Ash dieback and loss of biodiversity

Can management make broadleaved woodlands more resilient?

Alice Broome, **Ruth Mitchell**, **Ralph Harmer** evaluate the practical measures that might be taken to maintain biodiversity if we lose significant numbers of ash trees from our woodlands.

Ash dieback is a serious tree disease caused by an invasive fungus from East Asia that has spread quickly across northern Europe where it has killed many ash trees during the last decade. We know the fungus as *Chalara fraxinea*, but rather confusingly it is called *Hymenoscyphus pseudoalbidus* in other countries, the reasons for which are related to the complicated biology of the species, which can exist in sexual and asexual forms. Recently, taxonomists have been recommending that the correct name for both forms is *Hymenoscyphus fraxineus*. The disease was first confirmed in the UK in 2012 and at the time of writing has been found at 649 sites across the country with most infected, established woodland sites being in the east and south of England (Forestry Commission, 2014). Ash trees are an important and widespread component of our broadleaved woodlands, occurring as occasional groups of trees through to being the dominant species in the canopy. Ash trees provide a significant timber resource. There are about 150,000ha of woodland composed of ash in UK with a standing volume of 34 million m^3 that comprises about 11% of total broadleaved woodland area and 14% of broadleaved standing volume, the majority of which is in the southern half of the country (Table 1). If the progress of the disease follows the same pattern as it has on the continent then large numbers of trees will die, which will obviously have a major effect on timber production. In addition to its role in timber production, ash is a native tree species common in many broadleaved woodlands that are habitats for a wide variety of other plant and animal species. Consequently loss of ash could have significant effects on woodland biodiversity that might be both positive (e.g. by increasing open space in woodlands for warmth loving species) and negative (e.g. loss of habitat for the species which use ash trees). Whilst loss of timber production may be of greater concern to individual owners, the maintenance of biodiversity in broadleaved woodlands affected by ash dieback is an important issue at the UK national level.

Table 1. Areas and standing volumes of broadleaved woodlands in the UK

	Area (thousands of ha)			Standing volume (thousands of m^3 overbark)		
	Broadleaved trees	Ash trees	% Ash	Broadleaved trees	Ash trees	% Ash
Scotland	265.0	13.6	5.1	34,046	2,699	7.9
England	885.7	110.4	12.5	181,766	26,163	14.4
Wales	126.2	17.6	13.9	23,953	4,967	20.7
N. Ireland	34.8	4.1	11.8	*	*	*
Total	**1311.7**	**145.7**	**11.1**	**239,765**	**33,829**	**14.1**

Data adapted from Forestry Commission (2012), and the Northern Ireland register of woodland, and the Habitat Action Plan for Mixed Ash Woodlands. * = no data.

A recent project (Mitchell et al., 2014a&b) set out to assess the potential ecological impact of ash dieback on UK woodlands and species, and to investigate how adverse effects might be minimised by woodland management. Ecological impacts were

assessed in several ways but here we report on the study of biodiversity associated with ash trees. The aim of this study was to:

1. Identify which plant and animal species are associated with ash and how closely they are associated.
2. Identify other tree species that are, or could be, used by ash-associated species.
3. Describe a method to assess the potential impact of ash dieback on ash-associated species.
4. Use case studies as examples to develop a method to describe how broadleaved woodlands could be managed to alleviate the adverse effects of ash dieback on ash-associated biodiversity.

This study builds on the work by Mitchell et al., (2014a&b) and uses the large database that was developed by them that catalogues ash-associated species and their conservation status, and lists potential alternative tree species (Mitchell et al., 2014b). This AshEcol database (a Microsoft Excel file) and supporting documentation can be downloaded from the Natural England website.

How many species use ash?

The species that use ash were identified from the literature by a group of species experts (Mitchell et al., 2014a&c). Ash-associated species are those that use ash trees as a food source (e.g. many insects and some mammals), a place to breed/nest (e.g. some birds), or a habitat in which to live (e.g. epiphytic bryophytes and lichens) or in which to hunt for food (e.g. insects and birds that feed on other insects that use ash). The information was collated in a database. Part of the database lists the ash-associated species, their conservation status e.g. 'Red Data Book' or 'Birds of Conservation Concern', and the level of association they have with ash trees as evaluated by the group of species experts (five categories from 'obligate' to 'uses' – see Table 2). The database currently includes 955 ash-associated species that occur in the UK, more than half of which are lichens (Table 2). Species vary in their level of association with ash, but few are very closely linked to ash with about 5% having an obligate requirement and a further 6% being classified as highly associated on the basis that they rarely use other tree species. However, for most species the association is only partial or weaker as these are able to use alternative tree species. A further 78 vascular plants, along with other mammals and birds not counted above, use the habitat of ash woodlands not the tree itself.

