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A summary of the impacts of ash dieback on UK biodiversity, including the potential for long-term monitoring and further research on management scenarios

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Disclaimer:

This document is based on three other reports (Mitchell *et al* 2014; Hinsley & Pocock 2014; JNCC, *in press*) and therefore, some sections directly utilise the wording from these reports.

Contents

1 Introduction

Ash (*Fraxinus excelsior*) is an important woodland and non-woodland tree throughout temperate Europe. In the United Kingdom (UK), ash is most common in Wales and the more southern areas of England, compared to Scotland, Northern England and Northern Ireland. Ash trees are commonly found as individual trees (*e.g.* in fields) or as part of hedgerows, as well as woodland areas (Maskell *et al* 2013).

The future of the ash tree in the UK is currently threatened by an emerging invasive fungal disease, *Hymenoscyphus pseudoalbidus*, commonly called 'ash dieback' or '*Chalara*' (Pautasso *et al* 2013). The disease causes leaf loss and crown dieback, and frequently leads to tree death. Evidence from continental Europe suggests that there could be rapid spread of the disease and a high level of tree death in the UK (Kowalski 2006; Halmschlager & Kiristis 2008; Bakys *et al* 2009; Ogris *et al* 2009; Kjaer *et al* 2012; Pautasso *et al* 2013).

Since the detection of ash dieback within the UK in 2012, three reports have been produced by JNCC to help inform management of ash dieback, with a particular focus on biodiversity. The first report mapped the distribution of important ash within Great Britain (GB), where important ash was defined as a 'significant and hard to replace or re-create semi-natural feature with a strong role in ecosystem functioning' (JNCC 2012 and *in press*). Secondly, a research project was undertaken to gain an understanding of the impact ash dieback is likely to have on ash-associated biodiversity and the likely consequences given different management scenarios (Mitchell *et al* 2014). Lastly, the potential for long-term monitoring of ash dieback impacts on biodiversity was investigated by Hinsley & Pocock (2014). Currently further research is being undertaken and includes continued development of the different management scenarios for biodiversity and to make the information more accessible to woodland managers and decision makers. This work is due to be completed in spring this year.

This paper provides an overview of the information to date on ash dieback in relation to its impact on UK biodiversity, long-term monitoring of such impacts and future research requirements. This document is aimed at UK policy makers and technical advisors within public bodies, in order to help manage their response to ash dieback.

2 The importance of ash to UK biodiversity

A provisional map providing evidence of the location of important ash trees and woodlands throughout GB has been created by JNCC (2012 and *in press*). Further work is required before an equivalent map could be produced for Northern Ireland. This GB map has been used with other GB-wide data such as how disease would be expected to spread from individual locations and hence the importance of protecting particular locations from infection (Defra, 2013). However, further work would be needed before it could be used at a local scale for management of important ash sites.

Mapping the location of important ash throughout GB was a required first step in understanding the possible spatial extent of the impact of ash dieback on UK biodiversity. Mitchell *et al* (2014) then compiled current knowledge of ash ecology, which provides evidence of its unique position within UK woodlands, hedgerows, and as an individual tree, given the ecological functions of ash. Ash trees create a nutrient-rich, rapidly degradable litter with a fast nutrient turnover, which contributes to the high pH of the soil compared to that typical of other UK tree species. Furthermore, the ash canopy has high light penetration. Such ecological functions create ash-specific assemblages of species, both above- and below-ground, thus contributing to, and enhancing, UK biodiversity.

Mitchell *et al* (2014) found that 1,058 species were associated with ash trees. The 1,058 species are composed of (from smallest to largest numerically): birds, mammals, bryophytes (mosses, liverworts and hornworts), fungi, vascular plants, invertebrates and lichens; see Table 1. These species may utilise the ash trees themselves, and/or the surrounding habitat created by ash trees. Out of the 1,058 species, 44 were 'obligate' ash-associated species, in that they have only been found on living or dead ash trees. These obligate species include fungi, invertebrates and lichens. Sixty-two further species were highly associated with ash, and include fungi, lichen, bryophyte and invertebrate species. The dependence of at least 106 species on the ash tree and the habitat these trees create, demonstrates the importance of the ash trees' contribution to UK biodiversity.

Table 1. The number of species in different species groups associated with ash.

