THE SAPROXYLIC INVERTEBRATES OF HISTORIC PARKLANDS: PROGRESS AND PROBLEMS

Paul T Harding, NERC Institute of Terrestrial Ecology, Monks Wood, Abbots Ripton, Huntingdon, Cambs., PE17 2LS

Keith N A Alexander, The National Trust, 33 Sheep Street, Cirencester, Glos., GL7 1QW.

Introduction

Saproxylic invertebrates are some of the most threatened species in Britain. The present-day fauna includes relic elements of a fauna that was associated with the unmanaged forest cover in the first half of the Holocene (the *Urwaldtier*). Although some *Urwald* species are now extinct in Britain and others have become much less widespread (Buckland & Dinnin 1993), rich assemblages of saproxylic invertebrates have survived at a limited number of sites in Britain. Almost all of the species considered to be of particular importance for nature conservation are associated with native species of trees and shrubs (Alexander in prep).

Entomologists have traditionally regarded some saproxylic species as being of special interest and therefore collectable, but there has been little concerted effort to carry out research on the autecology and detailed habitat requirements of species. A survey of the literature (mainly post 1945) on 100 of the most threatened British saproxylic Coleoptera (Harding 1978a) showed that records were mainly from a small number of well-known sites or areas, most of which had been 'discovered' in the 19th century or earlier.

Surveys and research, initially funded by the Nature Conservancy Council (NCC), and, more recently, undertaken by entomologists on a largely *ad hoc* basis or as part of the work of the National Trust, have established an inventory of sites which are regarded as being of importance for the conservation of Britain's saproxylic invertebrates. In some cases, the management of sites has been examined and modified in attempts to further the conservation of these species.

This paper reviews progress with identifying the important sites and with preserving their interest for saproxylic species, but is concerned only with historic parklands: for a full review of pasture-woodland of special importance for saproxylics see Harding & Rose (1986).

Finding and defining important areas

In 1975, the Institute of Terrestrial Ecology (ITE) was commissioned by NCC to survey the extent and condition of the 'mature timber habitat' in lowland Britain. The work extended over four years and resulted, *inter alia*, in an inventory of areas of known and potential conservation value for saproxylic invertebrates. The inventory was based largely on published and anecdotal information on the occurrence of saproxylic species and on information about sites with numbers of large, old trees. Although no faunal surveys were carried out, about 100 sites were visited to assess the extent and quality of the habitat potentially available for saproxylic fauna. Close collaboration with Dr Francis Rose, who was carrying out surveys of epiphytic lichens for NCC, was maintained throughout the project.

Since 1979, although NCC was conducting a national survey of the 'ancient woodland' resource in Britain (Spencer & Kirby 1992), no large-scale work specifically concerning pasture-woodland was undertaken by either NCC or ITE. However, some of the potentially interesting sites listed by Harding (1978b) have subsequently been investigated by entomologists, albeit in a largely *ad hoc* and uncoordinated way. A few additional sites have also been discovered. Some of this work was supported by NCC with travel funds for site visits, and also some information has been collated through the Invertebrate Site Register (formerly run by NCC and now by the Joint Nature Conservation Committee).

The National Trust has had a key role in surveying important sites during the last decade, with most of the work on saproxylic species being undertaken or co-ordinated by KNAA. The saproxylic faunas of important sites such as Calke Park and Clumber Park were previously unknown. The surveys at these two sites were undertaken for the National Trust by Colin Johnson.

Index of Ecological Continuity

One further part of the ITE survey of the mature timber habitat was the compilation of a list of saproxylic species which were regarded as characteristic of the known sites of importance for such species (Harding 1977). This list was compiled from the combined knowledge of some of the most experienced entomologists in Britain at that time. A slightly revised list of the Coleoptera has since been published (Harding & Rose 1986).

The first lists were used by several authors to compare or evaluate sites (Hammond 1979; Welch & Cooter 1981; Atty 1983; Garland 1983) and the 1986 published version has formed the basis of an Index of Ecological Continuity using saproxylic Coleoptera (Alexander 1988). This Index complements that developed by Rose (1976) using lichens, but has the advantages that a larger suite of species is used (195 beetles compared with 30 lichens), the list is graded enabling more refined usage, and the species are not so sensitive to atmospheric pollution. Disadvantages are that, unlike lichens, most of the beetles can only readily be detected during a short season and many are difficult to sample. A recent paper (Hammond & Harding 1991) described the range of sampling techniques used in conducting qualitative and quantitative surveys of saproxylic invertebrates.

The Index has been used to provide a basis for the assessment of sites in nature conservation. Up-to-date information is needed to support conservation measures, but it is difficult to acquire a representative list of saproxylic invertebrates for a site without a great deal of field work by experts. Following the example of the Invertebrate Site Register, the Index is based only on post 1950 records (Harding & Alexander 1993).

The results of the Index are undergoing regular revision as new data for sites become available, and in this way the list of the top national sites is constantly updated (Table 1). A threshold of 20 in the Index is currently used to separate off the most important sites, but it may be necessary to increase the threshold to 30 or even higher as more data become available.

Most of the species used in the Index have a southern or eastern distributional range in Britain although a few species go against this trend, for example *Corticeus unicolor* and *Pyropterus nigroruber* (northern), *Ernoporus caucasicus* and *Pyrrhidium sanguineum* (western) and *Ampedus pomorum* and *Thymalus limbatus* (northern and western). A consequence of this imbalance is that the Index is most appropriate to southern, lowland Britain and it is not intended to cover the Caledonian pine forest fauna. More sensitive regional Indices now need to be devised so that regionally important sites are not assessed against a single national standard heavily influenced by south-eastern specialities such as several of the *Ampedus* species. Garland (1983) developed a list for the Sheffield area, and Fowles & Boyce (pers. comm.) are working on a similar approach for west Wales.

Despite the limitations of the Index, the sites listed in Table 1 may be regarded as having the best *national* examples of saproxylic faunal assemblages of Coleoptera. However, the failure of other 'good' sites to get onto this list may be due to inadequate or out-of-date data, or to the regional bias of the list.

Factors common to important sites

Several factors are common to many of the sites now known to be of importance for saproxylic invertebrates, in particular site histories and continuity of management (Harding & Rose 1986).

Table 1 Top national sites for the specialist saproxylic fauna of historic woodlands and pasture-woodlands (* = listed by Speight (1989) as of European importance).

Site Name	Area (Ha)	H1	H2	H3	Index	Origin	Protection
*Windsor Great Park							
& Forest	710	48	22	45	**233**	MDP/OF	SSSI
*New Forest	3,800	25	22	64	**183**	OF	SSSI
*Moccas Park	140	23	12	36	**129**	PW/C17 DP	NNR
*Epping Forest	1,150	10	11	47	**99**	OF	SSSI
Sherwood Forest	525	14	9	34	**94**	OF	SSSIpt
Richmond Park	940	10	9	26	**74**	MDP/PW/C17 DP	SSSI
Burnham Beeches	453	3	13	31	**66**	PW	SSSIpt
Clumber Park	1,500	6	8	31	**65**	OF	SSSI NT
Calke Park	80	6	6	34	**64**	AW/C17 DP	SSSI NT
Arundel Park	109	7	6	30	**63**	MDP	SSSI
Knole Park	383	6	9	26	**62**	C15 DP	SSSI
Wytham Woods	230	2	10	34	**60**	PW/AW	SSSI
Monks Wood	157	5	5	28	**53**	AW	NNR
Staverton Park	85	5	5	24	**49**	MDP	SSSI
Bredon Hill		8	5	13	**47**	PW+MDP	NNRpt
Dunham Massey Park	78	2	6	26	**44**	C16 DP	SSSI NT
Kedleston Park	819	3	3	27	**42**	MDP	NT
Blenheim Park	900	7	3	13	**40**	OF/MDP	SSSI
West Walk, Bere		2	4	25	**39**	OF	-
Duncombe Park	78	3	2	24	**37**	AW+MPD	SSSI
Buxted Park	c.90	4	3	17	**35**	MDP	-
Attingham Park	c.150	3	4	18	**35**	PW	NT
Box Hill		1	4	24	**35**	PW	SSSI NT
Grimsthorpe Park	92	1	3	26	**35**	C16 DP	SSSI
Icklingham Plains	c.180	5	2	15	**34**	PW	-
Hatfield Forest	360	4	4	14	**34**	OF	SSSI NT
Ashtead Common	c.200	6	4	7	**33**	PW	SSSI
Donington Park	c.120	4	3	15	**33**	MDP	SSSIpt
Savernake Forest	930	5	3	12	**33**	OF	SSSI
Forest of Dean	c.8,000	2	2	23	**33**	OF	SSSIpt
Thorndon Park	c.200	1	3	23	**32**	MDP	SSSI
Lullingstone Park	260	1	5	15	**28**	C16 DP	SSSI
Stockton's Wood	c.15	1	3	19	**28**	PW	NT
Brampton Bryan Park	175	1	-	25	**28**	C15 DP	SSSI
Cirencester Park	c.800	-	3	22	**28**	AW/PW	pSSSIpt
Woods							
Rockingham Castle	c.60	1	3	18	**27**	OF	-
Park	c.80	3	4	10	**27**		-
Shrubland Park	c.400	1	2	19	**26**	PW	SSSI NT
Croft Castle	630	3	2	12	**25**	OF/C17 DP	-
Chatsworth Park							
Lower River Weaver	c.100	2	1	16	**24**	AW	-
Woodlands	c.80	-	3	17	**23**	MDP	SSSI
Nettlecombe Park							

Table 1 (cont'd)

Site Name	Area (Ha)	H1	H2	H3	Index	Origin	Protection
Dinefwr Deer Park	97	-	-	23	23	PW/C17 DP	SSSI NT
Thorne Moors		-	2	19	23	OF/PW	SSSI
Harewood Forest	c.650	4	1	8	22	OF	-
Castor Hanglands	c.100	1	1	16	21	PW	NNR
Sandall Beat Wood	70	-	2	16	20	PW/AW	LNR

Key to abbreviations

H1, H2, H3

Numbers of species in three groups of species, as categorised by Harding & Rose (1986). These groups of species are graded (1=highest) according to the extent to which the species have been consistently recorded from areas of ancient woodland with continuity of dead-wood habitats.

Index

Score calculated using the Index of Ecological Continuity based on the above groups of species (Alexander 1988).

Origin

Historical origin of the area as present-day pasture woodland:

AW Ancient woodland
C15 15th century reference to the area as pasture-woodland
(C16, C17, C18 - similarly for subsequent centuries)
DP Deer park
MDP Medieval deer park
OF Formerly a legal Forest
PW Pasture-woodland (excluding deer parks)

Protection

Protection status of site

LNR Local Nature Reserve
NNR National Nature Reserve
NT National Trust property
SSSI Site of Special Scientific Interest
prefix p Proposed SSSI
suffix pt Part of site is SSSI

Site history

Most of the sites listed by Harding (1978b) and evaluated using the Index of Ecological Continuity (Table 1) were wooded Forests or Chases which were subject to medieval laws, parklands established in medieval times or more recently from farmland or 'waste' with trees, or wooded commons. Rackham (1980, 1986) discussed the origins of sites managed by the wood-pasture system. In many (but not all) cases these areas of land were the least rewarding for agriculture and lie on poor quality, often acidic soils, frequently in association with relic areas of wetlands. These similarities may more accurately reflect our ancestors' perception of the capabilities of the landscape than the habitat preferences of the invertebrates.

Continuity of management

There is an ever increasing body of opinion that almost all of Britain's present 'ancient' woodlands bear little resemblance to the Holocene forests before man became a major environmental influence. Therefore, it would be naive to consider those sites that are of importance for saproxylic invertebrates to be the last true relics of the *Urwald*. However, for species and assemblages to have survived to the late 20th century, there must have been some continuity of suitable tree cover at or near the site. Almost all of the most important sites identified to date originated as pasture-woodlands in the medieval period to the late 18th century (Table 1).

Pollarding was a traditional means of managing trees in pasture-woodlands. Pollarding has the effect of prolonging the life of trees, particularly oak, hornbeam, beech and field maple, and of creating a variety of niches for saproxylic fauna. Trees growing in open canopy often acquire the appearance of pollards, and have the potential to lose branches and grow new ones: these too provide prime habitat for saproxylics.

Landscape planting for mature trees, particularly in parks, began in the 16th century. Some sites have very complex histories and few have been researched in any detail. For example, Britain's only pasture-woodland National Nature Reserve, Moccas Park, has an apparent history of 18th century amenity planting into an earlier landscape which included former ploughland with hedgerow pollards, an area of wetland and steep, possibly wooded, slopes rising to what may have been a heath.

Many of the entomologically more important sites (Table 1) were Crown hunting lands at some time in their history. At Cirencester Park, where there is documentary evidence of woodland back to Saxon times, the Crown retained hunting rights up to the time of the Dissolution, even though the area had been given to Cirencester Abbey in the 13th century. Since the Dissolution, the park has been privately owned and was landscaped early in the 18th century, before the influence of Brown, Repton and their followers.