Table 2. Number of species and level of association with ash for six types of organism

	Level of Association					
Organism	Obligate	High	Partial	Cosmopolitan	Uses	**Total**
Birds			7	5	2	**12**
Mammals			1	2	25	**28**
Bryophytes		6	30	10	12	**58**
Fungi	11	19	38			**68**
Lichens	4	13	231	294	6	**548**
Invertebrates	30	24	37	19	131	**241**
Total	**45**	**62**	**344**	**330**	**174**	**955**

Level of association – five different categories of association describing the strength of dependency of species that use ash on ash trees. Five levels are: 'Obligate'= Unknown from other tree species; 'High' = Rarely uses other tree species; 'Partial' = Uses ash more frequently than expected; 'Cosmopolitan' = Uses ash as frequently, or less frequently than expected; 'Uses' = Uses ash but the importance of ash for this species is unknown.

Potential alternative tree species

The 48 alternative tree species listed in Table 3 were selected because they had the potential to grow at sites that currently support ash. The list contains both native and non-native species, some of which are not well-known. The value of these 48 tree species to ash-associated species was assessed and collated within the AshEcol database, which records whether each ash-associated species definitely uses or does not use each of the alternative tree species. Two other categories of association – 'likely' or 'rare' are also used with the caveat that these associations should be treated with caution (see Table 3 for definitions). However, in many cases the relationship between ash-associated species and alternative tree species is unknown. In general, tree species native to the UK support more ash-associated species than non-native tree species (Table 3). Oaks, beech, elms and hazel can all support more than half of the ash-associated species whereas sycamore is the only non-native to support a similar number. Although there are a few exceptions (e.g. sycamore, sweet chestnut, European larch), for most non-native tree species knowledge of their use by ash-associated species is poor and in general, information is available for less than 30% of species (Table 3 final column).

Elm supports the greatest number of the most vulnerable ash-associated species (i.e. obligate or highly associated and/or a high conservation status). Hazel, oak, aspen and sycamore also support high numbers of ash-associated species that are most vulnerable to ash-dieback.

Table 3. Number of ash-associated species supported by potential alternative trees and shrubs

Potential alternative tree species		Number supported	%
Native			
Oak sp	*Quercus robur/petraea*	640	94
Beech	*Fagus sylvatica*	505	92
Elm sp	*Ulmus procera/glabra*	477	86
Hazel	*Corylus avellana*	430	88
Birch sp	*Betula pubescens/pendula*	423	90
Alder	*Alnus glutinosa*	389	89
Rowan	*Sorbus aucuparia*	387	84
Aspen	*Populus tremula*	370	89
Hawthorn	*Crataegus monogyna*	302	88
Crab apple	*Malus sylvestris*	272	83
Field maple	*Acer campestre*	256	88
Holly	*Ilex aquifolium*	251	77
Large leaved lime	*Tilia platyphyllos*	242	81
Scots pine	*Pinus sylvestris*	216	81
Hornbeam	*Carpinus betulus*	169	88
Blackthorn	*Prunus spinosa*	167	81
Wild cherry	*Prunus avium*	116	88
Goat willow	*Salix caprea*	105	32
Whitebeam	*Sorbus aria*	100	82
Elder	*Sambucus nigra*	96	29
Bird cherry	*Prunus padus*	95	87
Privet	*Ligustrum vulgare*	92	75
Grey willow	*Salix cinerea*	91	31
Yew	*Taxus baccata*	89	86
Small leaved lime	*Tilia cordata*	84	31
Black poplar	*Populus nigra*	76	30
Wild service tree	*Sorbus torminalis*	7	22
Non-native			
Sycamore	*Acer pseudoplatanus*	473	88
Horse chestnut	*Aesculus hippocastanum*	208	81
European larch	*Larix decidua*	166	79
Common walnut	*Juglans regia*	149	81
Sweet chestnut	*Castanea sativa*	148	88
Black walnut	*Juglans nigra*	126	80
Plane sp	*Platanus x hybrid*	96	76
Silver fir	*Abies alba*	74	30
Turkey oak	*Quercus cerris*	70	32
Norway maple	*Acer platanoides*	60	31
Manna ash	*Fraxinus ornus*	29	30
Red oak	*Quercus rubra*	28	29
Western red cedar	*Thuja plicata*	17	22
American ash	*Fraxinus americana*	12	29
Green ash	*Fraxinus pennsylvanica*	12	29
Hop-hornbeam	*Ostrya carpinifolia*	10	20
Douglas fir	*Pseudotsuga menziesii*	8	29
Italian alder	*Alnus cordata*	6	23
Manchurian ash	*Fraxinus mandschurica*	6	29
Shagbark hickory	*Carya ovata*	1	19
Caucasian wingnut	*Pterocarya fraxinifolia*	1	19

