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Ash dieback: long-term monitoring of impacts on biodiversity

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Summary

The overall objective of this study was to scope-out the options for a long-term monitoring strategy of the impacts of ash dieback on biodiversity in the UK. This objective was addressed using a 3-day facilitated workshop at CEH Wallingford, bringing together expertise from CEH, various NGOs and the statutory agencies. The main questions addressed were: (1) What are the monitoring needs for ash dieback? (2) How suitable are existing surveys? (3) How does current monitoring need to be enhanced or extended?

Prior to the workshop, information was collected (via consultation with workshop delegates) to identify: (i) the receptors (i.e. species, taxa, processes, etc., likely to be affected) of ash dieback impacts; and (ii) the contexts (e.g. various woodland types, hedgerows, lone trees) within which ash occurs in the UK. Information concerning the attributes of a wide range of current surveys, monitoring schemes and relevant data-sets were also compiled using a pro-forma e-mail request and questionnaires. This report was compiled using the information from the pre-workshop consultations, the outputs from the workshop, and the information (and other documents) gathered by the questionnaires and related informal information requests/discussions.

The potential for current surveys to monitor ash dieback impacts appeared to be generally comprehensive, but with some important exceptions. Assessing impacts on invertebrates, including soil invertebrates, would probably require more effort because of the large numbers of species concerned, the wide range of niches occupied, and the complexity of the ash-specific and wider woodland environment resources involved. Fungi (including mycorrhizae and endophytes) were similarly likely to require more monitoring effort. In terms of the contexts within which ash occurs in the UK, small woods (classified as <0.5ha), including urban woods, and small, non-woodland features such as spinneys, copses, rows of trees, lone trees and hedgerows/hedgerow trees were also likely to require more survey effort – and especially so in respect of tree health and monitoring invertebrates and fungi.

Management activity and grazing/browsing by deer were identified as potentially important modifiers of impacts of the disease on habitat structure, composition and biodiversity. Management activity (such as felling and active replacement of ash) in response to infection, or as a means of mitigating its effects may make assessment of the impacts of ash dieback *per se* difficult to quantify. Similarly, disease impacts on regeneration (especially in the context of coppice) may be obscured or exacerbated by deer browsing. Such concerns also apply to management of ash outside of woodland, and especially in urban and infrastructure contexts where safety and insurance liabilities may have a higher profile.

Large-scale surveys appeared to have by far the most immediate direct relevance for a UK-wide ash dieback monitoring scheme. However, site-based surveys at a more local-scale have potential for expansion to wider geographical areas and, in particular, could provide pre-infection baseline data in the event of repeat surveys. There is also scope to increase and/or modify the information collected by both professional and volunteer-based surveys to better target ash dieback effects, but it was recognised that such changes, unless relatively small, might carry costs, for example increased survey time, changes in the data recorded, and risk of volunteer overload. These would also apply if monitoring were further extended to include additional tree diseases.

Eight large-scale surveys with the potential to comprise ‘the core’ of a monitoring scheme were provisionally identified as: (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, (f) designated sites

monitoring, (g) National Forest Inventory (NFI), and (h) National Bat Monitoring Programme. Despite the relatively large scale of geographic coverage of these schemes, it was recognised that recording methods and effort within some of them (e.g. agri-environment schemes and designated sites monitoring) varied between countries, and some schemes did not apply at a truly UK-wide scale. For example, Northern Ireland is not included within the National Forest Inventory, and agri-environment monitoring is mostly lacking in Scotland. Therefore, to obtain a truly UK-wide ash dieback monitoring scheme based on these surveys will require some extension and modification. Funding issues also apply, for example in terms of future repeat survey events (e.g. for Countryside Survey, and aspects of designated sites monitoring and agri-environment schemes) and for the BSBI/CEH plant and epiphyte surveillance proposals that have as yet only pilot project funding. These various cost implications are discussed below.

To operate as a coherent source of information, a mechanism for data integration and information exchange between the core surveys would be essential. The core surveys would also need to receive and exchange ash-dieback-related data and information with the large body of 'other' surveys outwith the set of core surveys. The location (for example, largely within the core surveys, within an existing 'umbrella' organisation such as the Biological Records Centre, or some new or additional approach), structure and function of a data/information integration unit or function should be a priority for further work.

