Natural England Commissioned Report NECR225c

# The role of trees outside woodlands in providing habitat and ecological networks for saproxylic invertebrates

# Part 2 Supplementary literature review and other notes

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# Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

## Background

This work was commissioned as a preparatory phase to explore options to design and plan a practical research study which answers the question: what is the role of trees outside woodlands in providing habitat and ecological networks? In order to help increase our knowledge of the role of non-woodland trees to providing landscape connectivity.

It reviews and summarises what is known about the underlying biology of the veteran tree ecosystem, the biogeography of trees in the English landscape, and the various techniques which have been developed to study the saproxylic invertebrate fauna associated with those veteran trees. A rationale is developed for targeting the proposed study at the heartwood-decay fauna of oak using transparent cross-vane window flight-interception traps.

There are three parts to the study:

- Part 1: Designing a field study to test initial hypotheses (NECR225a)
- Supplement to Part 1 (NECR225b)
- Part 2: Supplementary literature review and other notes (NECR225c)

Part 2 was funded by the Woodland Trust.

The work makes recommendations for a suitable design for the proposed study, based on a standardised sampling protocol. Four locations are identified as possible sites for field-testing the protocol, but significant shortfalls in our current knowledge of the local treescapes have been identified, and it is clear that further baseline tree survey is needed before the fully developed study can begin.

In the meantime, a field trial will be considered at one or more of the four identified study sites, possibly using combinations of site staff, the biological recording community and/or students to provide logistical support.

WOODLAND TRUST

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**SUMMARY**

The current project is a preparatory phase of work to explore options to design and plan a practical research study which answers the general question:

- what is the role of trees outside woodlands in providing habitat and ecological networks?

The current document presents supplementary information from an expanded literature review and also includes information which has become available since the original report was finalised.

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# 1 INTRODUCTION

## 1.1 Background

Additional literature survey was commissioned as a supplement to *The role of trees outside woodlands in providing habitat and ecological networks for saproxylic invertebrates. Part 1 Designing a field study to test initial hypotheses* (Alexander et al 2015). A full literature review is never really achievable due to potentially relevant information only being available in unpublished theses and reports, and valuable snippets may also be hidden within publications dealing with different issues. However, an attempt was made to go beyond the coverage achieved by the main report. The present survey focused particularly on new publications, subsequent to the main report, and these were used to find citations to earlier relevant publications that had not been examined for the main report.

The opportunity was also taken to provide updates on some other aspects covered by the main report.

# 2 ADDITIONAL LITERATURE SOURCES

## 2.1 Trapping methodologies – open v closed vane traps

The conventional use of flight interception traps results in capture not only of the target saproxylic species but also species with different habitat associations which are taken incidentally, and which are therefore generally regarded as vagrant species. The idea of using enclosed traps has been suggested whereby the trap and the deadwood to be sampled are enclosed within a netting structure in order to exclude such incidental catches. This is effectively a type of emergence trap – see section 4.4 in Alexander et al 2015 - and is only really practical for smaller items of dead wood or for rot holes. Birkemoe & Sverdrup-Thygeson (2015) report on a study comparing the catches in flight interception (window or vane) traps simply attached to a standardised and replicated unit of standing dead aspen tree trunk with both the trap and trunk enclosed together within a netting structure. The findings were not as expected. The closed traps did not catch a higher proportion of habitat specialists (aspen associates) or species at the lowest trophic level (wood feeding) compared to the open traps. Rather, the proportion of predators was higher and fungivores lower in enclosed versus open window traps, and no difference was found between different categories of habitat specialisation. The proportion of vagrant species was lowest amongst the beetles with the strongest specialisation (aspen associates) whereas there was no difference with trophic levels.

Open traps catch species that land on the wood unit during the entire trapping period, where enclosed traps only catch species that hibernate, or otherwise are established in the wood unit. Volatiles being released by the wood unit will also be attracting beetles which might then be trapped. Beetles which are not using wood as their primary habitat however are unlikely to respond to these volatiles and will encounter the wood units by more random processes and therefore may be expected to include a higher proportion of vagrants. The authors conclude that open traps are the best choice for catching as wide range of saproxylic species as possible although enclosed traps are best for studying those species actually using a certain wood unit.

## 2.2 Trapping methodologies – cavity emergence trapping

The use of cavity emergence trapping has been used for the first time in Britain during 2015 (Alexander & Jones, in press) and a parallel study is also under way at a separate site (D. Heaver, pers. comm.). The approach was developed by French workers for studying populations of the European Endangered Violet click beetle *Limoniscus violaceus* (Gouix et al, 2009 & 2011). This beetle develops in moist to wet accumulations of wood mould in the base of hollow trees, the larval habitat being accessible to the adult beetles through basal cavities. The basal cavity is covered by netting and a collecting device fitted so that invertebrates trying to escape from the tree - and crawling over the net in order to find a hole to escape through - enter a collecting bottle from which it is difficult to escape. The bottles are then examined periodically and the catches removed for identification. The process enables demonstration of successful breeding in particular individual trees. Traps were operated on seven veteran ash pollards at a Cotswold wood pasture site across the 2015 field season; a good range of species were found, including a European Vulnerable species, the Red-necked click beetle *Ischnodes sanguinicollis,* although in relatively small numbers. The advantage of this type of trap over flight intervention traps is that it does demonstrate breeding in the tree being sampled, and so is comparable with the closed vane traps discussed in the previous section.

## 2.3 Trapping methodologies – Carrel four-bottle traps

Improvements in construction of the Carrel four-bottle traps – see section 4.1.4. in Alexander et al 2015 - have been suggested (Laurence Bee, pers. comm.). The wooden base which needed to be replaced annually to avoid collapse from rotting has been replaced with a tough plastic alternative (marketed as saucers for pot-plants, costing around £2 each) and the bottles are attached using a nut and bolt approach using wing-nuts. The bolt holes can be made using a dibber – a pointed hand tool using for marking wood - and so the base no longer requires drilling. This all makes the trap both more durable and more flexible to assemble and dismantle as necessary.

