant relationships between site characters and the number of seedlings present on a quadrat.

Site character	Ash		Beech		Birch		Oak		Western hemlock	
	Abundance	Presence	Abundance	Presence	Abundance	Presence	Abundance	Presence	Abundance	Presence
Parent	Positive	Positive	Positive	Positive	Positive	Positive	Positive		Positive ^c	Positive
Canopy Cover	Positive	Positive	Positive	Positive ^a	Negative	Negative	Positive		Negative	
Bramble%	Negative		Negative ^b	Negative	Positive ^c				Negative ^b	
Bracken%	Positive ^b								Negative	
Grass%	Positive ^c		Negative	Negative	Positive ^c				Negative	

Presence = presence of seedlings; Abundance = numbers of seedlings; Parent = parent tree in 30 x 30 m plot; % = percentage cover.

Superscripts indicate the following:

a - indicates that significance of character is dependent on the order terms are fitted.

b - indicates that the character is only significant if site is included in the model.

c - indicates that character is only significant if site is not included in the model.

Method for estimating proportion of a site that is stocked with naturally regenerating trees

65. Examination of the survey results indicated that the data had a binomial distribution and that standard binomial sample sizes can be used to determine the number of samples needed to determine the proportion of a site that is stocked.

66. Before carrying-out the field survey at any site two factors need to be decided: Size of the temporary sample plots that will be used. These must be constant within a site and for ease of assessment their size should be in the range 2 x 2 m to 4 x 4 m. They are temporary and do not need to be marked, but can be estimated visually.

The criteria that determine whether or not a plot is stocked need to be fixed.

These criteria may vary with plot size, site, species and objectives, examples of possible criteria include:

- the presence of one sapling in a 2 x 2 m plot;
- 10 unbrowsed seedlings greater than 80 cm tall in a 3 x 3 m plot;
- 60 seedlings more than 1-year-old that are taller than 20 cm in a 4 x 4 plot;
- 4 oak saplings present in a 4 x 4 plot.

A wide variety of other criteria are possible and they may depend on local experience and forestry knowledge.

67. The sample plots must be distributed across the site. This is probably simplest to achieve using a systematic method in which plots are placed on transects distributed evenly across the site.

The method assumes that the percentage of a site stocked is one of three levels 70, 80 or 90 % and in order to assess whether this has been achieved use the following procedure:

- a. Decide the percentage stocking required.
- b. Choose the number of plots that need to be assessed from Table 13.

- c. Make a systematic survey of the site.
 - d. Count the number of plots that are stocked according to the criteria identified.
 - e. Determine whether the site is stocked by comparing the number of plots counted as stocked with the numbers in Table 13.
 - f. Resample sites where the number of stocked plots falls within the **uncertain** category. To do this survey another set of plots and add the number of stocked plots to that found in the first survey to create a combine total of stocked plots. Then compare the total number of stocked plots with those for the resampled site in Table 13.
 - g. When resampling a site, either place the additional plots on the same transects between the plots initially assessed, or assess plots on new transects placed between the original transects.
 - h. After resampling some of the sites may have an **intermediate** number of plots stocked and a decision on whether these sites have a sufficient area stocked should be made on the basis of experience gained after surveying the site and forestry knowledge.
68. As an example, for 80 % stocking a sample size of 30 plots is taken for the first survey. If 25 or more of the plots are stocked according to the criteria chosen then it can be assumed that the site is stocked. If 19 or fewer plots are counted as stocked then it can be concluded that less than 80 % of the site is stocked. If there are 20 to 24 plots stocked then the result is uncertain and a second sample of 30 plots should be assessed.

Table 13 Number of plots to assess to determine whether a site is stocked.

Percentage of site stocked	Number of plots	Assessment of first survey			Assessment of resampled sites			
		Stocked	Uncertain	Not stocked	Total Sample Size	Stocked	Intermediate	Not stocked
70	35	≥ 26	20 – 25	≤ 19	70	≥ 49	43-48	≤ 42
80	30	≥ 25	20 – 24	≤ 19	60	≥ 48	43-47	≤ 42
90	25	≥ 23	20 – 22	≤ 19	50	≥ 45	42-44	≤ 41

Percentage of site stocked = desired level of stocking; Number of plots = number of plots that must be assessed; Stocked = the number of individual plots which are stocked that indicates that the percentage stocking is achieved; Not stocked = the number of individual plots which are stocked that indicates that the percentage stocking is not achieved; Uncertain = the number of plots stocked which indicate resampling is necessary; Intermediate = the site managers experience will be necessary to decide whether the site is adequately stocked.