The other feature that characterises many important areas for saproxylic species is the recent neglect, or, much worse, the recent exploitation, of the tree cover. In fact, the neglect of some sites may have led to more habitat being available for saproxylic species than if the site had been actively managed. Few sites have been managed to maintain the tree cover by planting successive generations of trees and most sites have lost trees through felling or natural events.

The recent condition of selected sites

Few of the parklands that have been identified as being of importance for saproxylic invertebrates (many of which are now protected as SSSIs) have been surveyed to assess the amount and condition of the trees and shrubs that are likely to be the habitat of these invertebrates. Detailed surveys of the tree stocks at five sites were made by PTH for NCC in the late 1970s, and at some of these sites further surveys and tree numbering have been undertaken by NCC. The National Trust has a programme of tree surveys which has covered 60 of the 100 or more of its historic parks since the project was initiated in 1981. The initial survey records details of all of the existing individual trees and includes archival research on the management history of the park.

The total numbers of trees at six sites (Table 2) may seem impressive, but these six sites have been surveyed partly because they are among the best examples of well stocked, ecologically important parks. Comparison of these figures with field notes on nearly 100 other sites visited by PTH in the period 1975 to 1979, and with information from the National Trust surveys, shows that most other parks have many fewer trees, although some have areas of commercial forestry, with native species such as oak, beech and ash.

Subsequent losses of trees at these sites have been generally slight, although some felling has taken place at Shute and Dinefwr. The effects of droughts and gales in 1989 and 1990 were assessed for NCC at Moccas, Brampton Bryan and Dinefwr (Harding 1990) and are summarised in Table 3. Figures are given only where losses have occurred.

The ITE surveys, commissioned by NCC, gave an assessment, for each tree present, of the age class (dead, ancient, overmature, mature, young, sapling) and growth form (coppice, maiden, pollard). The full results of these surveys are given in a series of contract reports listed by Harding & Rose (1986) and have been summarised for two sites: Shute (Harding 1980) and Dinefwr (Harding 1981). The survey at Calke by the National Trust attempted to age trees by girth measurements, but provided no assessment of growth form or condition. Therefore data from the Calke survey are not compatible with those on age classes from the ITE surveys.

Analysis of the age structure of the tree stock at the five sites surveyed for NCC shows a consistent pattern of ageing. At these sites there is a high percentage of trees, of the native species, classed as either ancient or overmature. This pattern is summarised, in Table 4, for oak and beech at the four larger sites. Thus, the tree stocks at some of the most important parkland sites for saproxylic invertebrates are senescent (which may favour the fauna at the present time and probably for the next few decades), but they lack new generations of trees to provide suitable habitat in the future.

Proposals were drawn up for planting schemes for Moccas, Brampton Bryan and Dinefwr as part of the surveys for NCC (Table 5). Moccas was declared as a National Nature Reserve in 1981 and during the following decade some 1000 trees of native species were planted. A partial survey of the location and condition of the trees in this planting scheme is being undertaken in 1992 (Tom Wall pers. comm.). A recent management agreement for Brampton Bryan should lead to planting of a new generation of trees.

The National Trust uses its surveys of tree stocks in the preparation of planting plans. Such plans have been prepared for Dinefwr and Calke Parks and some limited tree planting has already taken place at these sites. The earlier (1979) planting scheme for Dinefwr predates the National Trust's involvement in the site.

Table 2 Total numbers of principal trees at selected sites

Species	Shute	Brampton Bryan	Moccas	Dunham Massey	Dinefwr Deer Park	Calke
			Sites			
Field maple	3		12			14
Sycamore	18	116	1	59	114	155
Horse chestnut		11	107	24	48	128
Alder		2	1	4	3	187
Birches	1	33		11		172
Box					3	
Hornbeam			1			2
Sweet chestnut	77	104	214	3	28	99
Hazel					9	
Hawthorn		11	14	11	20	491
Beech	4	211	250	282	82	168
Ash	58	4	15	10	32	37
Holly		1			4	2
Apple			1			1
Pines	10	56		20	26	81
Cherries				1	3	67
Native oaks	340	617	1,055	1,158	819	975
Rhododendron					21	
Willow/Sallow					1	20
Elder		17	2		1	
Rowan		2				
Yew		1			2	2
Limes	52	41	12	126	35	198
Elms	8	13	6	33	45	3
Exotic broadleaves		15	4	29	29	
Exotic conifers		51			9	
Total	571	1,306	1,695	1,771	1,334	2,802

Key to sites and dates of surveys:

Shute Deer Park, Devon, 1975/6; Brampton Bryan Park, Hereford/Worcester, 1979; Moccas Park, Hereford/Worcester, 1975/6; Dunham Massey Park, Manchester, 1979; Dinefwr (Dynevor) Deer Park; Dyfed, 1979; Calke Abbey Park, Derbyshire, 1986.

NB Totals include some dead standing trees.

Table 3 Examples of the accumulated loss of living trees due to natural events* in 1989 and 1990 compared with living trees in 1976/9**

			Moccas†	Brampton Bryan	Dinefwr Deer Park
Oak	Living trees	1976/9	438	613	786
	Losses	1989	1		4
	Losses	1990	4	4	35
		% loss	1.1	0.6	5.0
Beech	Living trees	1976/9	34	205	76
	Losses	1989	1		1
	Losses	1990	1	3	1
		% loss	5.9	1.5	2.6
Lime	Living trees	1979		41	35
	Losses	1989		1	
	Losses	1990		2	2
		% loss		2.4	5.7
Ash	Living trees	1979			28
	Losses	1990			3
		% loss			10.7
Sweet chestnut	Living trees	1979		100	27
	Losses	1989		1	
	Losses	1990		2	2
		% loss		3.0	7.4

* Surveys were made following the drought summers of 1989 and 1990, and following the winter gales of January and February 1990.

** Surveys in 1989 and 1990 used as baseline data from trees surveys in 1976 (Moccas) and 1979 (Brampton Bryan and Dinefwr Deer Park). Losses of trees in the intervening period are not listed.

† Lower Park area only.

Table 4 Age structure of oak and beech at four sites - number and percentage of trees

Oak	Moccas		Brampton Bryan		Dinefwr Deer Park		Dunham Massey	
	no.	%	no.	%	no.	%	no.	%
Dead	27	2	4	<1	23	3	13	1
Ancient	63	6	12	2	0	0	4	<1
Overmature	152	14	343	56	545	67	808	70
Mature	809	77	252	41	247	30	320	28
Young	4	<1	6	<1	4	<1	13	1
Total	1055		617		819		1158	

Beech	**Moccas**		**Brampton Bryan**		**Dinefwr Deer Park**		**Dunham Massey**	
	no.	%	no.	%	no.	%	no.	%
Dead	14	6	6	3	6	7	4	1
Ancient	0	0	0	0	0	0	0	0
Overmature	161	64	137	65	40	49	248	88
Mature	75	30	48	23	30	37	22	8
Young	0	0	20	9	6	7	8	3
Total	250		211		82		282	

These data are from surveys in 1976 to 1979 and define the age structures before active conservation measures were undertaken.

Key to age classes

Dead - Standing dead trees

Ancient - Fully grown trees which have suffered extensive dieback, with the majority of branches severely affected; many branches have been lost and there is substantial heart-rot

Overmature - Fully grown trees with dieback affecting a minority of branches, some of which may be completely dead; heart-rot is normally evident

Mature - Fully grown trees with negligible or no dieback of branches

Young - Trees still in active growth, but not yet fully grown.

Table 5 Tree stocks in 1976/1979 and proposed planting schemes (PPS)

	Moccas		Brampton Bryan		Dinefwr Deer Park	
	1976	PPS	1979	PPS	1979	PPS
Native oaks	1055	720	617	250	819	250
Beech	250	170	211	75	82	50
Ash	15	20	4	20	32	100
Field maple	12	20				
Small leaved lime	10	20		25		
Common lime	2		41		35	30
Hawthorn	14	n	11	20	20	40
Holly			1	10	4	10
Hazel					9	5
Alder	1		2		3	5
Sallow					1	5
Walnut	1		2		2	10
Sweet chestnut	214		104		28	10
Other broadleaves	121	50*	205		275	60
Totals	1695	1000	1198	420	1297	575

Key

* Owner's selection of trees

n Subsequent plantings have included hawthorn and additional ash and field maple

NB Not all tree species present at sites (see Table 2) are listed here.

Problems of site protection and management

Once a site has been identified as being of importance for saproxylic invertebrates, measures may be taken to provide some form of long-term protection to the site and to manage the site with the intention of preserving the known interest.

The selection criteria for biological SSSIs (Nature Conservancy Council 1989) cover sites such as parklands and ancient forest relics; many of the most important sites, identified using saproxylic Coleoptera as indicators, now have some measure of protection as SSSIs or National Trust properties (Table 1). As with any other habitat type, identification and statutory protection are merely two stages in the process of perpetuating the survival of the sites and their wildlife.

There are at least nine factors which must be considered in the process of site protection and management. It is particularly important to regard sites as populations of trees, with their own unique dynamics.

1. There is no scientific basis on which to judge that is the minimum size for a parkland to protect its known fauna. For saproxylic species the condition of individual trees is often crucial so that only one or two trees at a site may be suitable at any one time for an assemblage of species. However, a small isolated site, with few trees, for example Shute Park, Devon, will be more vulnerable to adverse events such as unsympathetic management, droughts or gales.

2. Those sites which have been surveyed in detail (Table 2) show a range of tree stocks, usually with oaks being most numerous. Although some saproxylic species are apparently not dependent on only one species or genus of tree, many species are limited only to oaks or beech or elms.

3. The age stucture of trees at most sites is heavily weighted to the older age classes (Table 4). This may favour saproxylics at the present time, but unless there are younger cohorts of trees at the site, there is a risk that in 50, 100 or 200 years there will be many fewer suitable trees at the site. It is sometimes difficult to get land managers, and even some conservation professionals, to acknowledge the need to establish new generations of trees. Natural regeneration is rarely practical because the sites are heavily grazed, so planting will usually be needed.

4. The density of trees varies considerably at sites. There is no scientific basis for determining how close together trees should be to ensure successful colonisation of newly available habitat by saproxylic species (some of which are flightless). At some sites, the variation in tree density within the site may mean that it is already fragmented into a number of effectively separate areas.

5. Harding (1990) has shown the erosion of the tree stock at three sites due to gales and droughts. There is no reason to believe that these sites are in any way exceptional, either in their rate of loss of trees or the events which caused the losses. In some cases the loss may already be critical. For example, the loss since 1975 of 15 (32%) of the beech trees in the open canopy area at Moccas Park may threaten the survival of several species which are believed to depend on beech.

6. The owners of sites may have a variety of objectives for the park, most of which will be related to getting a financial return from the land. These objectives often conflict with the conservationist's need to ensure the survival of large old trees and to manage the site for a long-term continuum of habitat availability.

Conflicts of objectives that we have encountered include:

Increase public access	-	fell 'dangerous' trees
	-	increase access areas such as paths and car parks
Increase grazing potential	-	improve pasture fertility
	-	remove lower limbs from trees to reduce shading
	-	remove fallen dead wood
Capitalise on timber	-	fell mature trees (remove the next potential generation of old trees)
Recreate historic landscape	-	remove old or 'damaged' trees
Introduce diversity	-	plant exotic species of trees
Leave it alone	-	long-term neglect and lack of regeneration.

7. Even among some conservation professionals there is a misguided view that dead wood which has fallen from a tree is of greater value for saproxylics than living old trees with dead wood. Fallen dead wood is certainly more accessible to entomologists trying to survey a site, but living large trees with some dead wood in the canopy and with heart rot are the true reservoirs of most populations. There are notable exceptions such as *Pyrrhidium sanguineum* and *Platypus cylindrus*, which breed only in newly detached oak branches, as well as newly cut logs in the case of *Platypus* (Winter 1993).

   However, any attempts to retain fallen dead wood, preferably in partial shade, will inevitably enhance the wildlife value of the site and will favour a number of saproxylic species.

8. Site owners/managers, especially the National Trust, are concerned to increase public access to sites. A few sites have been badly damaged by tidy-minded and over-zealous site managers: one of the worst examples we have encountered was at Studley Royal Park, North Yorkshire, where old trees have been systematically removed or have been shored-up by filling the hollow boles with concrete. This site has since been acquired by the National Trust and these practices have ceased.

9. Entomologists are a necessary evil! Only they are able to survey sites to assess their conservation value, but in doing so they inevitably have to destroy habitat and kill individual specimens. There is no quantitative evidence to suggest that collecting has so far threatened populations of saproxylics in Britain, but there is a real danger that unrestricted access for entomologists to collect could threaten the survival of some species at individual sites (see Annexes at the end of the volume). Traditional survey methods have been fairly crude, often with fallen dead wood being destroyed in the process of sampling. Less destructive methods are now being used on large-scale surveys (Hammond & Harding 1991), but the majority of entomologists will probably retain their technologically less sophisticated methods, which, when used by a *skilled expert*, are highly effective for finding species.

The role of the National Trust in conserving parklands

The National Trust owns and manages more than 100 historic parks across England, Wales and Northern Ireland. A high proportion of these have some nature conservation interest, while seven feature in Table 1 as parks of national significance for the conservation of saproxylic communities. These seven constitute 28% of the historic parks listed in Table 1.