## 2.4 A pheromone trapping study

Burman et al (2016) have reported on their study of the spatial ecology of Yellow-legged clearwing moth *Synanthedon vespiformis*. This is an early successional saproxylic and therefore expected to be relatively highly mobile in order to be able to exploit freshly dead damaged oak trunks as they become available, where the rich cambial layer has been freshly exposed. The habitat degrades with the next few years and the species needs to be able to breed and move on, searching for new habitat. Freshly sawn oak stumps are the classic situation exploited. A national survey was organised across Sweden using pheromone traps. The rationale was to use a viable and consistent sampling effort to obtain the first semi-quantitative data on presence and abundance across a large number of sites over a wide geographical range. A minimum separation distance of 500m was applied between traps; a total of eight traps had another trap within a 1000m radius, with the majority separated by many kilometres. Previous studies suggest that males may be able to detect lures at a maximum distance of 150-200m – the selected distances were designed to eliminate the effect of inter-trap competition. The results of the study suggest that the species is truly rare and with a genuinely scattered distribution, but can be locally abundant.

## 2.5 Wood mould boxes - an up-date

The use of artificial saproxylic habitat has enormous potential in providing information on the spatial ecology of saproxylic organisms. Natural habitat is spatially constrained by its very nature, but wood mould boxes (section 4.8 in Alexander et al 2015) – and similar artificial habitat structures - have the potential to be positioned and replicated in order to enable robust scientific studies.

Carlsson et al (2016) have recently reported on the operation of artificial habitat in the form of wooden boxes filled with wood mould; an earlier paper had reported on the results after four years, but this new paper reports after ten years of operation in the field. The abundance of species associated with tree hollows, wood rot and animal nests were found to have increased from the fourth to the final year, but species richness declined for all groups. The artificial habitats were found to have developed into a more tree-hollow-like environment during the decade long experiment, with few but more abundant tree hollow specialists.

The boxes had been placed at various distances (from 0 to 1800m) from known biodiversity hotspots with hollow oaks. The analysis found no statistically significant effects of time, distance from the core area, or their interaction. However, it should be noted that the species which were found in sufficiently large numbers to enable statistical analysis do not include key old growth associates.

Table 1 Beetle species found in the Carlson et al (2016) wood mould boxes in relatively great abundance

| **Species** | **GB status** | **IEC** | **O/F** | **Ecology** |
|---|---|---|---|---|
| *Ptinus fur* | | | F | Associated with debris in nests, etc |
| *Trox scaber* | | | F | Associated with debris in nests, etc |
| *Atomaria morio* | NR | | F | Associated with debris in nests, etc |
| *Phyllodrepa melanocephala* | | | F | [not present in GB] |
| *Cryptophagus micaceus* | NR | * | O | Associated with debris in nests, etc |
| *Prionychus ater* | | * | O | A true wood mould inhabitant |
| *Anaspis thoracica* | NS | | O | Old, semi-dry woody decay |
| *Anthrenus museorum* | | | F | Associated with debris in nests, etc |
| *Dropephylla ioptera* | | | O | Predators in decaying wood |
| *Ctesias serra* | | | O | Cobweb beetle |

O: obligate saproxylic; F: facultative
NR Nationally rare; NS Nationally scarce
*Species used in the calculation of the Index of Ecological Continuity

This is a very unimpressive list from a British perspective and so the demonstration of relative mobility – an ability to reach distant boxes – is not all that significant. Many of the species found in the boxes are common and widespread species associated with organic debris, eg in bird nests, wasp nests, spider webs. The silken fungus beetle *Atomaria morio* (Cryptophagidae) is of interest in a GB context as it is primarily known from concentrations of hollow trees in ancient wood pasture sites, particularly Windsor Forest & Great Park, but also Croome Park, Kedleston Park and Sherwood Forest. However, there are also sufficient records from other types of site to create doubt about any association with habitat continuity. The other rare silken fungus beetle *Cryptophagus micaceus* is also primarily known in Britain from ancient wood pasture sites – the New Forest, Windsor, Richmond Park, Moccas Park, ChatsworthPark and Dinefwr Deer Park – but also is not a strongly convincing species with regard to a need for strong ecological continuity. It is currently listed as having a strong association (Alexander, 2004) but merits downgrading. The only other species listed for the wood mould boxes that features as a collective indicator of old growth in Alexander (2004) is the darkling beetle *Prionychus ater* (Tenebrionidae); this is one of the most widespread inhabitants of accumulations of wood mould and powdery brown-rot in Britain's hollow trees, including most traditional orchards as well as historic parklands – it is a low grade indicator. The absence of abundance of high quality old-growth saproxylic species from the wood mould boxes undermines their value for conservation research.

A key problem with the wood-mould boxes is that they selectively attract late stage white-rot type decay fauna and those species associated with nests in hollow structures. A broadly similar fauna may be found in previously occupied bird nest boxes in most places in Britain. However, these are just the most abundant species found, *i.e*. those where robust statistical analysis was feasible. The 43 boxes studied did generate 2170 specimens of 91 saproxylic beetle species, and the full list does include some notable rarities from a British perspective, eg *Stenichnus godarti* (2), *Ampedus nigrinus* (2), *Globicornis nigripes* (1), *Gastrallus immarginatus* (1), *Lyctus linearis* (1), and *Hypebaeus flavipes* (7). The low incidence does suggest the boxes may not be the best way of studying the mobility of these species, although their ability to reach the wood mould boxes is of significant interest and may provide insights into the value of veteran trees in the wider countryside surrounding the richer saproxylic sites.

Two key methodological conclusions made by the authors were that the boxes would benefit from being larger in order to obtain a more stable micro-climate, and that the contents should be kept topped up with the mixture periodically, replicating the situation in hollow trees where there may be a constant rain of fresh debris from higher up in the tree, as decay proceeds, etc. The latter consideration had previously become apparent from work in Britain on Violet click beetle *Limoniscus violaceus* when using compost bins as alternative habitat for study purposes. Although it had been this British work (led by Ted Green of the Crown Estate) that had inspired the wood-mould box approach, it would appear that the Swedish researchers preferred to discover problems for themselves rather than learn from shared experience.