Group	Total
Bird	12
Bryophyte	58
Fungi	68
Invertebrate	239
Lichen*	546
Mammal	55
Vascular plant	78

*See Chapter 6 of Mitchell *et al* (2014) for an explanation of taxonomic differences resulting in there only being 546 lichens in this table.

The importance of ash varies for different taxonomic groups (Table 1), but the total of 1,058 species is a high number for a single tree species. Lichens have the highest number of species associated with ash (Table 1), and ash has the second highest number of known associated lichens of any UK tree species. The very high importance of ash for lichens, contrasts with similar analyses for invertebrates. Table 2 shows the results of JNCC analyses of the British Lichen Society database and the Database of Insects and their Food Plants for seven tree species.

Table 2. Ranking of seven different tree species for associated lichens and phytophagous invertebrates.

Tree	Lichens	Phytophagous invertebrates
Oak	1 (Highest)	1 (Highest)
Ash	2	7 (Lowest)
Silver birch	3	3
Sycamore	4	6
Aspen	5	2
Beech	6	5
Alder	7 (Lowest)	4

The analyses of lichens and invertebrates were based on different criteria: lichen species are only counted if they have a particular association with a tree, all invertebrate associations are counted. The ranking of associated lichens only includes species for which greater than 10% of attributed records had a particular tree species as a substrate within England, Scotland and Wales (according to records within the British Lichen Society database, with thanks to the society for providing access to the data). The ranking of associated invertebrates is taken from the Database of Insects and their Food Plants (DBIF: http://www.brc.ac.uk/DBIF/homepage.aspx) without any additional analysis of association level.

3 Predicted impacts of ash dieback on UK biodiversity

The research project undertaken by Mitchell *et al* (2014) assessed the ecological impact of ash dieback on UK woodland habitat and ash-associated species, as well as identifying six management scenarios and their likely consequences. The UK was split into 'ash-relevant' regions in order to assess the impacts of ash dieback and the potential effects of different management scenarios.

3.1 Predicted impacts on UK woodland

Where ash is currently present in UK woodland habitats, ash dieback will create gaps in the canopy. The greatest impacts of ash dieback on the general integrity of woodland habitats will likely be in Southern England and Wales, which is where the areas of ash and the frequencies of woodlands with abundant upper canopy ash are greatest.

The response of woodland communities following the loss of ash was assessed, assuming natural regeneration:

> For woodlands where ash currently occupies less than 10% of the canopy, the other tree species currently forming the main canopy cover are expected to grow and fill the spaces left by any dead ash, resulting in little new recruitment of trees or expansion of the shrub layer. Shade-tolerant shrubs already present in the understorey may grow to fill gaps in woodlands containing 10 to 20% ash in the canopy. This response is anticipated in three quarters or more of the current ash-containing woods in Scotland, Northern England and Northern Ireland.
>
> For woodlands where there is a greater component (>20%) of ash in the canopy, canopy gaps are anticipated to be larger and/or more frequent. Under these conditions, existing shrubs and particularly saplings are expected to fill the spaces in the canopy in addition to some expansion by other existing canopy tree species. Over a longer time-period, established saplings will replace shrubs and fill the canopy gaps. Sycamore is predicted to become particularly dominant in many of the sub-regions in this regard. Beech and small-leaved lime may form larger components in 'former' ash woodlands in southern England.

Thus, in UK woodlands the canopy gaps left by ash dieback are not expected to be long-lived or permanent. Where ash is fairly common (>20%), and large gaps are created, they will be filled by other tree species that are currently in the woodland or surrounding area. Where gaps are smaller, created by the loss of only one or two trees, the canopies of existing trees will expand to fill the gaps.

Ash-associated species were assessed as to whether they also used any of a selection of tree species, considered most likely to replace ash, either naturally or through deliberate plantings. Information on species' use of these alternative tree species was used to develop similarity indices, which showed that oak, alder, beech and aspen were most similar to ash in their ability to support this set of species. A mixture of tree species rather than a single tree species will support a greater variety of ash-associated species. Lack of data makes it difficult to model the full responses of ash-associated species to other trees.