Appendices

Appendix 1 Height (cm) of most frequent native and non-native tree seedlings present on 2 x 2 m quadrats at each site.

Site	Native species														Non- native species								
	AH		BE		BI		HAW		HBM		HZL		OK		SYC		DF	LC	PINE	WH			
Western hemlock felled																							
Bushey leaze 1	25	<i>10</i>	15	<i>0</i>									25	<i>10</i>									
Bushey leaze 2	30	<i>15</i>	15	<i>0</i>	37.5	<i>12.5</i>	1				55	<i>20</i>	15	<i>5</i>	35	<i>20</i>				50			
West.Wood 3	35	<i>15</i>	10	<i>0</i>	35	<i>15</i>							50	<i>0</i>									
Chiddingfold 4	25	<i>10</i>			50	<i>15</i>	35		50		75		17.5	<i>7.5</i>									
Shabbington 5	25	<i>7.5</i>			10	<i>0</i>	1						15	<i>5</i>			50	<i>0</i>		17.5	<i>10</i>		
Whitley Block 6	20	<i>5</i>			50	<i>15</i>																	
Chiddingfold 7					20	<i>5</i>					35		10	<i>0</i>					10	15	<i>5</i>		
Micheldever 8	15		50	<i>0</i>	50								25	<i>10</i>	25					47.5	<i>7.5</i>		
West Walk 9			20		75	<i>25</i>							15	<i>5</i>					75	<i>0</i>	50		
Ampfield 10	15		10		50	<i>15</i>					50		17.5	<i>7.5</i>	50		50	<i>25</i>		25	<i>15</i>	25	<i>0</i>
Ampfield 11			15	<i>0</i>	100	<i>20</i>							30	<i>5</i>	10				35	<i>0</i>	10		
Micheldever 12	10	<i>0</i>			75	<i>25</i>							15	<i>5</i>						100	<i>20</i>		
Whitley Block 13	10				100	<i>0</i>							25	<i>5</i>						75	<i>25</i>		
Western hemlock standing																							
Home Hut 14			10	<i>0</i>	35	<i>10</i>					12.5	<i>2.5</i>	10	<i>0</i>					10	10	<i>0</i>		
Stoke Park 15	25	<i>0</i>	25	<i>10</i>	50	<i>0</i>					50	<i>25</i>	25	<i>15</i>						35	<i>25</i>		
Ampfield 16	25	<i>10</i>	10	<i>0</i>	17.5	<i>7.5</i>					50		10	<i>0</i>						10	<i>0</i>		
Ranmore 17	25	<i>0</i>	10		50	<i>0</i>							15		35					25	<i>10</i>		
Chiddingfold 18	25	<i>10</i>			20	<i>12.5</i>	75		25	<i>15</i>			15	<i>5</i>						10	<i>0</i>		
Chiddingfold 19	20	<i>5</i>			42.5	<i>7.5</i>	20	<i>5</i>			62.5	<i>12.5</i>	25	<i>12.5</i>						37.5	<i>22.5</i>		
Alice Holt 20	30	<i>5</i>			30	<i>5</i>	50				35	<i>10</i>	35	<i>10</i>						25	<i>15</i>		
Redlands 21			50		5															7.5	<i>2.5</i>		

Values are medians with median absolute deviation in italics

Appendix 2 Frequency with which the different types of vegetation were found on each site.

Sites	No.	BRACKEN	BRAMBLE	GRASS	HERB	RUSH	SHRUB
Western hemlock felled							
Bushey leaze	1	3	85	41	94	0	0
Bushey leaze	2	2	98	57	81	12	5
West Wood	3	0	26	78	92	2	0
Chiddingfold	4	7	69	86	97	48	31
Shabbington	5	3	86	90	86	28	0
Whitley Block	6	0	68	68	100	11	5
Chiddingfold	7	0	45	33	58	27	0
Micheldever	8	13	100	46	71	13	8
West Walk	9	7	97	43	67	57	30
Ampfield	10	16	86	90	94	56	30
Ampfield	11	20	91	77	94	57	51
Micheldever	12	0	98	94	50	60	82
Whitley Block	13	3	93	53	83	47	17
Western hemlock standing							
Home Hut	14	5	61	32	92	47	55
Stoke Park	15	0	57	17	83	9	37
Ampfield	16	6	65	59	71	21	21
Ranmore	17	20	63	20	80	3	40
Chiddingfold	18	21	52	14	62	3	14
Chiddingfold	19	0	90	71	90	14	19
Alice Holt	20	0	82	47	94	38	21
Redlands	21	3	17	20	40	3	7
Total sites		14	21	21	21	20	17

Values are number of quadrats on which they were recorded as a percentage of the number of quadrats assessed. No. = site number

Appendix 3 Percentage cover of each type of vegetation at each site.