Number = number of ash-associated species, out of 955, known to use the alternative tree species i.e. association is classed as 'definitely', 'rare' or 'likely'. 'definitely' = ash-associated species is known to use the alternative tree species. 'rare' = ash-associated species recorded on the alternative tree species but only rarely. 'likely' = ash-associated species, although not known to use the alternative tree species, is known to use other tree species in the same genera or is known to use a wide range of deciduous tree species.

% = Percentage of ash associated species for which any information is available showing whether they use or do not use the alternative tree species.

Case studies

Case studies were carried out at 15 sites across the UK that are representative of the types of site occupied by ash and have conservation of biodiversity as a management priority (Figure 1). The sites are primarily nature reserves or SSSIs for which objectives and management plans have already been developed, and for which good records of species present in the woodland were more likely to be available than elsewhere. Information on each site was collated and analysed following a five-step procedure concluding with a recommendation for management. These recommendations are aimed at conserving ash-associated biodiversity that could be most vulnerable if ash dieback were to establish. The consequences for ash-associated biodiversity, if management continued as planned, was also considered. This is illustrated using the Roudsea Wood case study site as an example (Box 1).

Figure 1. Location of the 15 case study sites. (NB The inclusion of a site in a case study does not indicate that ash dieback is present at the site).

Methods

A five-step procedure was developed to assess case study sites and provide management recommendations.

Step 1 – What species are present at the site?

The best information available for all organisms at each site was extracted from electronic databases, eg. for sites in England, data were taken from the National Biodiversity Network (www.nbn.org.uk/) using species records for the site or the 10km square in which the site is located. Although the case study sites were designated for their known biodiversity value the data available about the species present often fell well short of expectations with information on many types of organism being sparse or non-existent.

Step 2 – Are any of the ash-associated species present vulnerable to loss of ash due to ash dieback?

The species lists for each site were cross-referenced with the AshEcol database to identify any organisms at the site that are associated with ash. The number of these varied across the 15 sites with most being classed as 'cosmopolitan' or 'uses' indicating a relatively weak association with ash. Species considered vulnerable if ash were lost at each site were those categorised as having a 'high' association with ash trees and these were short-listed as a priority for management action. As they can often use a wide range of alternative trees or shrubs, species with a 'partial' association with ash were not generally considered to be vulnerable at the case study sites unless they were also a UKBAP priority

Box 1. Demonstrating the five steps of the case study procedure usi

Step 1 – What species are present at the site?

For Roudsea Wood, the National Biodiversity Network included 3720 records contained in 17 datasets at a search resolution of 100m for the years 1980-2014. Many species were recorded several times and after sorting the total number of species recorded for Roudsea was 579. No records were available for vascular plants, birds, amphibians or reptiles, and the survey data for bryophytes included only one species. Although Roudsea Wood is a well-known and studied site, there are significant gaps in the species data available. However additional sources of information can be used in this step of the analysis and at Roudsea Wood, data for bryophytes were provided by the site manager.

Step 2 – Are any of the ash-associated species present vulnerable to loss of ash due to ash dieback?

Fifteen of the species recorded at Roudsea Wood were identified in the database as being vulnerable to loss of ash. One species – a moth, the centre-barred sallow (*Atethmia centrago*) – is classed as obligate on ash, three other species are classed as highly associated with ash and the remainder are classed as having a partial association with ash. Four of the 15 species had a Red Data Book or IUCN listing.

Step 3 – Which tree and shrub species can provide alternative habitat for the vulnerable species?

Half of the vulnerable species at Roudsea Wood also use a wide range of alternative tree species that are expected to occur on the site. However seven of the vulnerable ash-associated species, all of which are moths, may be badly affected by loss of ash as the number of alternative tree and shrub species they use is small and may be absent from the site. The six non-obligate species use between one and five alternative trees or shrubs, with the majority using privet (Table A).