If ash is lost from an ecosystem, ecosystem function is likely to alter, particularly functions such as nutrient cycling which are highly affected by ash. Changes to ecosystem functioning (*e.g.* nutrient cycling), might be minimised if trees with similar traits, such as canopy height and bark acidity, are used to replace ash. An analysis of plant traits showed that none of the trees analysed were very similar to ash, although single traits of some of the alternative tree species may match ash. Alder and aspen were identified as the trees most similar to ash overall, while sweet chestnut and Douglas fir were the most dissimilar.

While aspen was ranked relatively similar to ash by both ‘species use’ and ‘traits’, of all the tree species assessed, no single tree species is considered able to provide a suitable alternative for all ash-associated species as well as ‘matching’ ash in terms of ecological function and plant traits.

The tree species that are likely to replace ash via natural regeneration (*e.g.* birch, sycamore, beech) are not those considered most similar to ash based on ‘species use’ and ‘traits’. The most suitable tree species to replace ash will be site dependent. It will depend on: (1) which ash associated species are present at the site, (2) the environmental/climate conditions at the site (i.e. if the alternative tree species will grow there), and (3) the management objectives at the site. Applying the knowledge gained in Mitchell *et al* (2014) so as to make appropriate management decisions for sites throughout the UK, such as deciding on natural regeneration or active management or manipulation of species regeneration, is the purpose of the further research work currently being carried out.

3.2 Predicted impacts on UK species

There are a large number of species associated with ash, which will be impacted by losses of ash trees. Compared with other broad-leaved trees, as far as these are understood, the diversity of phytophagous invertebrates is relatively low, but ash trees have particularly important epiphyte communities of mosses, liverworts and lichens. Ash has increased in its relative importance for epiphytes since the widespread loss of elm trees, since both trees have high bark pH and can support similar epiphyte species.

Using combined information on species use of ash, conservation status and expert knowledge, species within two predicted impact categories were identified. The first category comprises species that are currently rare and may become rarer due to ash dieback; this category includes:

- Nine bryophytes (mosses and liverworts),
- 19 invertebrates, comprising two Lepidoptera (butterflies and moths), 14 flies, three beetles
- 54 lichens;
- Three bird species;
- Eight vascular plants;
- Rare bat species - if they roost in ash trees, or if ash trees form an important component of their landscape used for commuting or foraging.

The second category is for species that are currently common but may become rare or rarer as a result of ash dieback, and include:

- Some ash-associated bryophyte species which are only now recovering from 19th and 20th century air pollution;
- A suite of small Atlantic liverworts;
- Nine of the 11 ash-obligate fungi;
- 45 invertebrates comprising seven moth species, four beetles, 14 bugs, 11 flies, four ticks/mites and five thrips;
- Four lichen species.

Overall, it is recognized that if ash dieback does lead to widespread death of ash trees within the UK, it is likely there will be a high negative impact on populations of plant and animal species that use ash trees. Specifically, species of invertebrates, lichens and bryophytes are at most risk from ash dieback based on the number of species affected.

3.3 Management scenarios

Four different management scenarios were assessed in detail, which cover a range of different stand management options that are likely to be used in response to ash dieback and the death of ash trees. These four scenarios are detailed below:

(1) **Non-intervention** – stands are allowed to develop naturally with no interventions.
(2) **No felling with natural regeneration promoted** – no felling but otherwise stands initially managed for natural regeneration (*e.g.* fencing and vegetation management).
(3) **Felling** – all ash trees and coppice removed in one operation with, if necessary, additional trees of other species cut to make the operation at least break-even economically. The additional trees will always be less than 10% of the number of ash trees removed or canopy space created. No subsequent interventions carried out.
(4) **Felling and replanting** – felling in the same manner as (3) above, but then active management to replant with alternative tree and shrub species focussed on the felled areas of the stand, with subsequent management to develop overstorey species.

Management scenarios (1) and (2) are predicted to be better for ash-associated biodiversity in the short term, as they retain the ash and dead ash in the woodland for longer compared to management scenarios (3) and (4). After 50–100 years there is considered to be little difference between the first four management scenarios in terms of their impact on obligate and highly associated species, with most species declining or possibly becoming extinct. There is considered to be little regional variation in the predicted impact of the management scenarios for most species groups.