Site	No.	Bracken		Bramble		Grass		Herbs		Rushes		Shrubs	
Western hemlock felled													
Bushey leaze	1	10.0		35.0	<i>10.0</i>	10.0	<i>0.0</i>	30.0	<i>20.0</i>				
Bushey leaze	2	10.0		75.0	<i>25.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>
West Wood	3			35.0	<i>10.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0			
Chiddingfold	4	10.0	<i>0.0</i>	50.0	<i>15.0</i>	30.0	<i>20.0</i>	30.0	<i>20.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>
Shabbington	5	10.0		50.0	<i>15.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>		
Whitley Block	6			25.0	<i>0.0</i>	10.0	<i>0.0</i>	30.0	<i>20.0</i>	20.0	<i>10.0</i>	10.0	
Chiddingfold	7			25.0	<i>10.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>		
Micheldever	8	30.0	<i>0.0</i>	75.0	<i>25.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>
West Walk	9	35.0	<i>25.0</i>	50.0	<i>15.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>
Ampfield	10	80.0	<i>20.0</i>	35.0	<i>10.0</i>	60.0	<i>30.0</i>	30.0	<i>20.0</i>	20.0	<i>10.0</i>	10.0	<i>0.0</i>
Ampfield	11	10.0	<i>0.0</i>	35.0	<i>10.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	45.0	<i>15.0</i>
Micheldever	12			50.0	<i>25.0</i>	60.0	<i>30.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	30.0	<i>20.0</i>
Whitley Block	13	30.0		50.0	<i>15.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>
Western hemlock standing													
Home Hut	14	10.0	<i>0.0</i>	50.0	<i>25.0</i>	10.0	<i>4.5</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>
Stoke Park	15			50.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>
Ampfield	16	35.0	<i>25.0</i>	35.0	<i>10.0</i>	30.0	<i>20.0</i>	30.0	<i>10.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>
Ranmore	17	30.0	<i>20.0</i>	35.0	<i>10.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0		10.0	<i>0.0</i>
Chiddingfold	18	30.0	<i>10.0</i>	35.0	<i>10.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0		10.0	<i>0.0</i>
Chiddingfold	19			50.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>
Alice Holt	20			50.0	<i>7.5</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>
Redlands	21	60.0		10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0	<i>0.0</i>	10.0		10.0	<i>0.0</i>

Values are medians with median absolute deviation in italics; where values for MAD are blank then either there was none of the vegetation present or it occurred on too few quadrats for calculation, where value of zero then all cover scores recorded had the same value. No. = site number.

Appendix 4 Average height (cm) of vegetation at each site.