The Trust has been investigating the specific nature conservation interests of its historic parks as part of its national programme of biological surveys of its properties. Further specialist survey has been commissioned in parks which appear from early investigation to support rich saproxylic communities, and where further detail of the interests was needed for site management purposes. At the same time, the Trust has been carrying out tree surveys and archival research on its parks.

None of the Trust's parks were acquired for nature conservation reasons. They were generally acquired as part of the estate attached to a country house, sometimes for specific landscape or historic interests, eg Capability Brown or Repton designed landscapes. Until recently the Trust was the only conservation organisation which acquired and managed parkland habitats - English Nature is now increasingly becoming involved in parkland management, eg at Moccas, Brampton Bryan and Duncombe Parks.

The nature conservation interest of the Trust's parks was often not initially appreciated, but now, following the Trust's biological survey, specific interests and their management implications have been identified for most parks.

The Trust's management policies have been evolving over the years and the last decade has seen considerable advances in the appreciation of nature conservation and other interests in its parklands. It is now accepted in the Trust's landscape parks that relic interests, which date from before the period of landscape gardening, should be preserved and perpetuated so far as this is possible, ie that old trees which support important relic old forest saproxylic communities should be retained and kept alive as long as possible, and that their associated dead wood should be retained *in situ* wherever possible. It is also now accepted that rough pasture in parks should not be improved agriculturally. The whole approach to parkland management in the Trust is being re-appraised in liaison with the Trust's advisers on gardens, archaeology, forestry and nature conservation.

The way forward

Although an inventory of sites of known or potential importance for saproxylic invertebrates was compiled for NCC in the 1970s (Harding 1978b) there has been comparatively little follow-up. More of these sites should be surveyed by entomologists, where appropriate using quantitative techniques such as those described by Hammond & Harding (1991). More surveys in northern England, Wales and Scotland are particularly needed as these areas have been less well-worked than southern England in the past.

In some cases the information gathered in the 1975 to 1979 surveys will be seriously out-of-date, particularly for privately-owned sites which have not been protected by SSSI status or by management by the National Trust.

The Index of Ecological Continuity is based on fewer than 200 species of Coleoptera and has the potential to be extended to cover more beetles and other taxonomic groups (especially Diptera and Aculeate Hymenoptera) and to be restructured to provide regional indices. Alexander (in prep.) has begun considering other taxonomic groups.

There are two simple messages from our work:

1 Many important parklands have senescent populations of native tree species, which in some cases are vulnerable to natural events such as extremes of weather;

2 Unlike most other woodland types, natural regeneration is not and never has been a realistic option for the establishment of new generations of trees in pasture-woodlands (unless grazing and browsing mammals are excluded), so that active planting should be the priority for the regeneration of trees.

Criteria for the selection of sites for expensive management procedures need to be considered, if limited resources are to be used to best effect. In some cases the fact that there are owners or managers with a sympathetic approach to nature conservation and historic landscapes may be as important as the purely ecological criteria.

It is simple (but rarely easy) to throw money at a problem, but the results of expenditure need to be measured to be sure that the management of the site is having the desired effects. Techniques for monitoring saproxylic invertebrates and measuring the effects of management on populations have not yet been developed and there is a pressing need for research on possible methods. Techniques for monitoring should be based on quantitative sampling techniques, such as those described by Hammond & Harding (1991). Sites should be monitored to quantify changes in the availability of suitable habitat. Losses of trees, the fate of dead wood and any tree planting must be recorded so that any correlations with changes in the fauna may be assessed.

Conclusions

Although Britain has both an impoverished saproxylic fauna and sparse native woodland cover, when compared with much of the rest of Europe, we have probably the best documented fauna and a large number of known and potential sites at which saproxylic assemblages survive. Most of the known important sites have been scheduled as SSSIs under the Wildlife and Countryside Act 1981. Some of these sites are parklands which are, or should be, protected as historic landscapes and have been catalogued as such by English Heritage.

Considerable progress has been made, if slowly, in conserving sites for saproxylic species, and the United Kingdom has gone some way in following Recommendation No. R"88"10 of the Council of Europe Committee of Ministers on the protection of saproxylic organisms and their biotopes (see Speight 1989).

However, much of the basis for the evaluation of sites has been subjective and often anecdotal information, for the very simple reason that no other data were available at the time. Now it is time to build on our present state of knowledge and to bring a little more science into the process of evaluating and safeguarding sites.

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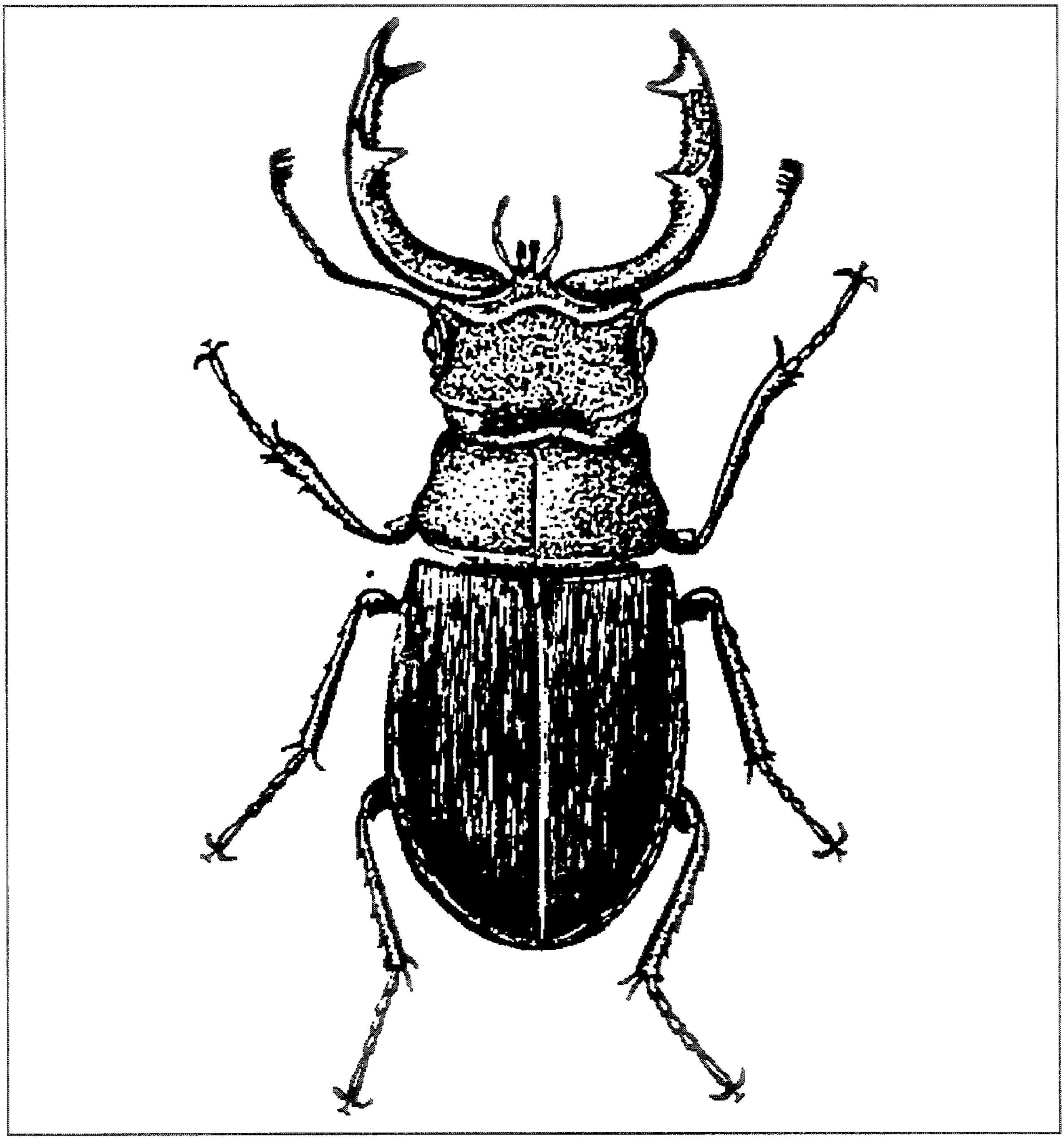


DEADWOOD - IS IT A THREAT TO COMMERCIAL FORESTRY?

Tim Winter, Forestry Commission, Alice Holt Lodge, Wrecclesham, Farnham, Surrey

Introduction

The question as to whether the retention of deadwood poses any kind of a threat to commercial forestry in Britain has been a controversial issue between foresters and conservationists in the recent past. I am going to look at the reasons for these differences of opinion and to examine whether foresters need to be concerned about leaving deadwood, bearing in mind that it is now recognised to be important for the future survival of many uncommon or nationally scarce species of saproxylic invertebrates.

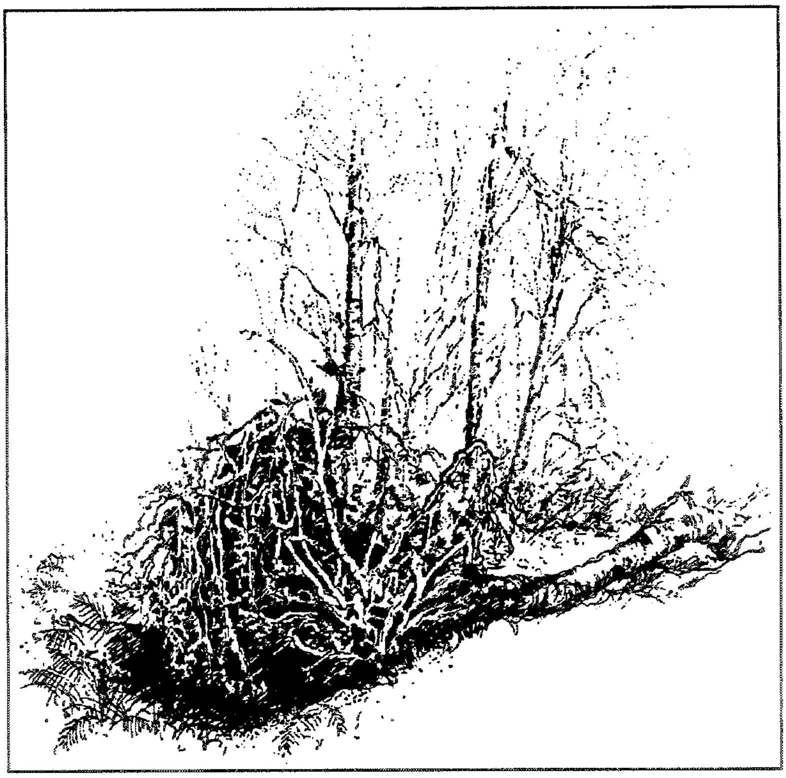
History of forest hygiene

From quite early on foresters were taught that hygiene in the forest is of prime importance to ensure that their crops remain as free as possible of damaging pests and diseases. In 1679 Moses Cook, writing in his guide to *The manner of raising, ordering and improving forest and fruit trees*, stated that "When trees are at their full growth, there be several Signs of their Decay, which give you warning to fell it before it be quite decayed". He was apparently aware too of the activities of insects such as cerambycids, buprestids and scolytids that live in the cambium and sapwood, as he also wrote "If worms be got between the bark and the body of your tree; they must be cut out; and the place done over with loom" (*sic*). This latter statement was reiterated and elaborated by J Mortimer in the 2nd edition of *The whole art of husbandry or, the way of managing and improving of land*, published almost 40 years later in 1708. Here Mortimer said that "The Teredo, Cossi [the goat moth *Cossus cossus*] and other worms lying between the Body and the Bark, poison the passage of the sap, to the great prejudice of the Trees; but the holes where they lie being found out, open them, and make a small slit from the bottom of them to let any moisture that may fall in them, run out, and do the place over with loam". So it appears that in the seventeenth and early eighteenth centuries there was an awareness of pests and diseases affecting large timber trees, with advice being given to fell any which were showing signs of ill-health or decay, although this was intended perhaps more for those in charge of parklands, rather than the larger woods.

The advice of these earlier writers seems to have been toned down or lost during the next century. By 1820 Robert Monteath, writing in *The forester's guide or a practical treatise on the training and pruning of forest trees* about "fir plantations" makes no mention of insect problems, even in the section dealing with "larch fir and common Scotch fir". Just a few years later, however, in 1839, J Main writing in *The forest planter and pruner's assistant* says, after an account of the activities of *Scolytus destructor* (Olivier) [= *S. scolytus* (F.)] on elms, that "There are many other insects which are injurious to trees by destroying the foliage, young shoots, bark, and even sound timber of several species. But these attacks on forest trees are all out of human power to prevent". Monteath (see above) mentioned a lack of entomological problems on either native Scots pine or introduced larch, but it was during the nineteenth century that planting of these, and additional exotic conifer species from both Europe and North America, took place on a wide scale. Because of this interest in the silviculture of European conifers, several forestry textbooks were translated from German into English at this time (Fürst (1892) & Fisher (1895)). This had an important bearing on the attitude to forest hygiene here in Britain. All of these sources deal in particular with two insects that have caused, and continue to cause, serious damage in conifer plantations, and are of great concern to European foresters. These are both in the family Scolytidae (or bark beetles) and are both potentially lethal pests of Norway spruce *Picea abies*. They are *Dendroctonus micans* (Kugelann), perhaps the slightly less worrying of the two species, and *Ips typographus* Linnaeus, a very aggressive scolytid. Given the right conditions following a natural disaster, such as widespread windthrow or snow- and ice-broken trees, *I. typographus* can rapidly increase in numbers within one season and can move on to kill a standing and apparently healthy crop. Notable outbreaks are listed by Wainhouse (1987) (Table 1). These past outbreaks have attracted the attention of a far wider audience than just European foresters and woodland owners. The devastation caused in Germany from 1868 to 1875 led Charles Tennyson Turner, brother of the Poet-Laureate Alfred, Lord Tennyson, to write a sonnet entitled 'The Sighing of the Boehmer Wald', published posthumously in 1884 (Winter & Burdekin 1987).