Step 4 – Site assessment

Roudsea Wood is developing into coppice with standards with many small coupes of varying age mixed with patches of stored coppice awaiting a restoration cut. It is being managed primarily for hazel dormouse, which is a European Protected Species. The overstorey is generally dominated by oak and small-leaved lime; there are some areas where ash dominates but over a majority of the site percentage canopy cover of ash is 5-10%. Other trees present include birch and hawthorn (which are common), rowan, crab apple, wild service tree and scattered conifers; a small amount of sycamore is present in the overstorey at the southern end of the wood. The understorey is predominantly hazel but other species such as spindle, blackthorn, and purging buckthorn are present. Whilst regrowth from coppice stools is vigorous and will ensure continuity of many of the existing trees and shrubs, the absence of substantial natural regeneration of any species during the last 20-30 years of coppice management, suggests that changing the relative abundance of different species using natural regeneration may be difficult.

species. 'Obligate' species will disappear as they only use ash and hence it was not possible to recommend management to conserve them.

Step 3 – Which tree and shrub species can provide alternative habitat for the vulnerable species?
Many of the most vulnerable ash-associated species are able to use a range of trees and shrub species, and a list of potential alternatives was drawn-up using information about what species use what trees/shrubs in the AshEcol database. Only those trees/shrubs definitely known to be alternatives were selected. If these trees or shrubs are already present on site or are introduced by managers then the vulnerability of ash-associated species to loss of ash may be reduced.

Step 4 – Site assessment
The sites were assessed to determine the amount and distribution of each tree and shrub species present and how they will respond to management. In addition, the potential of alternative tree and shrub species to grow was assessed, and site factors likely to have a significant influence on the choice of methods to manage the woodland considered.

Step 5 – What is the most appropriate management method to support ash-associated biodiversity?
The constraints identified in Step 4 were considered, in order to identify the most appropriate method of management when maximising ash-associated biodiversity is one of the main aims for the site.

ng Roudsea Wood as the example

The adverse effects of deer are obvious, including browsing damage to small trees, a browse line, and significantly less cover of bramble outside exclosures.

Step 5 – What is the most appropriate management method to support ash-associated biodiversity?
At Roudsea Wood, provision of habitat for hazel dormouse has a significant effect on the choice of stand management. Continued use of coppice with standards with some minor changes to existing procedures is probably the most appropriate method of future management.

Although there are alternative trees and shrubs for six of the vulnerable species of Lepidoptera that are present on site, these alternative species are not common. The spread of species such as wych elm and aspen is unlikely to take place by natural processes. Privet has intermediate shade tolerance and should survive the coppice regime being used; however it has not been seen recently.

The most reliable method to increase the amounts of these alternative tree species is by planting small numbers of transplants at appropriate locations. Planting should therefore take place within a coppiced area immediately after the fence has been erected and subsequent management should follow best practice to ensure establishment. The control of competitive vegetation within the fenced areas will be important.

The full case study can be found at: http://publications.naturalengland.org.uk/file/ 4712415308546048

Table A. Alternative trees and shrubs used by the most vulnerable ash-associated species identified at Roudsea Wood

Vulnerable species		Alternative tree and shrub species used by the vulnerable species								
		Alder	Hazel	Aspen	Goat willow	Grey willow	Horse chestnut	Privet	Black poplar	Elm
English name	Latin name									
The Coronet	*Craniophora ligustri*[H]	X	X					X		
Dusky Thorn	*Ennomos fuscantaria*[H,†]						X	X		
Yellow-spot Twist	*Pseudargyrotoza conwagana*[H]							X		
The Brick	*Agrochola circellaris*[P]			X	X	X			X	X
Lilac Beauty	*Apeira syringaria*[P]							X		
Barred Tooth-striped	*Trichopteryx polycommata*[P,†]							X		
Centre-barred Sallow	*Atethmia centrago*[O,†]									

Most vulnerable ash-associated = species with an obligate or high association with ash trees, or with a partial association but where the alternative host trees or shrubs are not present or infrequent at the site. O = species with an obligate association with ash trees. H = species with a high association with ash trees. P = species with a partial association with ash trees. †= species with Red Data Book designation.

Limitations of approach

There are limitations that need to be borne in mind when applying this approach to a woodland site. Firstly, the research has exposed gaps in our knowledge on species associations with trees. Whilst knowledge of relationships between ash trees and the species that use them in the UK is reasonably strong and well documented, our knowledge of the use ash-associated species make of other tree species is less and rather patchy. Levels of knowledge are low particularly for the potential alternative species that are non-native to the UK (see Table 3). As a consequence there is a lower likelihood that these trees would be selected for planting even though there is no evidence to indicate that they would not support ash-associated species. It should also be noted that the alternative tree species considered in the project have been selected as they are likely to establish on site types that support ash and we recognise that they may be only a subset of the range of trees and shrubs used by ash-associated species.