Site	No.	Bracken		Bramble		Grass		Herbs		Rushes		Shrubs	
Western hemlock felled													
Bushey leaze	1	75.0		35.0	<i>10.0</i>	35.0	<i>12.5</i>	50.0	<i>0.0</i>				
Bushey leaze	2	100.0		75.0	<i>25.0</i>	50.0	<i>7.5</i>	50.0	<i>15.0</i>	50.0	<i>0.0</i>	92.5	<i>57.5</i>
West Wood	3			35.0	<i>10.0</i>	75.0	<i>25.0</i>	35.0	<i>12.5</i>	50.0			
Chiddingfold	4	100.0	<i>0.0</i>	50.0	<i>15.0</i>	50.0	<i>25.0</i>	150.0	<i>50.0</i>	100.0	<i>0.0</i>	50.0	<i>15.0</i>
Shabbington	5	10.0		50.0	<i>15.0</i>	100.0	<i>50.0</i>	50.0	<i>15.0</i>	100.0	<i>0.0</i>		
Whitley Block	6			25.0	<i>0.0</i>	25.0	<i>0.0</i>	50.0	<i>0.0</i>	75.0	<i>25.0</i>	35.0	
Chiddingfold	7			25.0	<i>10.0</i>	35.0	<i>10.0</i>	35.0	<i>10.0</i>	50.0	<i>0.0</i>		
Micheldever	8	130.0	<i>0.0</i>	75.0	<i>25.0</i>	25.0	<i>10.0</i>	35.0	<i>15.0</i>	75.0	<i>0.0</i>	50.0	<i>0.0</i>
West Walk	9	137.5	<i>62.5</i>	50.0	<i>15.0</i>	50.0	<i>25.0</i>	35.0	<i>15.0</i>	100.0	<i>0.0</i>	75.0	<i>25.0</i>
Ampfield	10	130.0	<i>32.5</i>	35.0	<i>10.0</i>	50.0	<i>25.0</i>	50.0	<i>25.0</i>	87.5	<i>12.5</i>	35.0	<i>10.0</i>
Ampfield	11	50.0	<i>15.0</i>	35.0	<i>10.0</i>	35.0	<i>10.0</i>	50.0	<i>25.0</i>	100.0	<i>0.0</i>	100.0	<i>40.0</i>
Micheldever	12			50.0	<i>25.0</i>	75.0	<i>25.0</i>	35.0	<i>15.0</i>	100.0	<i>25.0</i>	130.0	<i>0.0</i>
Whitley Block	13	150.0		50.0	<i>15.0</i>	50.0	<i>15.0</i>	50.0	<i>15.0</i>	100.0	<i>25.0</i>	75.0	<i>0.0</i>
Western hemlock standing													
Home Hut	14	22.5	<i>12.5</i>	50.0	<i>25.0</i>	75.0	<i>0.0</i>	35.0	<i>15.0</i>	75.0	<i>25.0</i>	25.0	<i>10.0</i>
Stoke Park	15			50.0	<i>0.0</i>	25.0	<i>0.0</i>	25.0	<i>15.0</i>	100.0	<i>0.0</i>	50.0	<i>15.0</i>
Ampfield	16	115.0	<i>15.0</i>	35.0	<i>10.0</i>	50.0	<i>15.0</i>	50.0	<i>20.0</i>	75.0	<i>0.0</i>	25.0	<i>15.0</i>
Ranmore	17	100.0	<i>25.0</i>	35.0	<i>10.0</i>	30.0	<i>5.0</i>	35.0	<i>10.0</i>	100.0		30.0	<i>5.0</i>
Chiddingfold	18	100.0	<i>12.5</i>	35.0	<i>10.0</i>	30.0	<i>5.0</i>	35.0	<i>10.0</i>	50.0		30.0	<i>20.0</i>
Chiddingfold	19			50.0	<i>0.0</i>	75.0	<i>25.0</i>	50.0	<i>15.0</i>	100.0	<i>0.0</i>	42.5	<i>32.5</i>
Alice Holt	20			50.0	<i>7.5</i>	35.0	<i>10.0</i>	50.0	<i>25.0</i>	100.0	<i>0.0</i>	75.0	<i>25.0</i>
Redlands	21	100.0		10.0	<i>0.0</i>	10.0	<i>0.0</i>	25.0	<i>15.0</i>	35.0		30.0	<i>20.0</i>

Values are medians with median absolute deviation in italics; where values for MAD are blank then either there was none of the vegetation present or it occurred on too few quadrats for calculation, where value of zero then all cover scores recorded had the same value.

Appendix 5 Minimum, median and maximum number of ground flora species recorded in quadrats at each site excluding bracken, bramble, grasses, sedges and rushes.

Site / site number	min	median	max
Western hemlock felled			
Bushey leaze 1	0	3	8
Bushey leaze 2	0	2	7
West. Wood 3	0	2	6
Chiddingfold 4	1	2	6
Shabbington 5	0	2	7
Whitley Block 6	1	6	13
Chiddingfold 7	0	1	6
Micheldever 8	0	1	4
West Walk 9	0	1	4
Ampfield 10	0	2	6
Ampfield 11	0	2	4
Micheldever 12	0	0	4
Whitley Block 13	0	2	8
Western hemlock standing			
Home Hut 14	0	0	1
Stoke Park 15	0	1	3
Ampfield 16	0	2	7
Ranmore 17	0	2	5
Chiddingfold 18	0	1	7
Chiddingfold 19	0	2	13
Alice Holt 20	0	2	7
Redlands 21	0	0	4

Appendix 6 Analyses of relationships between the presence and abundance of seedlings and site characteristics.

Abundance = modelling the number of seedlings per quadrat (*i.e.* abundance) was carried-out using a generalised linear model (GLM). As the number of seedling per quadrat was truncated at 6, two models were used for the number of seedlings depending what proportion of observations had been truncated. For beech, oak and western hemlock where there were few quadrats with more than 6 seedlings (Table 8) a standard GLM with a log link and Poisson distribution was used. However for ash and birch where there were substantial numbers of quadrats with more than 6 seedlings a truncated Poisson GLM with a log link was used. Site was fitted as a fixed effect but the effect of not including site was also considered.

Presence = modelling the presence/absence of seedlings in a quadrat (*i.e.* frequency) was carried-out using a binomial generalised linear mixed model with logit link and site as a random effect.