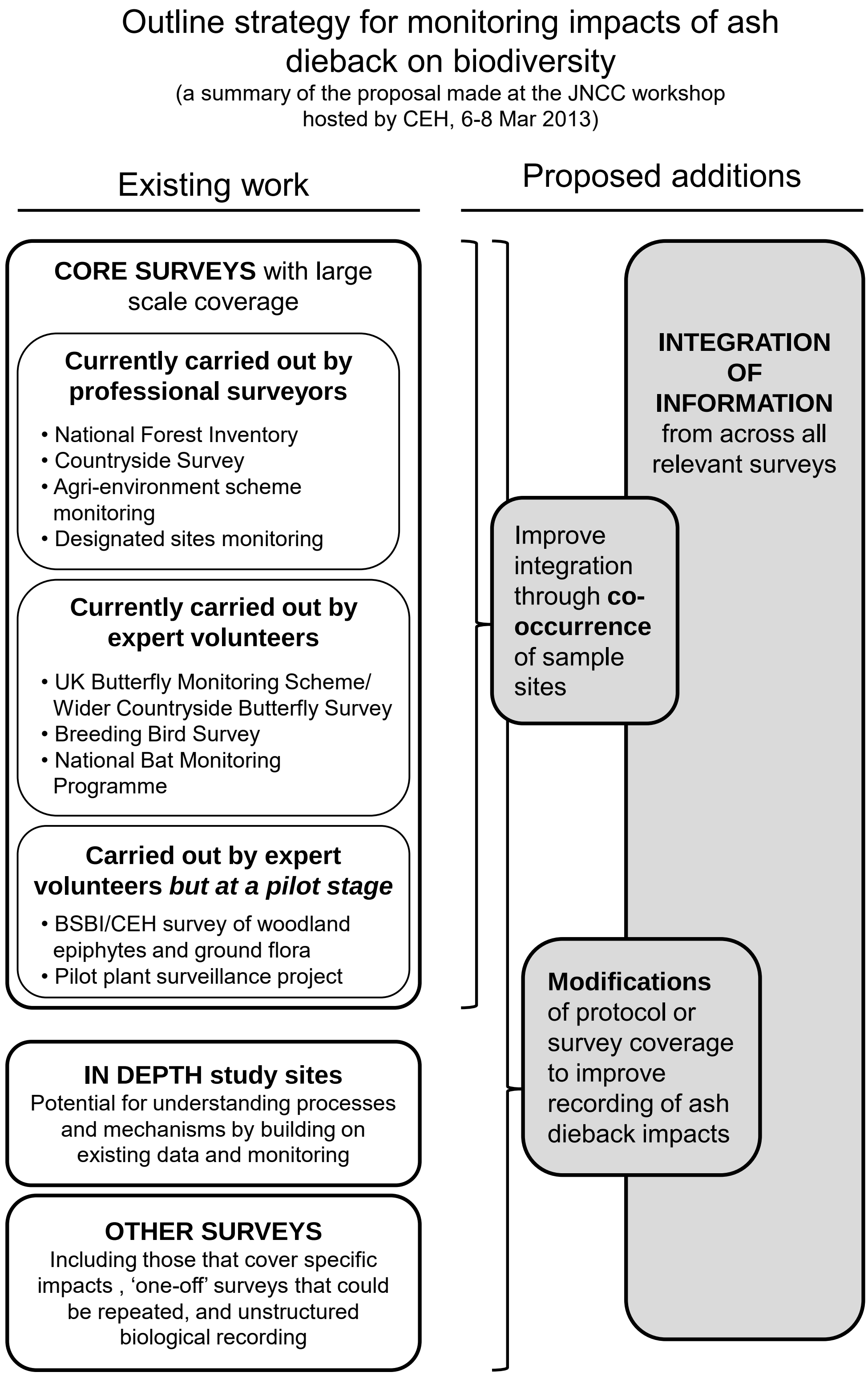
The basic structure of a set of core surveys, supported by input from the main body of 'other' surveys, and with an overall integration/information exchange function could be effective for monitoring direct, observable impacts of ash dieback in the first instance. It was further proposed that this basic monitoring structure would need to be supported by more in-depth research to evaluate the mechanisms and consequences of the disease for wider/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.

To maximise the benefits (and cost-effectiveness) of data collection across the eight core surveys, it was proposed that the potential to achieve co-occurrence (i.e. use of the same sites or sample squares across different surveys) should be a priority for further work. Efforts should also be made to maximise co-occurrence when setting up new surveys.

Building a monitoring programme for ash dieback on exiting surveys is cost-effective, but major potential cost areas were identified as funding for:

(i) Repetition and continuation of the core surveys (e.g. Countryside Survey and support for agri-environment and designated sites monitoring).
(ii) Repetition and continuation of 'other' surveys – highly notable in this respect being the Small Woods Survey (companion survey to the NFI).
(iii) New proposals (e.g. the BSBI/CEH pilot projects for monitoring woodland epiphytes and ground flora; ObservaTree).
(iv) Extension of core surveys, or something analogous, to areas where they are currently lacking.
(v) Investigation of how to best integrate information exchange across the core surveys and between the core and 'other' surveys.
(vi) Support for further research work and monitoring at selected in-depth study sites.
(vii) Investigation of how to maximise the benefits of co-occurrence of sites across surveys.
(viii) Investigation into a new network of co-occurring sites targeting a buffer zone within the boundary of areas at high risk of infection.