In 2009 the People's Trust for Endangered Species commissioned Paul Whitehead to dismantle compost bins which had been filled with a wood mould substitute as trailed by the Crown Estate and placed out on Bredon Hill National Nature Reserve (NNR) in the hope of attracting Violet click beetle (Whitehead, 2009). However, the wood mould was never topped up and left to dry out, much as happened in the Swedish study.

Table 2: Beetle species found in the wood-mould-filled compost bins on Bredon Hill NNR (Whitehead, 2009)

| **Species** | **GB status** | **IEC** | **O/F** | **Ecology** |
|---|---|---|---|---|
| *Anobium punctatum* | | | O | Dead sapwood |
| *Melanotus castanipes* | | | O | Decaying wood |
| *Carcinops pumilio* | | | F | Decaying organic matter |
| *Margarinotus merdarius* | | | F | Associated with debris in nests, etc |
| *Dorcus parallelipipedus* | | | O | Dead white-rotten wood |
| *Anaspis cf. costai* | **NS** | | O | Decaying wood |
| *Alphitobius diaperinus* | | | F | Associated with debris in nests, etc |
| *Pseudocistela ceramboides* | **NS** | * | O | A true wood mould inhabitant |

Although a different suite of beetles was found to be exploiting the resource the broad composition was very similar to that found by the Swedish study – most of the species found are common and widespread species associated with organic debris, eg in bird nests. It is also noticeable that the obligate saproxylics are of a similar character, with a single wood mould specialist – *Pseucocistela ceramboides* instead of *Prionychus ater*. Thus the Swedish wood mould study is now reaching the stage achieved by the earlier British field trials but this time the study has been carried out using robust scientific methodology.

No other progress has really been made as the wood-mould boxes have not proved to be very successful in attracting as good a range of saproxylic fauna as is more readily achieved using the passive interception approach of vane traps. It would seem premature to be considering the use of wood mould boxes at landscape scale in Britain until the methodology has been developed much further and is clearly demonstrated to be successful at detecting saproxylic species of particular interest here.

## 2.6 Spatial diversity

Müller & Goβner (2007) carried out a study of the fauna of isolated trees within stands of a different species, to test the impact of low host tree density on mobility within continuous canopy conditions. They used flight interception traps (design not mentioned) placed in the centre of each crown of 27 oak and 19 beech trees in a beech forest, with a control of traps on 40 oaks in an oak forest (20 000ha of 'Steigerwald' in northern Bavaria). Girth class was not recorded but the forests were a mix of high forest, coppice with standards, and stands undergoing conversion from the latter to the former. Oak density classes were calculated per 1ha around the sample trees. As the forest is in Germany it may be assumed that it was not open to grazing by large herbivores (grazing of woodland is illegal in Germany) although this was not explicitly stated in the paper.

The ecology of the trapped fauna was not discussed by the authors but an indication can be discerned from the species list provided. The fauna trapped suggests that the most abundant form of saproxylic habitat available was freshly fallen branches, as 59 specimens of the click beetle *Calambus bipustulatus* and 308 of the oak bark beetle *Scolytus intricatus* were trapped, and standing dead branches were also present in plenty as 24 of the longhorn beetle *Grammoptera abdominalis* were trapped – this develops in white-rot caused by the fungus *Vuilleminia comedans*. Old growth fauna is noticeably scarce in the record of trapped species but a single *Lymexylon navale*, two *Ampedus elongatulus* and four *Dromaeolus barnabita* were trapped. The first breeds in freshly dead heartwood exposed by bark damage, the second in brown-rotten heartwood, while the third is a species of moist white-rotten heartwood. Clearly there were a small number of veteran oak close by within the wider forest. The impression given by the trapped fauna is of oak trees of no more than 150 years age, probably closer to 100 years.

The authors conclude that for the saproxylic Coleoptera using dead wood on living oaks, the effect of isolation of the trees was not significant. The population densities on single oaks in a beech forest is similar to that of individual trees in oak forest. They offer a few suggestions for how the fauna maintains itself:

- Some oak associated species may be able to use beech trees as meeting points or as bridges to distant oaks;
- Some species which feed exclusively on oak as larvae may use other tree species as a food resource for the adult stage, e.g. feeding on other invertebrates, on sugars from aphid honeydew, or on pollen and nectar.

They go on to discuss that the beetles have evolved a successful strategy for colonisation – the dependence on isolated dead wood structures requires sensitive sensors to find these, e.g. using pheromones or scents from wood structures, but also by random dispersal. It should be borne in mind, however, that they were actually studying early-successional saproxylics – a point they appear to have overlooked – which necessarily are relatively mobile as their specific habitat is short-lived and the species needs to keep moving in order to find fresh habitat. The results are interesting from the point of view of the 'Trees outside Woodlands' project in demonstrating that species which are active through continuous canopy may be relatively mobile but the suggested reasons for this – an ability to use other tree species to some extent as 'bridges' - will not apply in similarly isolated oak trees in open countryside.

The authors also comment that larger distances between suitable structures can lead to isolation effects in otherwise common saproxylic beetles, as was found for the fauna living in fruiting bodies of wood-inhabiting fungi (Sverdrup-Thygeson & Midtgaard 1998; Komonen et al 2000). For these reasons, Schiegg (2000) pointed out the necessity of a dense network of dead wood structures in beech forests to protect saproxylic beetles. Sverdrup-Thygeson & Midtgaard (1998) was a study of the darkling beetle *Bolitophagus reticulatus* which develops in brackets of the fungus *Fomes fometarius* in boreal forests, and was discussed in Alexander et al (2015).