Table 1 Timber losses following *Ips typographus* epidemics (data from Bakke and Riege in Wainhouse (1987)).

Country	Date	Losses ($m^3 \times 10^6$)
Germany	1857-62	4.0
	1868-75	4.0
	1917-23	1.5
	1940-41	1.0
	1944-48	30.0
Sweden	1976-79	2.0
Norway	(1970)-82	5.0



Fortunately *I. typographus* has never become established in Britain (Winter 1985), although it has sometimes arrived here in large numbers under bark on spruce timber. This trade is therefore no longer allowed under the Plant Health (Forestry) (Great Britain) Order 1989, except for the importation of ladder poles, which is permitted under special conditions.

Unfortunately *D. micans* slipped through this vigorously applied plant health legislation (Bevan & King 1983), but it is being contained within an area in Wales, the Welsh borders and Lancashire, by restricting the movement of spruce timber (Statutory Instruments 1982 No. 1457 The Restriction on Movement of Spruce Wood Order as amended). Furthermore a predatory beetle, *Rhizophagus grandis* Gyllenhal, that is specific to this host (King & Evans 1984) has been successfully introduced as a means of biological control.

In the past the above pests of spruce were the main cause for concern in European forestry, but in Britain there were also fears about the pine shoot beetle *Tomicus piniperda* (L), which, while unable to kill pines under normal circumstances, can do so when trees are severely stressed by drought or because of defoliation by the pine looper moth *Bupalus piniaria* (L) (Crooke 1956). *T. piniperda* is also responsible for the degradation of freshly cut timber by blue stain fungi *Leptographium* spp., which are introduced via the beetle breeding galleries under the bark (Gibbs & Inman 1991). It can also adversely affect the shape of growing trees when the young, sexually immature beetles mine in the current foliage shoots of pine during the summer (Davies & King 1977). So this group of bark beetles, more than any other pests or diseases, was the reason why writers such as Fürst (1892) and Fisher (1895) so strongly recommended 'the quick removal of all sickly trees', 'the removal from the wood of all valuable timber with thick bark before the beetles emerge' and 'the uprooting of stumps and broken trees' in pine woods.

Where re-afforestation was to occur such hygiene methods were also necessary to prevent the weevil *Hylobius abietis* (L.) from increasing in numbers and causing serious economic damage. This species breeds under bark in stumps, roots or recently felled conifer timber in contact with the ground. The adult weevils feed on the stems of transplants, both on conifers and broadleaved trees, which are ring-barked and killed. A similar pattern of breeding and feeding occurs in all six species of *Hylastes* found in Britain. These scolytids breed in thinner barked material than *Hylobius*; the adults of five species tunnel into the root collars of pine transplants; the sixth species is found mainly on spruce. These insects are still the most serious pests of re-afforestation, but insecticides and other methods are now used to reduce the damage they cause (Stoakley & Heritage 1990).

Procedures such as those advocated by Fürst and Fisher are good forest practice in larger-scale forestry operations and plantations where much commercially grown pine is at risk. The promotion of good hygiene in such situations is also recommended by all twentieth century lecturers in forestry courses and writers such as Gillanders (1908) and Chrystal (1937). However, the principle has been taken further and been applied to all forest crops and in all situations, leading to a 'tidy garden' attitude towards woodland and forests.

Are such measures always necessary? Does stringent forest hygiene need to be applied to all forest crops? What advice should be given to the next generation of foresters, in whose care the new and more diverse forests in Britain will continue to expand during the next century? Is there any unavoidable conflict between their interests and the conservation of what few ancient trees we have left, both here and on the Continent, for future generations of saproxylic invertebrates?

Present-day timber pest problems: conifers

What has been said so far relates only to several well known pests of large-scale conifer plantations, two of which are restricted to exotic conifers in Britain, although *D. micans* can sometimes be found on pine. In this respect the area of conflict between the commercial forester and the conservationist in England and Wales scarcely exists; there are no native pine woods in either country and, except perhaps in the Breckland pine forests of East Anglia, there are few 'special' saproxylic insects associated with plantation trees. One exception, in southern Britain, where Scots pine (*P. sylvestris*) has been planted from the seventeenth century onwards, is the very restricted robber fly *Laphria gilva* (L.), which was discovered in 1938 in Windsor Forest. This species is associated with large pine stumps and deadwood; the larvae are probably predatory on saproxylic beetle larvae and its occurrence in Windsor in 1938 is interesting, since Scots pine had been established here in about 1760 in the Belvedere Plantations (Elwes & Henry 1910). However, the only subsequent records of this fly were in 1946 at Oxshott, Surrey, and at Silchester on the Hampshire/Berkshire border (Stubbs, A., in Shirt 1987). As there is no danger to the health of the forest through the presence of this fly, its specialised habitat can be left undisturbed in areas where the species may still occur.

Scots pine is our only native, high forest conifer and is of greatest interest in the Caledonian Forest areas of the central Highlands and north-west Scotland. Here the immediate conservation interest concerns the continuity of large and old trees. The Forestry Commission Census of Woodlands 1979-82 showed that, of a total area of 144,371 ha of Scots pine high forest in Scotland, 4,915 ha were planted before 1861. Initially therefore a forest manager might think that there is a risk of *T. piniperda* and two other bark beetles, *T. minor* (Hartig) and *Ips acuminatus* (Gyllenhal), causing some problems in the north. However, records from Forestry Commission colleagues at our Northern Research Station do not show any significant problem with these insects in areas where the Caledonian pines still exist; reports of damage by *Tomicus* spp. have been from newer afforested plantations only (S. Heritage, pers. comm.).

In the British Red Data Books (Shirt 1987) under the endangered or vulnerable categories there are seven Coleoptera, three Diptera and one species of Hymenoptera listed as being associated with, or reliant upon, decaying, dead or dying pines in Scotland. None of these species is in any way considered to be a potential pest.

In the case of other introduced conifers, such as the spruces *Picea*, larch *Larix*, Douglas fir *Pseudotsuga menziesii* and the silver firs *Abies*, grown as crops in plantations, there are a number of phytophagus insects now found in Britain that are specific to these trees. Of these insects only two are saproxylic species. *Trypodendron lineatum* (Olivier) is a minor pest of softwood logs, especially spruce, in the wetter parts of the British Isles, where it causes technical degrade of timber (Bevan 1987). *Ips cembrae* (Heer), first found in Britain in 1955 (Crooke & Bevan 1957), has killed stressed larch in the drier parts of Scotland. There seems to be little possibility that any of the rarer saproxylic invertebrates associated with these conifers in Europe or North America will ever reach Britain, and even less chance that they will become established here or cause health problems in commercial forest plantations.

Present-day pest problems: broadleaved trees

There are generally no major threats to the health of broadleaved trees equivalent to those posed by bark beetles to spruce and pine. Neither is there the same potential for timber-boring beetles (such as the scolytid ambrosia species and cerambycids) or siricid woodwasps to cause serious degrade of broadleaved logs, since such insects colonise just the outer wood, or the sapwood in trees forming heartwood, and this is generally discarded when the logs are converted into boards.

There are, however, one or two exceptions to this rule. The better known of these is the well publicised problem with Dutch elm disease caused by *Ophiostoma* (= *Ceratocystis*) *ulmi* (Buisman) C. Moreau. The species of bark beetles (*Scolytus* spp.) that are vectors of the fungus breed under the bark of freshly dead or dying elms (*Ulmus*). In some ecologically isolated areas, such as Brighton and Guernsey, attempts to control the spread of the disease have involved sanitation felling of all infected trees. To prevent transmission of the fungus, all bark on the felled trees must be destroyed. If the bark is removed first, then the remaining wood will still provide a suitable habitat for some saproxylic invertebrates, but the usual, and cheaper, solution is the burning of the entire tree. This has serious consequences, not only for any saproxylic invertebrates already established in rot holes and hollows, but also for future generations that will be deprived of a potential habitat. However, in the long term it is also damaging to allow the disease to progress unchecked, since this breaks the continuity of the habitat by killing all the elms within a few years.

A second exception with broadleaved trees has arisen in the last two or three years and, from the point of view of the timber trade, is potentially very serious. The oak pinhole borer *Platypus cylindrus* (F.) is listed in the rare category of the *British Red Data Books, 2: Insects* (Shirt 1987). Taxa included in this category are defined as having small populations that are not at present endangered or vulnerable but are at risk. They are usually localised within restricted geographical areas or habitats, or are thinly scattered over a more extensive range. The criterion used is that the species exists in only fifteen or fewer 10 km squares. Records from the Entomology Advisory Service at the Forest Research Station (Alice Holt Lodge) are consistent with the rarity of *P. cylindrus*. It was rarely encountered by foresters or the timber trade, with the only enquiries before 1989 being two in the 1950s, two in the 1960s, and one each in 1976 and 1983. There were single enquiries in 1989 and 1990, but then nine in the autumn of 1991, mainly from timber merchants, in some cases enquiring on behalf of other colleagues as well as themselves, indicating that damage was more widespread than just the number of enquiries suggested. A survey around the Forest Research Station showed that *P. cylindrus* is quite common at present in Alice Holt Forest, breeding in trees blown over in the gales of October 1987 and January 1990. It is most frequent in oak, but I have also found it in sweet chestnut and beech, and there are previous records in ash from other areas in Britain (Hicken 1963), and walnut in Europe (Schwenke 1974).

P. cylindrus is an ambrosia beetle, in the family Platypodidae, and the gallery system is constructed almost entirely by the adult beetles, the larvae feeding on ambrosia fungi growing on the tunnel walls. The bore dust from *P. cylindrus* galleries in late summer and early autumn is fibrous, composed of slivers about 1.5-1.8 mm long, compared with the granular bore dust from *Trypodendron* spp. (ambrosia beetles in the family Scolytidae). The gallery systems of *T. domesticum* and *T. signatum* only penetrate the sapwood and are therefore of no concern to the timber trade. The branched galleries of *P. cylindrus*, however, can penetrate deep into the heartwood of oak, take up to two years to complete and reach a maximum recorded length of 1.8 m (Hicken 1963). This has led to great concern in the timber trade when logs are air-dried for high quality cabinet making or construction work. Such timber is kept in the round for about four years, and there is a very real possibility of disastrous degrade occurring before such logs are planked. The current increase in *P. cylindrus* appears to be a consequence of the glut of suitable breeding material made available by the storm of October 1987, which affected an area that roughly coincides with the known distribution of the beetle in southern England, although it also occurs as far north as Shropshire and westward to mid-Wales. Further windblow of broadleaved trees occurred in these parts of England and Wales during January 1990. *P. cylindrus* is known to breed in timber up to four years after felling, so it appears that this formerly rare species may remain more common for several years to come. *P. cylindrus* damage however will probably not be viewed as a long-term problem for commercial forestry and thus should not become a reason for destroying ancient oaks and other broadleaved trees. Although this beetle certainly breeds in the parts of old trees where die-back is occurring, or in stumps of recently felled trees, it has never caused any problems to the timber trade until provided with a super abundance of breeding material in areas which have a long history of woodland cover. It will be interesting to try and record the development of this outbreak from rarity to pest during the next few years. This can most easily be done by collecting, with clear sticky tape, bore dust samples from logs from August to October. With the movement of timber from the south and west to sawmills in other parts of the country there is a very real possibility that *P. cylindrus* may subsequently be found to have become established in Midland counties, and even further north, during the next few years. It is fortuitous that the Scolytidae Recording Scheme, recently announced by the Biological Records Centre at Monks Wood, includes *P. cylindrus* on the new RA73 cards. As organiser of the scheme I will be pleased to receive any records of this species, as well as any bark beetles, both now and in the future.

Conclusions

Having considered the major risks to forest crops from insects that breed in dead or dying trees, we can return to the questions raised earlier.

1. Is there a need for stringent forest hygiene measures to be applied to all crops?

   There is a very real risk of damage caused by insects in coniferous plantations, more especially pine and spruce, and particularly where there are large-scale forest operations taking place. However the resulting need for sanitation is of very little concern to the conservation of saproxylic invertebrates in Britain, apart from in the Caledonian forest areas of Scotland. In broadleaved woodland the risk of insect damage to either trees or timber when ancient trees or deadwood are retained is almost nil. However, as recent circumstances have shown, even here there has been rather unexpected damage caused by a beetle considered to be rare, although the possibility that *P. cylindrus* might become more common was suggested soon after the 1987 storm (Winter 1988).