Secondly, implementation of this approach and the recommendations made are constrained by the quality of the species records available for the site being assessed. Provision of host trees for a particular ash-associated species can only be properly planned if the ash-associated

Table 4. Summary findings for 15 case studies

Site	% ash in canopy	Woodland structure	Number of species	Alternative trees and shrubs present on site	Recommended future management
Rassal	85	High forest / wood pasture	125	Several present but abundance low; could introduce aspen.	Establish new plants by natural regeneration or planting; prevent browsing damage by herbivores.
Glasdrum Wood	40	High forest	150	Several present but abundance low; could introduce blackthorn and elder.	Establish new plants by natural regeneration or planting; prevent browsing damage by herbivores.
Cleghorn Glen	30	High forest	55	A variety present but privet should be introduced.	Establish transplants in gaps after group felling; protect from browsing damage.
Marble Arch	80	High forest	87	A variety present but abundance of some is low.	Create gaps of suitable size for natural regeneration or planting.
Craig y Cilau	50	Scattered patches of trees amongst large areas of scrub	2	Present but abundance low; will be difficult to increase.	Establish transplants in areas fenced to exclude herbivores.
West Williamston	80	High forest	5	Common.	Create gaps of suitable size for natural regeneration or planting.
Coed Wen	90	Neglected coppice with standards	2	None; privet should be introduced.	Establish transplants in recently felled coppice coupes.
Roudsea Wood	5-10	Coppice with standards and stored coppice	27	Many present but privet should be introduced.	Plant privet in fenced, recently felled, coppice coupes.
Raincliffe and Forge Valley	45	High forest	9	Present but privet should be introduced.	Plant privet in gaps created by group felling.
Lathkilll Dale	95	High forest	9	Some present but abundance low; diversity should be increased.	Introduce new species by planting in gaps.
Downton Gorge	50	High forest	115	Present but privet could be planted.	Establish new plants within fenced, recently felled, coppice coupes.
Monks Wood	60	High forest	100	Present but abundance low.	Felling to reduce overstorey cover; prevent browsing damage by deer.
Bredon Hill	45	Wood pasture and scrubby woodland	80	Present but abundance low; could be introduced.	Establish trees by planting; prevent browsing damage.
Sapiston Grove	75	High forest	61	Present but at low abundance; introduce privet.	Establish privet using transplants; prevent deer browsing.
Hang Wood	70	Neglected coppice with standards	6	Present.	Reduce overstorey cover and prevent deer browsing.

Site: sites vary in size between 12 and 160ha; Figure 1 gives their location. Number of species = number of vulnerable ash-associated species.
Recommended future management = recommendations arising from application of the assessment process, aimed to alleviate the adverse consequences of ash dieback on ash-associated biodiversity.

species is known to be present. Consequently, a site that has been surveyed for the full range of flora and fauna is likely to have a better plan for maintaining ash-associated biodiversity, than one where species records are lacking.

Summary findings for the 15 case study sites

The key findings from the 15 case studies are summarised in Table 4. The majority of sites had a high forest woodland structure but several were neglected coppice sites, and others had abundant scrub but patchy canopy cover. Current percentage cover of ash in the canopy varied but was generally high. The number of vulnerable ash-associated species identified for individual sites varied between 2 and 150 species.

For all but one site (Coed Wen) the alternative tree and shrubs required by the site's vulnerable ash-associated species were already growing at the site, albeit in many cases at low abundance. Privet appeared as a key alternative species that needed to be introduced (at half of the case study sites) to support the vulnerable ash-associated species. Aspen, elder and blackthorn were the other alternative species recommended for introduction at two further sites.

Conclusions

The recommended management actions identified in the case studies indicate that conservation of ash-associated species in broadleaved woodlands containing ash will not require a radical change in practice. On the whole, recommendations focus on good silvicultural practice, the maintenance of woodland cover and adjustment of the relative mix and abundance of species already growing on the site. In some cases this means carrying out relatively intense management interventions (as recommended for Hang Wood), or continuing the current management regime but with slight changes (as recommended for Roudsea Wood). Revision of current management will be required at most sites to ensure that necessary changes in species mixture and abundance are achieved. The changes to practice will involve well-known forest operations such as preventing browsing damage, thinning and establishing trees by planting. However, at some difficult sites (e.g. Coed y Cilau) interventions may be impractical and non-intervention may remain the most appropriate option.

Although death of large numbers of ash trees could have significant negative impacts on species that use ash trees as habitat, interpretation of evidence from case study sites suggests that this impact may be limited by appropriate management using standard forestry practices to promote suitable alternative tree and shrub species. The answer to the question posed in the title 'Can management make broadleaved woodlands more resilient?' appears to be 'yes'.

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