Ranius et al (2011) carried out a similar study but using hollow oaks within an open landscape, examining the impact of the density of hollow oaks on the presence/absence of the more threatened species of associated saproxylic invertebrates. Significantly they conclude that conservation of the most threatened species (Rusty click beetle *Elater ferrugineus*) require conservation efforts at larger spatial scales than required to protect Hermit beetle *Osmoderma eremita*, a species which has been promoted as an indicator and umbrella species. This situation mirrors work by Komonen et al (2000) on food chains as larvae of the click beetle are a specialist predator of those of the Hermit beetle – see 2.5, below. The paper is however written in a heavy academic style and it is difficult to draw out the more useful information from the point of view of the 'Trees outside Woodlands' project. The authors state that Rusty click beetle appears to be more mobile than Hermit beetle but that high mobility is a poor strategy in today's fragmented landscapes, as it increases the risk for emigrants to die in the matrix, thus placing species with larger dispersal ranges at greater risk. Presumably this mobility level is still relatively low as common and widespread saproxylic species are capable of spreading across large expanses of unsuitable country and reaching suitable habitat at great distances. It does seem reasonable for specialist predators to be more mobile than their prey as they require large prey populations in order to maintain viable populations of their own species. Both Rusty click beetle and another of the relatively mobile threatened saproxylics considered in this paper – the false scorpion *Larca lata* – are best known in Britain from our largest expanse of open wood pasture with ancient oaks, Windsor Forest and Great Park. Indeed, *Larca lata* has only ever been found in Britain at Windsor.

Some of the data arising from the Ranius et al (2011) study may provide useful guidance for English conservation work:

- For Hermit beetle, 69 hollow oaks/$km^2$ are required within a radius of 192m
- For Rusty click beetle, 38 hollow oaks/ $km^2$ are required within a radius of 1104m

"To obtain a continuous supply of hollow oaks, younger trees are also required. A previous estimation has suggested that in an oak population with a stable age structure and only natural tree mortality (i.e. the highest density of hollow oaks possible to maintain in the long run, which we call "optimal oak pasture"), 7% of the trees have hollows with wood mould[1] (Jonsson & Ranius 2009), and the area needed for each oak is about 0.02ha (c.f. Ranius et al, 2009). Consequently, for Hermit beetle, optimal oak pasture has to cover 20% of the area within 192m, which means an area of optimal oak pasture of 2.3ha[2]. For Rusty click beetle, the corresponding values are 11% (42ha within 1104m). In Europe, regions with such high densities of hollow trees are rare today, but such densities were probably rather common in the old-growth broadleaved forests that originally covered wide regions in Europe. Thus, these hollow oak-dwelling species, which today are regarded as rarities, may have been common in virgin forests of Europe."

[1] This presumably refers to hollows of sufficient volume to support populations of the species under study and may be assumed to refer to oaks which have extensively hollow trunks filled with wood mould.
[2] 2.3ha is the figure for 20% of the area of the circle formed with a radius of 192m

## 2.7 Influence of surrounding landscape and special connectivity

Smolis (in press) investigated the presence of Hermit beetle *Osmoderma eremita sensu lato* in rural avenues in south-western Poland in relation to its known restricted dispersal capacity and to the spatial configuration of suitable forest habitats. The study considered 201 avenues and found the expected positive relationship between the beetle population and with higher proportions of hollow trees and a greater mean tree diameter. All of the inhabited avenues were located significantly closer to potential forest habitats and had a higher cover of broad-leaved and old-growth forest in their surroundings. His results indicate that the occurrence of this beetle in the avenues is strongly associated not only with the availability of trees suitable for colonisation, but also with the distance from the nearest potential source habitats. This means that conservation action should seek to restore connections across the landscape, but especially between the known sites and broad-leaved forests acting as source populations.

This study is reminiscent of the pattern of distribution of Noble Chafer *Gnorimus nobilis* in southern England, with the major population concentrations being in the areas with highest density of traditional orchards on the warmer and drier side of the Forest of Dean, either side of Malvern Chase, and linking up to the Wyre Forest (Alexander & Bower, 2011).

## 2.8 Dead wood connectivity

Schiegg (2000) investigated the impact of dead wood connectivity within forest habitat on species-richness, comparing the saproxylic fauna of areas with large distances between dead wood pieces (low spatial dead wood connectivity) and areas with high connectivity. Although the study was carried out within continuous forest cover it does provide insights into the impacts of habitat fragmentation and increasing isolation of suitable habitat trees. Elsewhere (Schiegg, 2001) she had demonstrated that sites with high connectivity of dead wood pieces had more species and higher diversity of saproxylic Diptera and Coleoptera than sites with clumped dead wood distributions. This is important in woodland management as it provides evidence that the accumulation of fallen dead wood into so-called ‘habitat piles’ is actually bad practice, actually reducing species-richness and diversity. While this has been assumed intuitively by saproxylic ecologists it is rare that supporting evidence has been forthcoming. Schiegg (2001) goes on to say that leaving pieces of many different types of dead wood with short distances between them supports particularly vulnerable species and facilitates recolonization by regionally extinct species.

The work was carried out in Sihlwald forest reserve, to the south of Zurich, Switzerland using trunk-window traps and eclectors – see section 4.4 in Alexander et al (2015) - and focused on dead wood of beech. Out of a total of 175 species, 30 were found to be characteristic of high dead wood connectivity. The strongest examples found were the short-winged mould beetle *Euplectus fauveli*, the minute fungus beetle *Cis lineatocribratus* and the longhorn beetle *Leptura aurulenta*, a species-assemblage which would be impossible in Britain where the *Cis* is confined to highland Scottish birchwoods, the *Euplectus* to the south-east of England (New Forest, Hatfield Forest, Windsor and Burnham Beeches), and the longhorn to the wooded rias of south-west England plus the New Forest and Arundel Forest area. But, interestingly, these three species clearly require large expanses of suitable habitat in Britain too. Schiegg (2000) additionally comments that no old growth species were found in her samples, which reflects a long history of forestry management across the site and which ceased only about 20 years ago; the species present in her traps are species which managed to pass the bottleneck of intensive forestry or immigrated from other forests. Thus there is an important distinction made between true old growth species which require continuity of old growth habitat over time, and indicator species of dead wood spatial continuity. High spatial connectivity of dead wood does not automatically imply the presence of relict old growth species, as they also depend on temporal continuity of dead wood.