2. Secondly, is there any conflict between the forest manager and the conservation of deadwood and uncut trees?

   In most woodland, none at all, but, as stated above, the forest manager does need to take measures in commercial conifer plantations to limit the build-up of the weevil *Hylobius abietis* and certain bark beetles that breed in fresh stumps and other larger trunks left on the forest floor after felling operations or windblow. However such management is usually in places of very limited interest for saproxylic invertebrates. The only area where the practice of forest hygiene may conflict with deadwood conservation is in the Scottish Highlands, where native and over-mature Caledonian pines still exist.

   In order to maintain a high standard of hygiene in susceptible conifer plantations the forester must monitor and manage harvesting operations to avoid increases of potential pest species. It is stressed that restraint should be exercised (safety reasons permitting) in clearing away any other deadwood from the forest environment just to keep the woodland tidy.

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THE LIABILITY OF OWNERS AND OCCUPIERS OF LAND WITH LARGE, OLD TREES IN ENGLAND AND WALES*

Charles Watkins, Department of Geography, University of Nottingham, Nottingham, NG7 2RD

Neil Griffin, Solicitor, Scott Rowe, Axminster, Devon, EX13 5DS

What liability do you have?

Suppose you are an occupier of land and somebody gets injured whilst on your land, and then seeks to claim against you. That person must prove: you owed him or her a duty of care; you were in breach of that duty; and that he or she suffered damage as a result.

The duty owed depends on whether the injured person was a lawful visitor or not. Lawful visitors include:

a. anyone you have invited on to your land such as your guests. (This includes people who have an implied invitation to visit you, such as the postman, tradesmen delivering and probably, too, the vicar calling to see you uninvited);

b. anyone who has paid to enter your land, such as visitors to a stately home or spectators at a point-to-point;

c. people who enter in exercise of a right conferred by law. This would include, for example, a policeman entering to arrest somebody, and an employee or agent of an electricity board who has entered to lop trees in the way of overhead cables (Parliament 1926).

The duty owed to lawful visitors

An occupier owes to all lawful visitors what is called a "common duty of care". This is defined by the Occupiers' Liability Act, 1957, as, basically, a duty to take reasonable steps to ensure that your premises (including woodland) are reasonably safe for visitors for the purposes for which they are permitted to be there (Parliament 1957). In deciding whether you have fulfilled your duty, the Court has to draw the line somewhere. It has to consider "all the circumstances of the case". The Act says that you must be prepared for children to be less careful than adults, but that you may expect that an expert will guard against any special risks which are part of his or her job. So, for example, if you called in an arboriculturist to inspect a dangerous tree, and he or she got hurt whilst inspecting it, you would probably not be liable. The arboriculturalist should have known better. You may be able to discharge your duty by erecting adequate warning notices, but you must be aware that a child may not understand such a notice. So, if children are likely to be among your 'lawful visitors' a notice would not be enough.

Note

*This is a modified version of two previously published papers: Griffin, N.M. and Watkins, C. 1986. Liability for dangerous trees, *Quarterly Journal of Forestry*, **80**, 23-26; and Griffin, N.M. and Watkins, C. 1986. Public access to woodland and the owner's liability as an occupier of land, *Quarterly Journal of Forestry*, **80**, 151-158.

Contracting out of the duty owed to lawful visitors

Since the passage of the Occupiers' Liability Act 1984, you can contract with a visitor to restrict your liability under the 1957 Act. This act had allowed an occupier to contract out of the common duty of care. However this provision is qualified by the Unfair Contract Terms Act 1977 (Parliament 1977) which provided that, if the occupier was "a business", then the occupier could not contract out of his "business liability" for causing death or personal injury, and could only contract out of liability for other damage if he proved that his exemption clause (excluding liability) was "reasonable". The aim of the provision was to stop businesses from getting out of their obligations under the 1957 Act, but it had an unfortunate side-effect on farmers and foresters who found that they were unable to exclude their liability to people who were using their land for leisure purposes such as rock climbing or orienteering through old woodland. This caused considerable concern to the various land-use groups.

Section 2 of the 1984 Act says that there is no "business liability" when an occupier grants access to his land for educational and recreational purposes, even if the occupier is "a business", unless the occupier's business purpose is to provide land for educational or recreational use. Where there is no "business liability" the restrictions of the Unfair Contract Terms Act 1977 do not apply, and so an occupier can exclude his or her liability to lawful visitors.

Thus if you are in the business of forestry or agriculture you can allow people to come orienteering or rock-climbing on to your land, and make such visitors agree that your duty to them is excluded. You must not take any money from them. If, however, you run a wildlife park, an arboretum or a stately home, you are in the business of providing land for recreational or educational purposes and cannot exclude your liability. Landowners who use 'honesty boxes' for visitors to pay a small sum for the upkeep or fencing of the land should note that this might be construed by the Courts as being "the business of providing land for educational purposes" and so be caught by the Unfair Contract Terms Act.

The duty owed to people other than your lawful visitors

This category includes not only trespassers, but also people who enter your land on a public footpath or bridleway, or by virtue of a private right of way across your land. It does not include persons on the highway. In the rest of this paper we use the general word 'trespassers' to include not only those who are truly trespassing, but also those who are lawfully using public or private rights of way.

The old law was that an occupier owed no duty to trespassers, beyond a duty not to do any act intended to injure them, such as setting spring guns (Bird v Holbrook 1828). A trespasser trespassed at his own risk. This rule could work very harshly upon children who trespassed innocently. In Addie v Dumbreck (1929) a trespassing boy was killed by machinery whilst playing. The House of Lords held that the occupier was not liable. This decision was criticised as being inhumane, and so the Courts found various ways to get round it in subsequent cases, and so make the occupier liable. (Lord Denning spoke in Pannett v McGuinness (1972) of "the ways and means by which we used to get round Addie v Dumbreck".) The law became unclear.

On 7 June, 1965, a six-year old boy called Peter Herrington was playing in a public field at Mitcham, Surrey. He wandered through a broken fence onto a railway line and was badly injured by the live electric rail. He sued the British Railways Board and the case went up to the House of Lords where judgement was given for the boy (Herrington v British Railways Board 1972). The Law Lords conceded that they were not following the Addie case. Unfortunately, however, their speeches still left the law slightly uncertain. Various interest groups were keen to get a clear statement of the law, and eventually the Occupiers' Liability Act 1984 was passed. Nevertheless, the speeches of the Law Lords in the Herrington case may still be of help in the interpretation of the 1984 Act.

The Occupiers' Liability Act 1984 sets out, in Section 1, when you, as an occupier, owe a duty to persons other than your lawful visitors (Parliament 1984). You now owe a duty to such persons if you occupy land and: you are aware of any particular danger on your land (or have reasonable grounds to believe that a danger exists); and you know (or have reasonable grounds to believe) that such persons are in the vicinity of the danger or may come into its vicinity; and the risk is one against which, in all circumstances of the case, you could reasonably be expected to offer some protection.

If these conditions are fulfilled, you owe a duty to take such care as is reasonable, in all the circumstances of the case, to see that such persons are not injured by the danger. In appropriate cases, you may discharge that duty by the use of warning notices - but this in itself may not be enough where children are involved.

The duty only arises at all if you know, or have reasonable grounds to believe, that people other than your lawful visitors are likely to come within the vicinity of the danger. Lord Reid said in Southern Portland Cement Limited v Cooper (1974, 97-98) that: "an occupier is entitled to neglect the bare possibility that trespassers may come to a particular place on his land but he is bound at least to give consideration to the matter when he knows facts which show a substantial chance that they may come there."

This still leaves the question 'What is reasonable care, in all the circumstances of the case?' The Law Commission (1976) said that a Court should take into account, amongst other things: the age and character of the trespasser; the purpose of the trespass (for example, whether the trespasser was intending to steal); the likely cost of taking precautions.

In Herrington (1972, 796) itself, Lord Diplock said that there could be other material considerations for the Court. These included: whether the danger was permanent or intermittent; the severity of the injuries the danger was likely to cause; in the case of children, how likely it is that they will be attracted to the danger. The law had, long before Herrington, recognised that certain things can be an "allurement" to children and required occupiers and others to take special precautions. In Glasgow Corporation v Taylor (1922), the corporation had some deadly nightshade (Atropa bella-donna L.) in one of its parks, which grew attractive but poisonous berries. A seven-year old child picked some, ate them and died. The corporation had done nothing to give effective warning to children of the dangers, and was held liable, even though the child was trespassing. Likewise, in Cooke v Midland and Great Western Railway of Ireland (1909), the railway knew that children habitually played with a railway turntable, but did nothing to stop them. One day, a four-year-old child was injured. The railway company was held liable, even though the child was trespassing: the turntable was an allurement.

Two further examples may be put forward. In Mourton v Poulter (1930), the defendants were found liable when a nine-year-old boy was hurt by a tree falling onto him as it was felled. In Buckland v Guildford Gas Light and Coke Co. (1948), the defendants were found liable when a 13-year-old girl left a footpath, climbed a tree, and was killed by high tension electric cables which had become concealed by the tree's foliage growing round them; the tree had a low branch and no warning notice. So, the occupier must take special care when he knows that children play on, or are likely to play on, his or her land.

The Law Commission (1976) said that the financial resources of the occupier should not be considered when deciding what was "reasonable care". This was not the view of the law Lords in Herrington (1972): Lord Reid, Lord Wilberforce and Lord Diplock all said that the Court should consider the occupier's means. Lord Wilberforce referred to the similar principle set out in Goldman v Hargrave (1966), which was affirmed in Leakey v National Trust (1980).

The Law Lords in Herrington also made comments which might serve as practical advice for occupiers who wish to comply with the 1984 Act. Reviewing the case law to Herrington (1972, 779), Lord Pearson said: "In simple language, it is normally sufficient for the occupier to make reasonable endeavours to keep out or chase off the intruder who is likely to be or is in a dangerous situation. The erection and maintenance of suitable notice boards or fencing or both, or the giving of suitable oral warning, or a practice of chasing away trespassing children, will usually constitute reasonable endeavours for this purpose .... .

He went on to refer to "the agility, ingenuity and persistence of boy trespassers", and commented that: "It would in many, if not most, cases be impracticable to take effective steps to prevent (instead of merely endeavouring to deter) trespassers from going into or remaining in places of danger. The cost of erecting and maintaining an impenetrable and unclimbable, or, as it has been put, 'boy proof' fence would be prohibitive, if it could be done at all." He went on to quote with approval the Lord Chief Justice in Edwards v Railway Executive (1952, 437): "Had [the Railway Executive] to provide watchmen to guard every place on the railways of the Southern Region where children may and do get onto embankments and lines, railway fares would be a great deal higher than they are already."

Lord Diplock said in Herrington (1972) that the duty may well require you to erect a suitable fence or obstacle. The fence should be difficult to get through: this would make it clear to any child that the land beyond the fence was forbidden territory. In the Herrington case itself, all five Law Lords found for Peter Herrington. The evidence was that the British Railways Board knew that the fence was broken, knew that small children were getting onto the railway, and did nothing to repair or maintain the fence.

Implications for woodland management

There are many operations in forestry which are highly dangerous, and some of these would also be highly alluring to children. The occupier must be especially careful, particularly when he knows that children might be about or that *de facto* access occurs regularly. The forester and forest workers must keep their eyes open for playing children and chase them away. However, you should be aware of the warning of Lord Justice Edmund Davies (as he then was) in Pannett v McGuinness that it may well not be enough just to warn off trespassing children. Anything which is especially dangerous, such as a deep reservoir holding water in case of fire, or a yard holding potentially dangerous equipment, should perhaps be specially fenced. Even greater precautions are required if public footpaths run through a wood where dangerous operations are being carried out: in some cases it may even be necessary to post watchmen to check that no one enters the dangerous area. Lastly, although prevention is better than cure, the woodland owner should have adequate insurance.

Liability for dangerous trees

On the 25 February, 1961, there was a thunderstorm over Western Australia. A red gum tree was struck by lightning and caught fire. Its owner cut it down, and then left the tree to burn itself out. In fact, the fire revived and spread to a neighbour's land causing considerable damage. The neighbour sued. The case eventually came before the Privy Council in England, which acted as the final appeal court for Australia, and whose decisions are persuasive precedents in English law. The owner argued that he was not liable because the damage arose from something naturally on the land. The case was argued for three days and from it emerged a principle which affects all landowners with trees (Goldman v Hargrave, 1966).

The Court held that the owner of the tree was liable for the damage. A hazard had arisen. A duty then arose, and the owner had to take reasonable steps to remove or reduce the hazard. In deciding what is "reasonable" the Court said that it must consider the financial circumstances of both the owner and the victim, and the likely cost of the steps required. A poor owner would not be expected to undertake expensive works.