However, it should be noted that these predicted outcomes are based on the assumption that in scenarios (1) and (2) all ash will be lost by 50–100 years. This assumption is based on experiences in parts of continental Europe where this disease has already spread widely infecting a high proportion of ash. However, the UK may not follow a similar pathway, for example if some ash trees are tolerant of the disease and survive. If some ash survives then obligate species may just decline rather than becoming extinct, although predicting the effects on obligate species is complex. Ash survival is less likely in scenarios (3) and (4), and hence the fact that obligate species may survive strengthens the arguments in favour of scenarios (1) and (2). It would be helpful to know the impacts of the different scenarios on partially associated species, as this could further help to differentiate between the scenarios.

Two other management scenarios were briefly considered:
(5) **Thinning** - regular operations to thin stands by removing diseased and dead trees or coppicing ash, with, if necessary, additional trees of other species cut to make the operation at least break-even economically.
(6) **Felling with natural regeneration promoted** - all ash trees and coppice are removed in one operation with, if necessary, additional trees of other species cut to make the operation at least break-even economically. Following which, there is active management initially to achieve natural regeneration in the stand, with subsequent management to develop overstorey species.

The predicted outcomes from management scenarios (5) and (6) are currently being assessed in terms of the impact on ash-associated species, and predictions are due in spring 2014 (see Section 4.2.2 for further detail).

4 Long-term monitoring of ash die-back and future research

Long-term monitoring of the impact of ash-dieback on UK biodiversity needs to be integrated with other sources of information on woodland condition, in order to inform coherent management responses. Whilst management is necessarily a local decision, impact monitoring is most likely to be informative at a broad scale, with results then used to assist in the provision of more local advice. Hinsley & Pocock (2014) investigated the possibility of establishing a long-term monitoring strategy within the UK to monitor the effects of ash dieback on biodiversity, and how this could be achieved in the most cost-effective manner.

4.1 Long-term monitoring strategy of impacts on biodiversity

The proposed monitoring strategy is built on a core of eight large-scale existing surveys to provide monitoring of essential taxa and contexts. These core surveys are:

(a) agri-environment monitoring schemes (collectively across different country schemes);
(b) Breeding Bird Survey;
(c) UK Butterfly Monitoring Scheme/Wider Countryside Butterfly Survey;
(d) BSBI/CEH draft proposals for monitoring woodland epiphytes and ground flora;
(e) Countryside Survey (and Northern Ireland Countryside Survey);
(f) designated sites monitoring (such as Common Standards Monitoring);
(g) National Forest Inventory (NFI); and
(h) National Bat Monitoring Programme.

This core provides generally complementary data across much of the UK, although coverage in Northern Ireland is variable. Whilst future funding issues can affect any of these surveys, it is particularly noted that core survey (d) is currently unfunded beyond a pilot phase, and that there is high uncertainty around the funding of core survey (e). The exact scope of future core surveys (a) and (f) is also uncertain. There is currently an ongoing process to review expenditure on biodiversity monitoring and surveillance within Defra and the arms-length bodies with a view to producing a more strategic approach.

The use of these core surveys would provide an excellent balance between professional surveys and those carried out by expert volunteers. Surveys (a), (e), (f) and (g) are all professional surveys, whilst (b), (c), (d) and (h) use expert volunteers.

Key information gaps that these core surveys would not cover are:

(a) Invertebrates other than butterflies;
(b) Fungi associated with ash;
(c) Small woods;
(d) Non-woodland trees;
(e) Urban trees and small woods;
(f) In-depth surveys on key sites that could assist in interpreting the UK-wide data.

Small woods and non-woodland trees are included within Countryside Survey, though this has future funding uncertainty and only low temporal frequency of survey. A possible additional survey that could cover small woods is the Forestry Commission Small Woods Survey (companion survey to the NFI), which has the potential to be included as a core survey. It monitors trees outside of woodland (the lower area limit for woodland being defined as 0.5ha), which includes all trees within areas that the UK would define as ‘small woodlands’, such as copses and spinneys, plus single trees and trees within hedges. However, it is currently unfunded.

This basic monitoring structure would need to be supported by more in-depth research to evaluate the mechanisms and consequences of the disease for wider or deeper ecological processes and ecosystem functions. Sites with existing long-term research programmes and data-sets would be most suitable and cost-effective to fill this role. Such sites (*e.g.* Monks Wood NNR Cambridgeshire, Bradfield Woods NNR Suffolk, Swanton Novers NNR Norfolk) in areas at high risk of early infection could also supply results to model impacts and inform data collection and management advice as infection spreads.