Research into the ecology of traditional orchards in the Czech Republic (Horak et al, 2013) has found that species richness in a wide range of taxa was enhanced by an increase in the area covered by orchards in the surrounding landscape; traditional orchards help maintain biodiversity in rural agricultural landscapes, and an increase in the area covered by similar patches in the surroundings also increases species richness. One aspect discussed was the influence of the longer spatio-temporal continuity provided by traditional orchards which may have existed for a hundred years or more. Similar work has been carried out in Swiss orchards (Bailey et al, 2010) where it was found that the effects of habitat isolation were found to be more important than the effects of habitat amount with a range of taxa (but not saproxylics). Effects at patch scale were more frequent than landscape scale effects. Another Czech study (Horak, 2014) found that species richness was positively driven by very high canopy openness and the rising proportion of deciduous woodlands in the matrix of the surrounding landscape. It is very evident that canopy openness is vitally important for saproxylic assemblages but there has been little or no research on the extent to which this effect begins to decline as openness tends towards increasing fragmentation and isolation – an aspect the study proposed in Alexander et al (2015) was particularly designed to investigate. Horak's (2014) data indicates that a 250m radius is the key distance, i.e. habitat trees should be no more than 250m apart, and he suggests that this radius appears to reflect the level of the relative dispersal ability of saproxylic beetles from the viewpoint of possible practical measures in the landscape. Parallel results might be expected from studies of veteran trees in the landscape.

## 2.9 Food chain effects of isolation

A study by Komonen et al (2000) has found that forest fragmentation truncates food chains of specialised species in the course of time since isolation, with extinction of specialist species at high trophic levels. The study focused on the specialist insects associated with the bracket fungus *Fomitopsis rosea* – this fungus causes a brown-rot in conifers - in old growth boreal forest in Finland. The fungus hosted a species-rich community with relatively many specialised old growth forest insects within their control sites in extensive old growth forest. Two isolation time classes were also studied in parallel: 2-7 years and 12-32 years since isolation. They found that the frequency of the host fungus and the frequency of the associated insects were significantly lower in the forest fragments than in the control areas. The median number of trophic levels decreased from three in the control areas to one in the fragments that had been isolated for the longest period of time. While the bracket fungus was able to persist in the more isolated fragments, both the numerically dominant moth *Agnathosia mendicella* – the larvae of which feed on the tissues of the bracket fungus – and its associated parasitic fly *Elfia cingulata* had become extinct. The old growth insects become extinct even though the fungal host remains available. This is an important study as it shows that it is not merely the case that individual species decline along with habitat fragmentation and isolation, but the food chains also simplify.

# 3 OLD GROWTH SAPROXYLICS APPARENTLY WITHIN ORDINARY COUNTRYSIDE

## 3.1 The Ashby Folville fauna

Lott (1997) reported on a remarkable saproxylic fauna found in a veteran hedgerow ash tree at Ashby Folville (SK713114) in Leicestershire. The tree had a large opening at one side of the base which gave access to damp decayed heartwood which had been subject to extensive tunnelling by Lesser Stag Beetle *Dorcus parallelipipedus*. He commented that fruiting bodies of Dryad's Saddle *Polyporus squamosus* were present on the tree later in the season [NB unlikely to be the main hollower; *Inonotus hispidus* is the typical hollower of veteran ash trees; whereas *P squamosus* tends to make rot-holes in the upper trunk in old branch scars]. The heartwood sample was extracted using a Tullgren funnel. Two samples were taken, one on 22 Feb 1997 and again on 31 March. Two specimens of *Batrisodes adnexus* were found in the first sample and another in the second. All were female – no males have ever been found in Britain and the species is assumed to be parthenogenetic. *Batrisodes adnexus* has mainly been found in Windsor Forest and Great Park, with just a single record from Epping Forest. The species has been assessed as being a Grade 1 indicator of ecological continuity of suitable saproxylic habitat (Harding & Rose, 1986; and Alexander, 2004)

The site was described as:
"an agricultural landscape with no known history of woodland cover. The nearest area of ancient woodland is the Leighfield Forest complex c8km to the south-east, but these woods have been managed predominantly as coppice and, to date, they have not been found to support a saproxylic beetle fauna of more than local significance." The author goes on to discuss the significance: "a rich saproxylic fauna was found in the same tree and it seems likely that this assemblage has developed over some time."

The comment re woodland cover is odd as it is continuity of veteran trees that determines the associated fauna not the availability of 'woodland'. Examining the OS maps shows the site to be along a distinct stream valley, a tributary of the River Wreake, and so continuity may have occurred through linkages within this linear habitat corridor. Charnwood Forest lies immediately to the west of the main river valley and about 10km to the west of Ashby. The Ancient Tree Inventory currently has no registered trees in the immediate neighbourhood - which might reflect either the absence of volunteer recorders or the absence of trees - but there is a cluster of veteran trees mapped at 4 - 5km to the east at Burrow Hill (Burrough Hill Country Park). Leighfield Forest is a remnant of the medieval Forest of Rutland (Whitlock, 1979). Ashby Folville therefore lies between two medieval forest areas and is linked to one of them via river valleys. A relict old growth fauna suddenly becomes much less surprising.