There remained some doubt as to whether this Australian case accurately stated the Law of England. A case in 1979 (Leakey v National Trust, 1980) removed this doubt. Rising from the Somerset levels is a steep conical hill of some nine acres called the Burrow Mump. This is accessible from the A361, near Burrowbridge, Somerset, and is owned by the National Trust (1983). Following the dry summer and wet autumn of 1976, a considerable quantity of soil fell from the Mump onto a garden owned by Mr Leakey. He sued the Trust, who claimed that they were not liable: the hazard arose from something naturally on the land. The Court of Appeal applied Goldman v Hargrave and found the Trust liable.

These decisions mean in essence that if you have a tree on your land, you are under a duty to ensure that the tree does not cause harm to anybody. This duty arises when you know, or ought to know, that the tree is likely to cause harm. Some trees such as yews are poisonous and are therefore likely to cause harm. Most trees, however, are only likely to cause harm if they are diseased or dying or perhaps if they are growing near a highway.

You are required to take all "reasonable steps" to prevent or reduce the harm: this is the scope of your duty. Liability for dangerous or overhanging trees had traditionally been based on what the law calls "nuisance". There had been indications that the new concept of "negligence" was spreading into nuisance by trees, and the Goldman and Leakey cases showed that this was how the law was developing.

Liability for poisonous trees

If the trees are self-sown or otherwise 'naturally on the land', or are there as a natural use of the land, or are brought onto the land in the course of the natural use of land, then you owe no special duty save as set out above. But, if you brought the trees onto your land, and it is not a natural use of the land, then you are strictly liable for any damage done if any parts of the tree (such as branches or leaves) 'escape' from your land. This is called the rule in Rylands v Fletcher, or strict liability for dangerous things on land. In Crowhurst v Amersham Burial Board (1878) the defendants had planted on their land a yew tree which overhung the plaintiff's meadow whereby a horse of the plaintiff fed on the projecting portion of the yew and was poisoned. The defendants were found liable.

Liability for non-poisonous trees

There is some authority for suggesting that the Amersham principle applies to non-poisonous trees as well. In Smith v Giddy (1904) the Court of Appeal held that a defendant was liable when his elm and ash trees overhung the plaintiff's premises and interfered with the growth of his fruit trees; the Court found for the plaintiff and said that this was an application of the Rylands v Fletcher principle. But in Noble v Harrison (1926) it was held that Rylands v Fletcher liability did not apply to trees which are a natural use of the land, whether self-sown or planted.

Trees near the highway

Here the damage is likely to arise if the trees blow down or if branches drop off. The two problem areas are whether you know, or ought to know, that the tree is dangerous, and secondly what steps you should then take.

Knowledge of harm arising. There had been many cases upon this before Leakey. You are required to act as "an ordinary prudent landowner would act" (Caminer v Northern and London Trust, 1950 per Lord Normand, 493). He made that statement in a case where an elm tree had blown down and hit a motor car. It was held, on the evidence, that the owners of the tree had acted prudently; there was nothing in its appearance to warn them that the tree was dangerous, and so they were not liable.

The practical advice is to call in experts if you have the slightest doubt. In Caminer (1950, 496) Lord Oaksey said: "Landowners are not all experts in the management of trees, and those who are not perform their duty if they take reasonable steps to employ experts." Lord Oaksey did not say what he meant by "reasonable steps". In practice, it is submitted that the employment of a qualified forestry expert would be sufficient.

This leaves the problem of when to call in the expert at all. From the cases, the principle appears to be that there must be 'something' to put you on your guard that all is not well with the tree. You need not know what is wrong, but you must, or should, notice that something is wrong. In Quinn v Scott and another (1965), the National Trust was found liable when an old beech tree on the Clumber estate, Nottinghamshire, fell onto a main road in front of a minibus. The Trust was liable because there were visible indications that the tree was not healthy, and the Trust's woodsmen ought to have noticed these signs and taken action.

This case may be compared with the Caminer case above (no visible signs, no liability) and the case of Cunliffe v Banks (1945) where the defendant was not liable because he had taken all reasonable steps to ascertain the condition of the tree and could not have realised that it was likely to fall. In British Road Services v Slater (1964), the Lord Chief Justice found that the defendants, who owned a tree adjoining a road, were not liable when a lorry hit a branch which overhung the road. The judge held that, objectively, the overhanging bough was what is called a 'nuisance', but that neither the lorry driver, the local authority nor the local policeman considered it a hazard, and so the tree's owners were not liable. It is submitted that they would be liable if another lorry had hit the bough after the case: by then, the owners should have been aware of the hazard.

The present law is summed up in Clark and Lindsell on Torts (1989, 546): "[the owner] is not bound to call in an expert to examine the trees, but he is bound to keep a look out and to take notice of such signs as would indicate to a prudent landowner that there was a danger of a tree falling."

The need to take reasonable steps to prevent harm. The old law had been that a landowner was not liable for damage done by things naturally on his land, with the possible exception of fire. With the extension of the idea of negligence the Courts realised that they might place a high duty on someone who could not afford the expense of removing or reducing the nuisance. They therefore introduced the concept that, in considering what were "reasonable steps", the Court should consider the financial and other circumstances of both the tree owner and the victim; in other words, that the "inequality of bargaining power" between the parties should be taken into account. In Goldman v Hargrave (1966, 996), Lord Wilberforce said: ".... the owner of a small property where a hazard arises which threatens a neighbour with substantial interests should not have to do as much as one with larger interests of his own at stake and greater resources to protect them: if the small owner does what he can, and promptly calls upon the neighbour to provide additional resources, he may be held to have done his duty: he should not be liable unless it is clearly proved that he could, and reasonably in his own circumstances should, have done more."

This was approved by Lord Justice Megaw in Leakey (1980, 37), where he added that it should be a broad assessment and the court should also consider the physical capacity of the parties. In fact, the tree owner in Goldman v Hargrave could easily have put out the fire with water once the tree had been cut down; he did not do so and was found liable. We must wait and see how the Courts will apply the principle in Goldman v Hargrave: practically, the richer owners of trees should be aware of the principles.

Conclusion

The number of people making use of public footpaths through woodland, and visiting country parks, houses and woodland for recreational purposes is increasing. At the same time, there is increasing pressure, from a nature conservation point of view, to retain large old dead trees. Where public access is allowed or being planned, woodland owners and occupiers need to be aware of their liability to visitors. The duty owed to visitors to your woodland depends on whether the visitor is lawful or not. An occupier of land owes to all lawful visitors a "common duty of care". With the passing of the Occupiers' Liability Act 1984, an occupier can contract with a visitor to restrict his or her liability; there is no "business liability" unless the occupier's business purpose is to provide land for educational or recreational use.

Over the years the Courts, and now Parliament, have increased the duty which you owe to people other than lawful visitors, including trespassers and people following a public footpath, entering onto your land. The Occupiers' Liability Act 1984 clarifies the situation. It is now clear that you owe a duty if you know, or have reasonable grounds to believe, that such people are likely to come within the vicinity of a danger against which you could reasonably be expected to offer some protection. You may have to take special precautions in instances where such people are likely to be children.

Finally, if you have a tree on your land, you are under a duty to ensure that the tree does not cause harm to anybody. An owner or occupier is not bound to call in an expert to examine trees, but is bound to keep a look out and take notice of such signs as would indicate to a prudent landowner that there is a danger of a tree falling.

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POSITIVE MANAGEMENT FOR SAPROXYLIC INVERTEBRATES

R S Key, English Nature, Northminster House, Peterborough

S G Ball, Joint Nature Conservation Committee, Monkstone House, Peterborough

Introduction

Research and positive action are necessary to ensure the future of the saproxylic fauna at the sites where the species are still well represented and to reverse the declines in their abundance. We must find methods to sample the fauna without damaging its habitat and ways to monitor the health of the ancient trees on which it depends. In some cases we need to prolong the lives of existing ancient trees and to accelerate the rate at which younger trees start to provide saproxylic habitat. Better knowledge of the autecology of selected saproxylic species is required to assess what other habitat components saproxylic species use. How important, for example, are nectar sources as feeding stations for adults? Experimental management should be carried out to address problems and to enhance sites. It should be monitored to see whether the fauna at risk colonises the niches created and, if this proves successful, such management should then become a routine part of habitat management. It is, however, easier to state the research needs than to develop ways of getting the work done.

The problems - knowledge

The sites

Knowledge of the important sites for this fauna has improved in recent years, but much remains to be discovered. Recent intensive surveys of several sites, e.g. Burnham Beeches (Purvis & Hammond 1990), have revealed a richer saproxylic fauna than was previously suspected. Surveys of smaller parklands and woodland with a long continuity of management, which has permitted the survival of old trees, continue to reveal additional localities with significant saproxylic elements in their fauna (Harding & Alexander 1993). It is likely, however, that few sites of importance equivalent to, say, Moccas Park, Herefordshire, remain undiscovered, as sites which have large numbers of ancient trees and a long history of forest cover are unlikely to have been overlooked.

Site-based inventories have been collated in Harding & Rose (1986) (see also Harding & Alexander this volume) and in the Joint Nature Conservation Committee's Invertebrate Site Register (ISR) (Ball 1989) and also by Keith Alexander of the National Trust's biological survey. Alexander (1988) has developed a simple scoring method to rank sites by the richness and rarity of their saproxylic beetle fauna, based on the list in Harding & Rose (1986).

Existing information about the saproxylic fauna at most sites is anecdotal and results from visits by amateur entomologists, often over an extended period. Many species appear to exist in small populations with life cycles that last many years and which do not, therefore, produce many adults each year. Moreover, most cannot be recorded except in the adult stage without seriously damaging the habitat. These factors make the saproxylic fauna very difficult to survey quickly, comprehensively or in a replicable manner. Recent work by the Natural History Museum (Hammond & Harding 1991; Hammond & Owen in prep.) has suggested that Malaise and interception traps may provide useful sampling methods. Such techniques, employed systematically, would greatly improve our understanding of the extent and distribution of at least some elements of the fauna.

The species

Available information on the ecology, rarity and degree of threat for many saproxylic species has been summarised in Red Data Books (Shirt 1987; Bratton 1991) and in a series of 'national species group reviews' produced by the ISR (e.g. Falk 1991; Hyman & Parsons 1992). Many species exhibit very disjunct distributions, which probably reflect a random pattern of survival in relicts of habitat with a continuity of ancient trees (Warren & Key 1991). The recognition of species indicative of a long continuity of saproxylic habitat is most advanced amongst the Coleoptera, with lists being produced of species which are significant nationally (Harding & Rose 1986) and regionally in northern England (Garland 1983). Attempts to identify such species in other groups have been made, for example in the Diptera, Syrphidae (Stubbs 1982; Whiteley 1987) and for a variety of orders for species of European significance by Speight (1986, 1989). Alexander (in prep.) provides an annotated checklist of British lignicolous and saproxylic invertebrates.

The autecology of most species is not well understood and the identification of some species as being saproxylic has been based largely on the assessment of their fidelity to sites with a long continuity of ancient trees. A knowledge of a species' ecology can obviously assist in studying it. For example, following the discovery of the larval habitat requirements of *Callicera rufa* (Diptera, Syrphidae), a hoverfly which breeds in rot holes in ancient pine trees, Rotheray & MacGowan (1990) were able to improve greatly on previous knowledge of its status and distribution in only a single season's work.

A better understanding of species' niche specialisations also allows prediction of their likely response to management of their habitat. This need not involve difficult or expensive studies, since simple techniques, such as the use of emergence traps (Owen 1992), can be used to narrow down larval requirements. A more detailed knowledge of particular species' ecology, and the consequent possibility of finding them more consistently, would also allow populations to be monitored to determine trends and assess the success or otherwise of habitat management. The apparent failure of much of the saproxylic fauna to move out of relict dead-wood habitats into older trees in surrounding areas of younger woodland provides circumstantial evidence that many species have very poor powers of dispersal, although it might also reflect a lack of suitable niches. If mobility is the key problem, the importance of the remaining habitat fragments cannot be over-stressed (Buckland & Dinnin 1991; McLean & Speight 1993).

The trees

At sites of known or potential value for saproxylic invertebrates we need information about the trees themselves, for example the numbers of ancient, middle-aged and young trees (cf Harding & Alexander 1993) and whether the rate of replacement is sufficient to maintain or increase the number of ancient trees in future, the quality (in terms of habitat for saproxylic invertebrates) of the individual trees, their health and the niches they provide. These features must then be monitored to determine whether management is achieving its aims.

The procedures described below apply equally to living trees, standing dead trees, fallen trees and larger pieces of fallen timber.

Tree marking To enumerate, assess and monitor the trees at a site, individual trees must be distinguishable by some form of indelible marking. Trials in Windsor Forest and Great Park (E. Green, pers. comm.) have shown that many popular types of tree tag are unsuitable for long-term marking of ancient trees. Many are difficult to attach to the very rugose bark of ancient trees, and continued bark growth may eventually engulf or obliterate the tag or force it off the bark altogether. Green found that numbered aluminium tags swinging freely on long (at least 10 cm) aluminium nails (essential lest a chainsaw is ever used on the tree) driven only a short way into the bark was the best way to overcome this problem. Tags were attached to the tree at approximately 2.5 m above ground to reduce the likelihood of vandalism.