A range of possible options for further investigation were identified. These include:

(1) Identifying a suitable framework for integration of information from the core surveys and other sources in order to provide a coherent understanding of ash dieback impacts;
(2) The possibility of limited modifications to recording within existing surveys in order to better capture the impacts due to ash dieback;
(3) The potential for using an extended network of sites with co-occurrence of sampling techniques from the core survey methods.

4.2 Current research

Work to extend that of Mitchell *et al* (2014) is currently being completed. This research is increasing our knowledge of potential alternative trees to ash, as well as extending the outcomes of the six management scenarios and making the information more accessible to woodland managers and decision makers. This research is due for completion in spring 2014 and is detailed below.

4.2.1 Expanding the number of alternative host tree species

Further tree species are being investigated for their potential to host ash-associated species. This will include a 'trait analysis' to determine the most useful traits for alternative tree species based on the use ash-associated species make of different aspects of the ash tree.

Further research on some of the alternative tree species likely to replace ash is underway to identify their ecological characteristics and functions, which affect how they behave in combination with other species. For example, how a tree's canopy shade, or its propensity for nutrient cycling, or the chemical composition of the leaves, would impact on the ground flora or tree regeneration associated with ash woodlands. This information will give a fuller picture of the changes in ecology that would happen after the loss of ash, if it was replaced by these tree species either as a result of natural colonisation, or from management interventions.

4.2.2 Extending the management scenarios

The impact of management scenarios (5) Thinning, and (6) Felling with natural regeneration promoted, were not previously investigated. The impact of these scenarios on obligate and highly associated species is now currently being investigated.

Descriptions of the possible changes in woodland structure and ground flora are currently being investigated for all six management scenarios in woodlands where there is a greater proportion of ash in the canopy (20-50%). These scenarios include a small percentage of ash remaining in the woodlands due to tolerance to ash dieback. The impact of these scenarios on partially associated species is being assessed as it is expected that actions to mitigate the impact of ash dieback, for example by planting alternative tree species, will be of greater benefit to partially associated species than obligate or highly associated species.

We are also working to make our current knowledge on the ecological impact of ash dieback more accessible to woodland managers by developing a series of case studies and worked examples, to show how it can be used to inform management choices at a site level, within the wider context of the wood. Fifteen case studies will show how the database of alternative tree species for ash-associated species and the traits information can be used, and ideally sites will have an existing management plan and these case studies will show how the plan (and objectives of management) could be modified to address the impacts of ash dieback. All the above information will be available to woodland managers and decision makers via a front end to the database that allows access to the information and links to other relevant research and guidance.

4.3 Future work on ash-associated species

There is still additional work that needs to be undertaken to understand how to minimize the impact of ash dieback on UK biodiversity.

The research undertaken by Mitchell *et al* (2014) did not cover the impacts of ash dieback on ash trees themselves (*e.g.* the extent of dieback within a tree, the age of trees worst affected, the proportion of affected trees, *etc.*). If available, this information could be combined with the current information provided by Mitchell *et al* (2014) to provide more refined and detailed predictions of the likely impacts of ash dieback on ash-associated species.

There is further information that could be analysed to refine our understanding and predictions of the likely changes to floral and faunal species given ash dieback. Such work includes:

(1) a more accurate analysis of response and succession to be modelled for responder trees and shrubs;
(2) a review of empirical evidence on plant responses to changes in shading over long time-periods for meaningful estimations on whether ground flora species would be lost due to a change in light levels, or if they had the potential to re-colonise had they been lost;
(3) analysis on whether ground flora species would be lost due to competition between species;
(4) and finally, further work on the potential impacts of ash dieback on ground fauna species not directly associated with ash trees but which are found in ash woodlands.

However, there would still be difficulty in predicting outcomes for species in the face of ash dieback, and thus, the balance between the amount of extra work undertaken and the value of the knowledge gained needs to be assessed before carrying out any of the above research.

4.4 Future work on other trees

There are many other pests and diseases that are threatening the health of UK trees. In order that we may understand in advance the potential impacts of tree pests and diseases on associated biodiversity and on ecosystem function, there is a need for similar research on other tree species. This could help to populate environmental impact values in Pest Risk Analyses and within the UK Plant Health Risk Register. This would allow us to ensure that sufficient priority is given to preventing the establishment of pests and diseases that impact native trees.

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