Table 3: The full saproxylic beetle list from the veteran ash tree at Ashby Folville

| Species | SQI | IEC | Status | Ecology |
|---|---|---|---|---|
| *Plegaderus dissectus* | 8 | 2 | Nat Scarce | White-rotten heartwood |
| *Abraeus globosus* | 4 | | Local | White-rotten heartwood |
| *Aeletes atomarius* | 16 | 1 | RDB3 | White-rotten heartwood |
| *Paromalus flavicornis* | 2 | | Local | Decayed wood |
| *Quedius scitus* | 8 | 2 | Nat Scarce | White-rotten heartwood |
| *Euplectus kirbii* | 8 | | Nat Scarce | Decayed wood |
| *Batrisodes adnexus* | 32 | 1 | RDB1 | Decaying heartwood |
| *Melanotus villosus* | 1 | | Common | Decayed wood |
| *Cerylon histeroides* | 4 | | Very local | Decayed wood |
| **Saproxylic Quality Score** | **83** | | | |
| **No of qualifying species** | **9** | | | |
| **Saproxylic Quality Index** | **922** | | | |
| **Index of Ecological Continuity** | | **10** | | |

The full saproxylic beetle list from the veteran ash tree is shown in Table 3. Although the Saproxylic Quality Index (SQI) should not be applied to such a small dataset, the resulting SQI is extraordinarily high, suggesting European significance. Fowles suggested 590 as the threshold for a site of European significance. A threshold of 40 species is however suggested, below which evaluation is unreliable. It was also acknowledged that some specialist collecting techniques may produce SQIs that may be unduly high. This is probably because lists generated by such methods are likely to contain species whose status is imperfectly known and hence overrated. Tiny beetles which live deep within decayed heartwood are probably a case in point. In contrast, the more conservative Index of Ecological Continuity (IEC) approach suggests local to regional significance, which is much more realistic for this particular example.

Lott comments that such an assemblage is an illustration of the potential conservation value of veteran hedgerow trees in the wider countryside. This is a very important point and one that wildlife conservation bodies need to take seriously if old growth faunas are to be maintained at viable population levels. This aspect is a key part of the rationale behind the proposed study.

## 3.2 The Cotheridge fauna

Whitehead (1996) reported a very comparable situation at Cotheridge (SO75) in Worcestershire. There exists on the floodplain pasture of the River Teme a rectilinear stockade of hawthorn, undoubtedly of post-medieval age. At some time in the past the hawthorns were allowed to develop without management; since that time all of the lower lateral growths were cut and removed, allowing livestock to move between the individual trees and exposing the trunks to full sunshine. A small nest of Brown tree ant *Lasius brunneus* was found beneath dead bark at the base of one of the standing hawthorns, together with a specimen of the small rove beetle *Euryusa sinuata*. In Europe this beetle is associated with thermophilous broad-leaved old growth conditions and is rare throughout its range as a result. It was initially graded in Britain as Endangered (Hammond, 1987) as at that time it was only known from the Windsor Forest area (1923-1983), including Silwood Park (1964) and Langley Park (1979). It was subsequently discovered at Burnham Beeches and its status reduced to Red Data Book (Indeterminate) (Hyman, 1992). While it has often been found with Brown tree ant, it does also occur in the absence of the ant – it may be that the ant enhances its habitat in some way. The species been found more widely in the Windsor area in recent years – Bushy Park, Hampton Court Park, Kew Old Deer Park, and West End Common, Esher - and it has become clear that there is also a substantial population in the Worcestershire area – Croome Park, Longdon Marsh, and at Baddesley Clinton in Warwickshire.

Whitehead (loc. cit.) also notes the presence of three Nationally Scarce deadwood beetles at the Cotheridge site: the woodworm *Hadrobregmus denticollis*, the checkered beetle *Opilo mollis* – which feeds on woodworm species – and the long-horned beetle *Anaglyptus mysticus*. These are all fairly typical of old hawthorns; only the checkered beetle is considered to have any requirement for ecological continuity and only to a weak extent.

## 3.3 Other agricultural landscapes associated with river networks

Alexander & Foster (1999) reported on the role that river floodplains may play in providing a level of ecological continuity for saproxylic assemblages at landscape scale. The study was based on a biological survey of the National Trust's Coleshill and Buscot Estate (SU29) which includes a section of the River Thames floodplain at its confluence with its minor tributary the River Cole. The estate is predominantly highly intensively managed farmland which appeared to be in no better or worse condition than neighbouring intensive farmland. The two rivers include networks of field drains and hedgerows lined by mature and over-mature trees, including old pollards as well as standards, and with crack willow, ash, oak and native black poplar. Only a few hundred years ago this would have been grazing marsh country and effectively an open pasture-woodland system – Buckland and Dinnin (1993) have pointed out that many localities with relatively rich saproxylic faunas have a core of old wetland, the wetness of the ground conditions having protected the tree cover from intensive exploitation for timber or small wood products. Thus today's fauna is a survival from an earlier landscape.

The SQI cannot be applied to this dataset as the full record of saproxylic beetles found is not available but the IEC is similar to that found at Ashby Folville, the key differences being the presence of two British Red Data Book species at the latter site.

The authors draw attention to similar studies elsewhere. M.F.V. Corley (in Peachey, 1982) reported a rich area of farmland along another section of the Thames farther downstream, at Pucketty Farm, Littleworth (SU39).

Table 4 The saproxylic beetle list from Pucketty Farm

| **Species** | **SQI** | **IEC** | **Status** | **Ecology** |
|---|---|---|---|---|
| *Dropephylla ioptera* | 1 | | Common | Subcortical |
| *Coryphium angusticolle* | 2 | | Local | Subcortical |
| *Siagonium quadricorne* | 2 | | Local | Subcortical, sappy |
| *Sepedophilus littoreus* | 2 | | Local | Fungus feeder |
| *Dorcus parallelipipedus* | 2 | | Local | White-rotten wood |
| *Sinodendron cylindricum* | 2 | | Local | White-rotten wood |
| *Hedobia imperialis* | 8 | | Very local | Subcortical & sapwood |
| *Xestobium rufovillosum* | 4 | 3 | Very local | Brown-rot heartwood |
| *Hemicoelus fulvicornis* | 1 | | Common | Dead branches |
| *Nemozoma elongatum* | 24 | | | Bark beetle predator |
| *Tillus elongatus* | 8 | 3 | | Woodworm predator |
| *Anthocomus fasciatus* | 4 | | Very local | Woodworm predator |
| *Epuraea limbata* | 2 | | Local | Subcortical, sappy |
| *E. silacea* | 1 | | Common | Subcortical, sappy |
| *Soronia grisea* | 2 | | Local | Subcortical, sappy |
| *S punctatissima* | 2 | | Local | Subcortical, sappy |
| *Pediacus depressus* | 16 | 2 | Nat Scarce | Subcortical |
| *Endomychus coccineus* | 2 | | Local | Fungus feeder |
| *Cis bidentatus* | 2 | | Local | Bracket fungi |
| *Litargus connexus* | 2 | | Local | Ascomycete feeder |
| *Mycetophagus multipunctatus* | 2 | | Local | Bracket fungi |
| *Bitoma crenata* | 4 | 3 | Very local | Subcortical |
| *Pseudocistela ceramboides* | 8 | 2 | Nat Scarce | Wood mould |
| *Vincenzellus ruficornis* | 2 | | Local | Subcortical |
| *Mordellochroa abdominalis* | 4 | | Very local | Dead dry sapwood |
| **Saproxylic Quality Score** | **109** | | | |
| **No of qualifying species** | **25** | | | |
| **Saproxylic Quality Index** | **436** | | | |
| **Index of Ecological Continuity** | | **7** | | |