Ideally, all trees at a site should be marked, especially if there are large age gaps in the tree population with few young trees. In large sites, or ones where regeneration is good, it may be impractical to mark all young trees. In such circumstances an estimate of the number and species of trees below the minimum size for marking should be made, which will at least enable the likelihood of replacement of older generations of trees to be assessed (Harding & Alexander 1993).

Tree recording Important habitat features of the individual marked trees need to be recorded in such a way that future changes can be identified. Various methods for enumerating and evaluating standing and fallen trees have been developed (Brown 1974), for quantifying rot-holes in forests (Carey 1983) and for assessing the quality of individual standing or fallen dead trees (Dajoz 1974; Lang & Forman 1978; Cline *et al.* 1980; Lambert *et al.* 1980; Trisca & Cromack 1980; MacMillan 1981; Sollins 1982), although these methods have rarely been used in Britain. Potentially the most useful is the line intersection method (Warren & Olsen 1964; Van Wagner 1968), which can give a very good estimate of the overall amount of fallen dead wood per unit area. This has been used experimentally in Britain to assess the overall resource in certain types of woodland (Kirby 1992; Kirby *et al.* 1991).

None of these methods enables the fate of individual trees and pieces of fallen timber to be tracked through time. This can be done however using a method devised by the Nature Conservancy Council in the 1970s and developed by E Green, for which a manual is in preparation by English Nature. This method has the advantage that an individual tree can be recorded in only a few minutes in a reproducible way. It records the total number of primary and secondary limbs above a certain size, their length and various aspects of their condition, the condition of the tree bole and the existence of fallen timber derived from the tree. Certain features of particular value to saproxylic species, such as missing bark, rot holes, sap runs, evidence of red and white heart rot and fungal fruiting bodies, are also recorded. The results lend themselves to computer analysis, essential if the overall resource at a site is to be followed over time, although the necessary software has yet to be developed.

Management

Gaps in the generation structure of the trees occur at many of the most important sites for saproxylic faunas, especially in old parklands that have traditionally been grazed. For example, Harding (1981) gives age classes for broadleaved trees in Dinefwr Deer Park, Dyfed, where only four of the 819 oaks were classed as 'young' (as opposed to 'mature', 'over-mature' or dead) (see also Harding, this volume). This was a typical example amongst approximately 100 areas surveyed. Such gaps within a particular site might not matter if the surrounding landscape contained an adequate mixture of young to mature trees of appropriate species that would be allowed to grow on and senesce. Throughout Europe, however, (McLean & Speight 1993) this is rarely the case and for the foreseeable future we must sustain invertebrate populations within broadly their current sites.

While new parkland trees have been planted recently at many of these sites, it is vital to ensure that old trees survive in sufficient numbers until the new generation starts producing suitable deadwood habitat. For oak maiden trees, this may be in the region of 200 years, although it is usually less for other species. Planning such management over time-scales of many decades or even centuries is difficult for conservation workers facing uncertain funding and lack of staff continuity. There may be, however, scope for some 'short-circuiting' of this process by the 'pre-maturation' of young and mature trees (see below).

Planting and site enlargement

Ancient trees should be replaced as they die naturally of old age to ensure an appropriate age structure and pattern of trees on the site for the long term. In sites with grazing, it may be necessary for the manager to plant and protect appropriate trees.

Most sites with significant assemblages of saproxylic invertebrates are small and isolated (McLean & Speight 1993) and would benefit from enlargement of the area with suitable habitat. This may be achieved by planting appropriate trees on the surrounding land and managing them in the long term to produce old-growth conditions. Where blocks of land within a site have been converted to arable or planted with conifers, these could also be replanted and returned to more sympathetic management.

There are both legal and financial problems in achieving these aims. No mechanism exists whereby the statutory conservation bodies can purchase, or grant-aid the purchase of such land if it is currently of no great value for wildlife and it is unlikely to be included within the boundaries of Sites of Special Scientific Interest. English Nature has however introduced a Wildlife Enhancement Scheme, which might be developed in future, and which goes beyond SSSIs, and the Countryside Stewardship Scheme run by the Countryside Commission (1992) can also give financial incentives for appropriate management of certain habitats in areas other than those under statutory protection. A welcome development of the latter is its extension to historic landscapes, specifically including 'parks and deer parks', and it is important that the needs of saproxylic invertebrates are incorporated into the Scheme's implementation. The scheme is entirely voluntary, and efforts should be made to encourage the take-up of the scheme in areas around the most significant sites for saproxylic faunas. A drawback is that agreements last only ten years, although they can be renewed.

The designation of Environmentally Sensitive Areas (MAFF 1989) around significant sites for saproxylic fauna could also be potentially very useful. Designation encourages traditional farming methods by providing financial incentives within a defined geographical area. Unfortunately not many of the most important ancient tree sites are in the ESAs declared so far.

Since 1985 there has been increased emphasis on broadleaf planting in the lowlands (Forestry Commission 1985) and, more recently, ambitious plans to plant new Community Forests on the edges of major urban areas (Countryside Commission 1989). These new woods will be colonised by a woodland fauna, in time, but are largely an irrelevance for old forest invertebrates. However, if they incorporate existing mature trees these should be left to grow on indefinitely. The new woods can then form part of a larger, very long-term strategy to enlarge and link existing important sites.

Old trees

The survival of most ancient trees results from intensive management of the trees themselves and also of the surrounding woodland or parkland. Most commonly, the trees have been pollarded and their surroundings have been grazed. Together, these two forms of management result in wood-pasture. Sadly, in very few instances has there been a continuity in the appropriate management of both trees and the surrounding area. Often pollards have become grossly overgrown and the pasture has been ploughed or fertilized such that its floral diversity is much reduced. In other places the pasture has developed, through neglect or by planting, into dense high forest.

Competition from younger, more vigorous trees Dense natural regeneration or planting may lead to ancient trees being overtopped by luxuriant younger foliage. This problem is particularly acute where fast-growing evergreen conifers have been planted close to old trees, denying them light throughout the year. Surrounding trees, as well as the understorey, also compete with ancient trees for soil moisture and nutrients. The combined effects of this competition are sometimes sufficient to kill an ancient tree outright.

In such instances it is usually appropriate to open up the canopy around old trees and clear away competing trees and undergrowth. This may, however, have to be carried out gradually, as sudden extreme changes in the degree of exposure to the sun and reduction of humidity may themselves have an adverse effect. The humid conditions in a more closed canopy may also have produced valuable epiphytic lichen and bryophyte communities, which would suffer if exposed to too much sun and wind.

Trees recently exposed by storms or felling Some old trees, including overgrown pollards, may lose branches or be blown over following sudden exposure resulting from felling or windthrow of surrounding trees. This has become a serious problem at some important sites for saproxylic invertebrates as a result of the major storms in southern Britain in 1987 and 1990. Some dieback is not a problem in conservation terms but the tree may be deemed unsafe (Watkins & Griffin 1993) and hence is likely to be felled. One management option is then to reduce the height of the tree for safety purposes, at the risk of the death and loss of the tree, so that at least the bole is retained as a resource for saproxylic species.

Top-heavy old pollards and their rejuvenation by repollarding A more common problem results from the neglect of old pollards, many of which have not been cut for a century or more. Neglect often results in what is, in effect, a grove of mature trees growing on the top of the original bolling, which is often decayed internally or has a relatively shallow rootplate. Such trees are prone to wind damage, often with loss of large parts of the crown, splitting or shattering of the main bolling or overturning of the whole structure through failure of the root system. They are viewed with suspicion where public safety is an issue (Watkins & Griffin 1993).

The most appropriate remedy is to repollard such trees in the hope of stimulating regrowth and rejuvenating them, with the intention of recommencing a traditional pollard cycle. This treatment may kill veteran trees outright and early attempts met with little success. Sometimes no regrowth occurred at all - presumably the result of absence or inhibition of epicormic buds in the bark of the old bolling - or there followed a brief period of successful regrowth, which then failed, often with takeover by pathogenic fungi (Coop 1991; Lonsdale 1991).

More successful pollard management has been revived recently on some of the old wood-pastures in southern England. Repollarding has been carried out at Hatfield Forest (Sisitka 1991) and Hainault and Epping Forests (Mitchell 1989; Coop 1991) in Essex, to determine how well trees will repollard after 100 or so years of crown growth. Certain species of tree, notably willow, ash and hornbeam, repollarded more successfully than others. Oak was found to be variable in its response to repollarding, whereas beech was found to be least successful, under the conditions in the study (Mitchell 1989).

A good success rate with beech has since been achieved, at Burnham Beeches in Buckinghamshire, by not removing all the limbs when repollarding, thereby allowing the bolling to continue to continue to receive the products of photosynthesis (Read *et al.* 1991; Read, quoted in White 1991). Any form of shading of the cut surfaces inhibits regrowth. Research is also under way at Burnham Beeches into grafting bud material onto live but effectively dormant bollings, to compensate for the failure of epicormic growth.

Tree surgery Problems may arise where corrective tree surgery is being considered, either to render a potentially dangerous tree safe, or to improve the visual appearance or 'health' of the tree. As any manual of tree surgery illustrates (e.g. Bridgeman 1976), the damage and decay that produce the niches that are of importance for saproxylic invertebrates are regarded as highly undesirable on living trees by most tree surgeons. There is considerable scope for better cooperation between those working for the conservation of organisms dependent on ancient trees and those most skilled in the actual management of the trees. Any tree surgery being applied to significant or potentially significant ancient trees should be agreed in advance and in detail with the practitioner. Limbs with decay should not automatically be cut back to sound wood, cavities should not be drained, filled and sealed and damage to bark should not automatically be regarded as in need of remedial treatment. Outright felling of an ancient tree should be regarded as unacceptable, and in the case of a dangerous tree where surgery is impractical, serious consideration should be given to fencing or otherwise isolating unsafe areas from the public.

'Pre-senescence' of young trees

At sites where the number of very old trees is small but where there are plenty of mature trees not yet producing dead-wood habitat, or where there are generation gap problems, it may be possible to 'pre-senesce' some younger trees by initiating decay prematurely.

New pollards The establishment of new pollards is essential at many sites if continuity is to be maintained in the long term. The significance of pollarding for saproxylic invertebrates is that it prolongs the life of a tree considerably and is likely to speed up the inception of wood decay. Pollard bollings may survive for 300-500 (-800 for oaks) years, considerably longer than the 'natural' life span of many trees, particularly shallow-rooted species such as beech (Edlin 1971). Wind resistance is reduced by never allowing the development of a large crown of boughs and foliage, and the centre of gravity is lowered, thereby reducing the likelihood of wind-throw. The tree is also regularly rejuvenated by stimulating production of vigorous young growth (Le Seur, quoted in Edlin 1971).

Trees in isolation, such as parkland pollards, are more likely to lose branches through wind damage (Cartwright & Findlay 1958) and are more likely to become infected by fungi than are trees growing in closed canopy woodland. They are consequently likely to produce more microhabitat for saproxylic invertebrates. Exposed cut wood is periodically created when the tree is pollarded and can be colonised by saproxylic fungi and insects. The uneven structure of a pollard crown favours the retention of water and the development of rot holes and, eventually, heart rot. The bolling of the tree eventually comes to contain significant quantities of decaying wood habitat, which continues to be replenished by new growth from the cambium.

New pollards are relatively easily produced and are being created at a number of sites in southern England, notably at Burnham Beeches (Read *et al.* 1991) and Hainault Forest. Many new pollards were created unintentionally throughout south-east England during the severe storms of 1987 and 1990 and the subsequent tree surgery. There is, however, likely to be little documentation of the results of this phenomenon and it is doubtful whether such trees will continue to be pollarded in the future.

'Tree mutilation' Speight (1989) recommends the deliberate mutilation of trees to allow ingress of water, fungi and saproxylic invertebrates. Considerable research has been carried out in the USA on the management of 'snag' trees (i.e. standing dead trees) and the creation of decay cavities in dead and living trees, primarily for the provision of nesting sites for hole nesting birds and den sites for various species of mammal. Such methods would however seem suitable for the 'pre-senescence' of trees for old forest invertebrates. Methods include the use of chain-saws to initiate rot hole formation (Sanderson 1975; Carey & Sanderson 1981; Carey & Gill 1983), the inoculation of heart-rot inducing fungi to create hollow trees (Silverborg 1959; Toole 1965, 1966; Conner *et al.* 1983; Conner & Locke 1983) and even the use of explosives to produce standing dead trees, shattered boles and branch stumps to initiate fungal cavity formation (Bull *et al.* 1981). Inoculation techniques for wood-decaying fungi have also been developed for the production of edible species (Chang & Hayes 1978; Campbell & Slee 1985). All of these techniques could be applied to the creation of dead wood habitat for invertebrates in mature trees, given sufficient resources and the co-operation of woodland managers. In the United States some work has been done looking at the use of artificially created cavities by invertebrates (Heaps 1981; McComb & Noble 1982) but this looked at species utilising water-filled artificial tree holes or species sheltering in cavities rather than saproxylic species.

Other possibilities include the deliberate damage of tree bark to allow in water, fungi and invertebrates, or to stimulate the production of sap-runs, which are the sole habitat of certain specialists.