The list is based on an extended period of recording in the 1960s and 1970s, and so is not directly comparable with the relatively short sampling sessions at Ashby Folville and Buscot/Coleshill. It is also unclear to what extent it is a complete list and so the calculated SQI (see table 4) needs to be treated cautiously. The SQI is high but less than national significance (500), whereas the IEC once again portrays a more realistic assessment of local to regional significance.

Kirby and Lambert (1992) report on a survey of willow pollards along the River Cam at Cambridge in 1990. Only the more interesting species are detailed and so the SQI cannot be calculated on the available data.

Table 5: The saproxylic beetle list from willow pollards along the River Cam

| **Species** | **IEC** | **Status** | **Ecology** |
|---|---|---|---|
| *Aderus populneus* | | Nat Scarce | Heartwood decay |

| Species | IEC | Status | Ecology |
|---|---|---|---|
| *Aromia moschata* | | Nat Scarce | Young healthy willow growth |
| *Cossonus parallelepipedus* | 3 | Nat Scarce | Heartwood decay |
| *Dorcatoma flavicornis* | 3 | Nat Scarce | Brown-rotten heartwood |
| *Eledona agricola* | 3 | Very local | *Laetiporus sulphurous* brackets |
| *Paromalus flavicornis* | | Local | Decaying wood |
| *Pseudotriphyllus suturalis* | 3 | Nat Scarce | Bracket fungi |
| *Scaphisoma boleti* | | Nat Scarce | Bracket fungi |
| | | | |
| **Index of Ecological Continuity** | **4** | | |

A pattern becomes to emerge that river valleys can act as both refugia and habitat corridors for saproxylic invertebrates, even for some species which appear to be characteristic of old growth, but also that site quality tends to be much lower than found in the classic ancient wood pasture situations – the IEC values tend to be relatively low.

Of course, it is highly probable that some individual beetles do disperse out from their old growth refugia and penetrate into the surrounding landscapes. In the majority of cases it seems that no mates are found and/or suitable breeding habitat is either absent or of poor quality, and new populations do not become established. In rare cases a small breeding population may develop but remains fragile and vulnerable, only to eventually die out as conditions deteriorate. Thus the discovery of a single specimen of a species considered to be an indicator of old growth conditions but far away from known rich sites may not be significant.

It is important however to treat records of individual species with great caution and to focus more on assemblages of the supposed old growth species. The earliest list of proposed indicator species included a number which have subsequently expanded out from their refugia in old growth sites in response to changing conditions in the wider countryside. Climate change may be having a significant impact on this thermophilous fauna – the natural range of much of the old growth fauna known in Britain is actually a central European one, centred on areas with much warmer and drier climate than that of much of Britain. This is very evident in the locations of some of the richest sites in the warmer and drier south-east and in the rain-shadow country on the east side of the Welsh mountains. This may mean that species previously limited in their mobility through relatively cold and damp conditions may become better able to spread out from their old growth refugia. This does appear to be happening to some extent, especially amongst the necessarily more mobile early-successional part of the saproxylic fauna. Species requiring dying or freshly dead timber need to be relatively mobile as a suitable tree or piece of wood may only remain suitable for a year or two, as succession proceeds. Thus Oak jewel beetle *Agrilus biguttatus*, oak tanbark-borer *Phymatodes testaceus* and oak pinhole borer *Platypus cylindrus* have all been expanding their presence across the English countryside in response to various oak diseases and conditions which have provided suitable breeding habitat in far greater abundance. Similar responses are apparent in the literature, e.g. following the appearance of Dutch elm disease, and with species exploiting freshly split oak which benefited from an upsurge in fencing as a result of the various Enclosure Acts.

# 4 THE PROPOSED FIELD STUDY

Nicklas Jansson has been looking again at the tree distribution maps of the four proposed study sites. He concurs with John Smith that we currently lack situations with very isolated hollow trees. The longer the gradient the more we will find clear differences. At present we have identified areas with relatively high densities of suitable trees and almost everything down to relatively isolated trees, but few very isolated trees. He recommends that we seek to find some examples of very isolated trees. Ideally these should be in the landscapes surrounding the existing case study sites - see section 6.3 in Alexander et al (2015) - but one or more additional sites would also increase the statistical robustness of the study, and especially where these include very isolated trees. He suggests that we need some example trees with gaps of several kilometres between them and other trees. Potential additional study sites are detailed in Alexander et al (2015) but Grimsthorpe Park and/or Needwood Forest may be especially suitable, the latter especially as voluntary help might be available for tree mapping through the Staffordshire Wildlife Trust (J. Webb, pers. comm.).

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# 6 REFERENCES

ALEXANDER, K.N.A. 1987. Some notable deadwood associated Coleoptera from N. Somerset. *Entomologist's Record* **99**: 156.

ALEXANDER, K.N.A., BENGTSSON, V.J., JANSSON, N., & SMITH, J.P. 2015. *The role of trees outside woodlands in providing habitat and ecological networks for saproxylic invertebrates. Part 1 Designing a field study to test initial hypotheses.* Unpublished contract report for Natural England.