Some studies have looked at outright killing of live trees for similar purposes: the use of ring barking ('girdling') and the use of fire and herbicides to create standing dead trees (Styskel 1983; Conner *et al.* 1981; Conner *et al.* 1983: Bull & Partridge 1986). These are less likely to benefit saproxylic invertebrates, except in the short term, as they do not provide for the continuity of the dead wood resource into the future that is necessary to conserve the fauna. In addition felled and standing dead sound timber does not produce the diversity of niches necessary for saproxytic species. Decay starts from the exterior of the log and penetrates inward, heart-rot and rot holes do not develop, and the duration of existence of individual pieces of timber is much shorter than for decaying wood on living trees, which is a renewable resource. Tree killing should only be considered as useful in this context where there is a need to thin excessive regeneration or to remove undesirable, usually alien, species of tree. Even then, ancient specimens are best conserved, as they may already provide useful habitat for saproxylic species.

Retaining dead wood

In many ancient woods thinnings, loppings and the occasional felled tree are left for conservation purposes. Sometimes these are made into habitat piles (e.g. Brooks 1980; Watkins 1990), although there is relatively little merit as far as the saproxylic fauna is concerned in creating a pile rather than leaving material scattered on the woodland floor in more natural conditions. (With small material there is some benefit in piles because a great constancy of humidity is maintained.) Only opportunistic and ubiquitous saproxylic species however, with relatively undemanding niche requirements, are likely to take advantage of such habitat. While it is useful that an increase in these species may result from such efforts, leaving small-sized deadwood is no substitute for the retention and eventual replacement of living, ancient trees.

In sites important for saproxylic invertebrates as much large deadwood as possible should be left. Where dead material is retained, consideration should be given to its location. Most saproxylic species are unable to utilise dead timber in dry, open conditions in full sunlight, such timber sometimes becoming almost 'heat sterilized'. Most timber falling in the open should be moved into moister, shadier conditions. (This may also make the site look more "tidy", an important consideration where there is heavy public access within a formal park setting as at Dunham Massey.) There are, however, some species of saproxylic beetles, notably the brightly-coloured jewel beetles, which need timber in just such hot dry conditions, while empty insect burrows in such conditions are important nest-sites for specialised solitary wasps and bees. Not all dead material therefore should be moved out of the sun. At present there is no information to suggest that importing dead logs, to boost the amount of deadwood on a site has any value for deadwood specialists.

Subsidiary habitat features

A number of features of the habitat surrounding the trees themselves may be of importance for saproxylic invertebrates. Foremost among these is the availability of flowers as the prime source of energy from nectar and protein for egg laying from pollen and/or predation on other insects visiting such flowers. Many species favour the blossom of hawthorn, or various members of the Umbelliferae or Compositae. No studies have been carried out as to how dependent saproxylic species are on these resources, or on the distance that adult insects travel to utilise them. Anecdotal observations, however, do suggest that sites with such features tend to support richer faunas. Therefore flowers such as hawthorn, hogweed, angelica and even thistles and ragwort should be encouraged, to provide this resource. Most flowers are usually associated with sheltered open areas within the woodland or parkland, such as sunny glades, rides, hedgerows and scrubby woodland edges. These features should be retained, or even created where appropriate, although overmature trees or their limbs should not be sacrificed for the purpose. Open space may also be important in providing clear flight lines between saproxylic habitat and nectar sources or mating sites and in allowing dispersal of adult saproxylics between ancient trees both within and between sites.

The invertebrates themselves: is there a case for translocations?

Direct translocation of invertebrates to try to re-establish populations is likely to be successful only for species whose ecology is well known, whose popularity attracts sufficient resources to pay for the site management, and where habitat management can be maintained in the long term. For most insect species these conditions are not met and their conservation depends on maintaining suitable management on sites where they still exist.

Speight (1989) recommends the re-establishment of saproxylic species at their former sites as larvae in logs or trunks, which are transferred between sites. This may seem a more attractive proposition, but it is fraught with difficulty and controversy because, along with the target species, other fauna and flora will be present but unrecorded. Such inadvertent translocations make it more difficult to determine the true status and biogeography of the species concerned. This problem is beginning to arise already in the case of other habitats, with the increasing use of 'habitat transfers' either between conservation sites or from threatened sites to 'safe' localities.

In addition, while conditions in the translocated log may be suitable for the species within in it for some time, in the absence of detailed knowledge of its ecology there is no guarantee that suitable niches are available at the receptor site and the exercise may simply be a drain on the source population.

Translocations are not automatically ruled out in every case by the above arguments, but certainly any proposed scheme should be approached with caution.

The future

The importance of woodlands containing post-mature habitats has recently been recognised by the Council of Europe (Council of Europe 1988; Speight 1989) and the Forestry Commission (Forestry Commission 1990), but there are still huge problems in implementing the recommendations. Much more publicity is needed, however, to encourage a positive attitude towards these insects.

The incorporation of sympathetic tree management into practical work on conservation sites should increase in the future. Integration of habitat for old forest invertebrates into modern commercial woodland is a much more challenging problem. This fauna requires trees to senesce and die naturally over timescales measured in centuries. These trees cannot realistically contribute to the commercial management of the forest for timber production unless a commercial market can be created for pollard products. They may however add to the amenity value of the wood, but even this may eventually lead to conflict with safety considerations when the trees get into the ideal state to produce habitat for saproxylic invertebrates. Therefore it is probably sensible to concentrate current effort on conserving and enhancing the habitat at sites where this fauna currently survives.

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ANNEX 1

A conservation guide for the entomological investigation of deadwood habitats

Dead wood

Do not remove bark or dig into dead wood on living trees and so endanger their long-term survival. In particular do not make a "first incision".

Try to use non-invasive methods. Emergence and interception traps and the examination of nearby nectar sources provide alternative methods to investigate the dead wood fauna.

Individual old trees of known value for rare species should be left alone, rather than visited by a succession of entomologists.

Replace bark if possible. It is worth carrying a small hammer & nails to do this but do not do so if there is the slightest chance of the wood being subsequently cut up with a chain saw. Refrain from removing vertical bark if it cannot be replaced.

Do not remove all available fungal fruiting bodies from dead wood and after investigating them, put them back.

Replace old nests, leaf litter, fungi and wood mould from hollows and forks so that larvae and pupae can complete their development.

Replace overturned logs. This applies equally to stones, litter, moss, piles of excavated soil, shingle etc.

Do not damage or move dead wood used by solitary wasps and bees. These relocate their burrows by sight and may be unable to find them again if they cannot recognise their surroundings.

It is better to investigate a small quantity of dead wood thoroughly, perhaps even to destruction, than make superficial studies on, and hence damage, a large quantity.

Give due consideration to the other biological interests of dead wood. It may be important for fungi, lichens or bryophytes.

Grubbing, beating and sweeping

These can be potentially quite damaging to vegetation. Exercise restraint in orchid meadows etc - the sweep net may inadvertently double as a scythe!

The most effective form of beating is a short, sharp shock - a sudden tap on a branch is more likely to dislodge beetles than a prolonged thrashing which can damage foliage and branches.

Searching vegetation for feeding signs can be much more productive and lead to a far better understanding of species' ecology.

Carry out only a small number of sweeps before examining the catch and releasing unwanted insects. Species of other groups are often less robust than beetles. Otherwise the result is a mangled ball of squashed flies and bugs.

Beware of nesting birds when carrying out any of these operations. Disturbance near a nest site may cause birds to desert.

Surplus material - specimens and pabulum

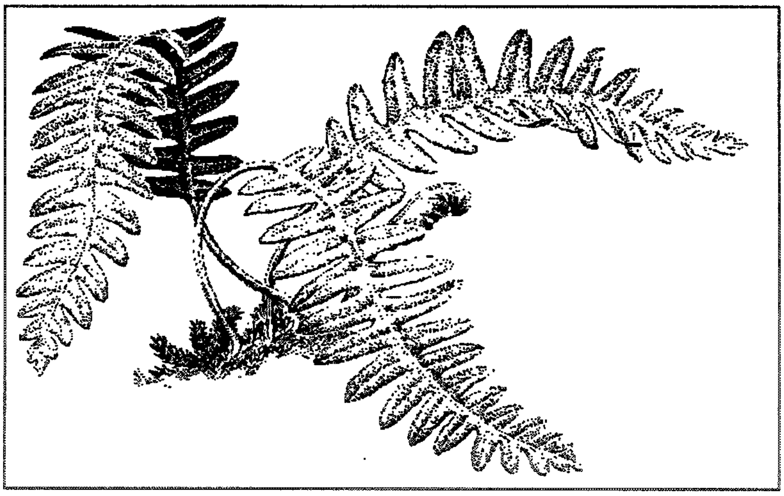
Do not release surplus beetles in the garden or add pabulum to the compost heap to allow any remaining insects to "take their chance". If at all possible, return surplus living specimens and pabulum to the site from which it was taken. If it is not possible to return such material, it is better destroyed and surplus livestock killed and distributed to other entomologists. Other entomologists may discover released specimens or ones emerging from discarded material. This will obscure knowledge of species' natural distribution and may make them appear more widespread than they really are.

Introduction

Any establishments or introductions should not be undertaken without consulting either the statutory nature conservation body for the country, the Biological Records Centre or the JCCBI, who have produced a code for insect introductions.

Protected species

These should not be collected or their habitats disturbed in any way. In certain circumstances a licence to conduct serious studies of protected species may be obtained from the statutory conservation body of the country in which the study is to be carried out - English Nature, the Countryside Council for Wales or Scottish Natural Heritage.



ANNEX 2

An invertebrate conservation code for dealing with storm-damaged woodland

Tree species

Native species, especially though not exclusively oak and beech, are more valuable than introduced ones. Except in the native pine areas of Scotland and possibly the East Anglian Breckland, broadleaves are far more valuable than conifers. In ancient parklands, some very large sweet- and horse-chestnuts are also of importance.

Size and age

The biggest and oldest trees are the most valuable. Fallen young trees, or even mature as opposed to over-mature trees, are usually less important to scarce species but are still of value.

State of timber

Where there is any established decay in fallen timber, particularly red heart rot in the main bole or larger branches of a tree, it should not be removed or destroyed. Completely sound timber is less valuable for invertebrates but will still be of use if left to rot in moist conditions. Where wood is destined to become firewood it should, if possible, be matured off site.

Standing damaged trees

Storm-damaged trees and resultant pollards offer an opportunity for suitable habitat to develop on younger trees. If at all possible, lopping or pollarding should be encouraged to make living, but damaged, trees safe, as an alternative to the trees being felled completely. This is important not only on the big old trees, but also on the younger and mature trees which might otherwise be felled for timber.

Broken branches

Naturally broken or shattered branch stumps eventually lead to rot-holes, heart rot and hollows which are valuable habitat for invertebrates. Broken branch stumps should not be sawn off, nor wounds treated with fungicidal preparations or sealants. Hung-up limbs obviously need dropping to the ground for safety reasons and also to prevent desiccation.

Immediate treatment of fallen material

Where possible, this should be left *in situ*. Where the volume of timber is too great to be acceptable, selected material can be removed, taking into account the first, second and third criteria above. Where it is unavoidable that timber be moved before being allowed to decay naturally, the amount of cutting-up to make it manageable should be kept to an absolute minimum. Large branches can be sawn from boles, but each should be kept whole wherever possible. In parkland it may be preferable for most fallen timber to be moved into the shade of other trees to prevent heat sterilization. Some should, however, be allowed to remain in direct sunshine for certain specialist species.

Stacking

Fallen timber (boles and branches) should not be stacked. Piles of small branches and twigs (brashings) are of more value than scattered material as a greater constancy of humidity is maintained. Much should be retained on site, although the volume may be so great that it may be necessary to remove or destroy the excess.

Bonfire sites

Where material is burnt make sure that it is consumed entirely if the bonfire site is to be used again. If partially burned material remains for any length of time (particularly during spring, summer or autumn when the insects are active), it should not be disposed of in subsequent bonfires.

Long-term future of fallen material

It has sometimes been recommended in the past that fallen timber be left for a finite number of years before being removed or destroyed. ***This advice is ill-founded and fallen timber should be left to decay away naturally.*** In parkland and other open situations, bracken, bramble etc. should be allowed to grow over fallen timber. The shade so provided will prevent heat sterilization and desiccation of the wood by direct sunlight.

Replanting

Replanting should be with the same species as those lost, although the opportunity can be taken at this point to increase the proportion of desirable species. A proportion of the new trees could be pollarded when they reach about 15 years or 15 cm diameter at breast height and subsequently managed on a pollard rotation. These trees will become of value for saproxylic fauna earlier than unpollarded trees and are likely to live to a much greater age.

Open space created by the storm

Newly created glades are useful for many invertebrates and should be left unplanted wherever possible. If the glade area is open to the exterior of the wood, then the margin should be planted up as shelter from exposure unless three is other semi-natural habitat adjacent to the open space. The vegetation of newly created clearings should be maintained to encourage a diverse structured grassland with flowering herbs and a margin of coppice-style scrub. This may be achieved by rotational mowing to include an occasional summer cut and scrub cutting on a coppice-length rotation.