ALEXANDER, K. & BOWER, L. 2011. The Noble Chafer and Traditional Orchards - an old-growth species in the English cultural landscape. *British Wildlife* **23**: 17-22.

ALEXANDER, K.N.A. & FOSTER, A.P. 1999. Scarce wood-decay beetles in a river floodplain farmed landscape in the Upper Thames Valley. *British Journal of Entomology and Natural History* **12**: 213-214.

ALEXANDER, K.N.A. & JONES M. In press. Experience with using cavity emergence traps to sample saproxylic invertebrates at a Cotswold wood pasture site. *British Journal of Entomology & Natural History*.

BAILEY, D., SCHMIDT-ENTLING, M.H., EBERHART, P., HERRMANN, J.D., HOFER, G., KORMANN, U. & HERZOG, F. 2010. Effects of habitat amount and isolation on biodiversity in fragmented traditional orchards. *Journal of Applied Ecology* **47**: 1003-1013

BIRKEMOE, T. & SVERDRUP-THYGESON, A. 2015. Trophic levels and habitat specialisation of beetles caught on experimentally added aspen wood: does trap type really matter? *Journal of Insect Conservation* **19**: 163-173.

BUCKLAND, P.C. & DINNIN, M.H. 1993. Holocene woodlands, the fossil insect evidence. In: KIRBY, K. & DRAKE, C.M. (eds) Dead wood matters: the ecology and conservation of saproxylic invertebrates in Britain. *English Nature Science* **7**.

CARLSSON, S., BERGMAN, K.-O., JANSSON, N., RANIUS, T. & MILBERG, P. 2016. Boxing for biodiversity: evaluation of an artificially created decaying wood habitat. *Biodiversity & Conservation* **25**: 393-405.

GOUIX, N., ZAGATTI, P. & BRUSTEL, H. 2009. Emergence of beetles from hollow trees – habitat requirements for *Limoniscus violaceus* (P.W.J. Müller, 1821) (Elateridae). In: BUSE, J., ALEXANDER, K.N.A., RANIUS, T. & ASSMANN, T. *Saproxylic Beetle – Their role and diversity in European woodland and tree habitats.* Proceedings of the 5th Symposium and Workshop on the Conservation of Saproxylic Beetles, pp133-148. Sofia: Pensoft.

GOUIX, N. & BRUSTEL, H. 2011. Emergence trap, a new method to survey *Limoniscus violaceus* (Coleoptera: Elateridae) from hollow trees. Biodiversity and Conservation (published on-line DOI 10.1007/s10531-011-0190-1)

HAMMOND, P.M. 1987. *Euryusa sinuata*. In: Shirt DB (ed.) British Red Data Books: 2. Insects. Nature Conservancy Council, Peterborough.

HORAK, J. 2014. Fragmented habitats of traditional fruit orchards are important for dead wood-dependent beetles associated with open canopy deciduous woodlands. *Naturwissenschaften* (doi:10.1007/s00114-1179-x)

HORAK, J., PELTANOVA, A., PODAVKOVA, A., SAFAROVA, L., BOGUSCH, P., ROMPORTI, D. & ZASADIL, P. 2013. Biodiversity responses to land use in traditional fruit orchards of a rural agricultural landscape. *Agriculture, Ecosystems and Environment* **178**: 71-77.

HYMAN, P.S. 1992. A review of the scarce and threatened Coleoptera of Great Britain. Part 1. Joint Nature Conservation Committee: *UK Nature Conservation* No.**3**.

JONSSON, B.G. & RANIUS, T. 2009. The temporal and spatial challenges of target setting for dynamic habitats: the case of dead wood and saproxylic species in boreal forests. In: Villard, M-A. & Jonsson, B.G. (eds) *Setting conservation targets for managed forest landscapes.* Cambridge University Press, Cambridge, pp207-226.

KIRBY, P. & LAMBERT, S.J.J. 1992. Some beetles collected during as survey of pollard willows along the River Cam, Cambridge. *British Journal of Entomology and Natural History* **5**: 75.

KOMONEN, A, PENTILLÄ, R. LINDGREN, M. & HANSKI, I. 2000. Forest fragmentation truncates a food chain based on an old-growth forest bracket fungus. *Oikos* **90**: 119-126.

LOTT, D.A. 1997. *Batrisodes adnexus* (Hampe) (Pselaphidae) in Leicestershire. *The Coleopterist* **6** (3): 102-103.

PEACHEY, C. 1982. Review of the invertebrate sites in England: Provisional Review of Oxfordshire. *Invertebrate Site Register Report* No. **8**, Part II. Nature Conservancy Council, London.

RANIUS, T., NIKLASSON, M & BERG, N. (2009) Development of tree hollows in pedunculated oak (*Quercus robur*). *Forest Ecology & Management* **257**: 303-310.

SCHIEGG, K. 2000. Are there saproxylic beetle species characteristic of high dead wood connectivity? *Ecography* **23**: 579-587.

SMOLIS, A. (in press) Isolation from forest habitats reduces chances of the presence of *Osmoderma eremita* sensu lato (Coleoptera, Scarabaeidae) in rural avenues. *Journal of Insect Conservation*

SVERDRUP-THYGESON, A., & MIDTGAARD, F. 1998. Fungus infected trees as islands in boreal forests: spatial distribution of the Fungivorous beetle *Bolitophagus reticulatus* (Coleoptera: Tenebrionidae). *Écoscience* **5**: 486-493.

WHITEHEAD, P.F. 1996. The northernmost British record of *Euryusa sinuata* Erichson, 1837 (Coleoptera: Staphylinidae). *Entomologist's Gazette* **47**: 255-256.

WHITEHEAD, P.F. 2009. NE Bredon LV Report – active data file. People's Trust for Endangered Species (unpublished).

WHITLOCK, R. 1979. *Historic Forests of England*. Moonraker Press, Bradford-on-Avon.