(ix) Increased frequency of monitoring within a rolling programme scenario plus the costs of analyses and reporting.
(x) Information gathering in relation to management activity in response to ash dieback.



Contents

1 Objectives (compiled from Annex A of the invitation to tender), summary of approach, and reasons for monitoring

1.1 Objectives

1. Identify the questions about impacts and changes due to ash dieback that long-term monitoring will need to answer.
2. Identify which components of ecosystems (and management measures in response to ash dieback) will need to be monitored.
3. Assess the cost effectiveness of current monitoring schemes and surveys to evaluate the impact of ash dieback and related diseases on species, woodlands and sites.
4. Identify gaps in current monitoring, including assessment of management responses.
5. Review long-term monitoring from elsewhere in Europe that is relevant to ash dieback.
6. Outline a long-term monitoring strategy for the UK of the impacts of ash dieback and related management measures including potential delivery mechanisms and costs.

1.2 Summary of approach

Given the short time available for this work and the wide range of monitoring activity that occurs across the UK, the above objectives were addressed using a facilitated workshop at CEH Wallingford (Wednesday 6 March to Friday 8 March 2013). The workshop comprised experts in the field from the statutory agencies (Joint Nature Conservation Committee, JNCC; Countryside Council for Wales, CCW; Department for Environment, Food and Rural Affairs, Defra; Northern Ireland Environment Agency – Natural Heritage, NIEA; Forestry Commission, FC; Natural England, NE; Scottish Natural Heritage, SNH), and from the Centre for Ecology and Hydrology (CEH) and its collaborators (Bodsey Ecology; Botanical Society of the British Isles, BSBI; Bournemouth University, BU; British Trust for Ornithology, BTO; Forest Research, FR; Woodland Trust, WT). The list of workshop delegates is given in Appendix 1. The workshop, built on preparatory work designed to maximise its efficiency and to deliver within a set time-frame, used a combination of break-out groups reporting back to the whole workshop and whole group discussions.

The approach of a focussed workshop has been adopted successfully in the past (e.g. Sutherland *et al* 2006, 2011). Pocock *et al.* successfully adopted a similar approach for the recent 'Monitoring Change' workshop held at CEH Wallingford in January 2013, which involved 40 participants from across the recording community (e.g. statutory agency staff, recording schemes and societies, researchers).

The work was jointly led and co-ordinated by Dr. Michael J.O. Pocock and Dr Shelley A. Hinsley of CEH.

1.2.1 Broad questions addressed at the workshop

1. What are the monitoring needs for ash dieback?

At a policy-level, identify reasons and requirements of monitoring. At a practical ecological level, assess what needs to be monitored (both biodiversity and ecosystem functions), and also where it needs to be monitored (i.e. within the landscape context of the ash). The output of this to be an annotated grid identifying the 'what and where' required for ash dieback monitoring (Objectives 1 and 2).

2. How suitable are existing surveys?

Assess how well a wide range of current survey and monitoring systems (and relevant existing data-sets) could fulfil the monitoring needs. Use expert opinion to summarise the attributes of current surveys for consideration at the workshop. Delegates will then consider their strengths, weakness and cost-effectiveness with regard to monitoring ash dieback (Objective 3).

3. How does current monitoring need to be enhanced?

Identify gaps in current monitoring and how they might be filled by extension or adaptation of existing monitoring and/or by new activities (Objectives 4 and 5).

4. A long-term monitoring strategy for the impacts of ash dieback for the UK.

Identify the key requirements of a long-term monitoring strategy for ash dieback with special reference to coverage, context, frequency and cost-effectiveness (Objective 6).

1.3 Summary of reasons and/or requirements for monitoring ash dieback

The question below was circulated to workshop delegates before the workshop, and the following reasons/requirements for monitoring ash dieback were summarised from the responses received. The most comprehensive response was received from JNCC, and this is reported in full in Appendix 2. These responses contribute to meeting Objective 1.

Question: In your role as representative of your organisation at the Workshop, please could you answer the following question:

> *What does your organisation/department see as the main purpose(s) or required outcome(s) of monitoring the impacts of ash dieback on biodiversity in the UK, and how (if at all) are these requirements likely to be influenced by cost? Possible examples could include:*
> - *To inform policy concerning…………..?*
> - *To facilitate provision of advice to landowners, managers, farmers, etc.?*
> - *To inform forestry management?*
> - *For public information?*
> - *For nature conservation, landscape character, etc.?*
> - *For science?*

1.3.1 Reasons/requirements for monitoring

i. Statutory and legal obligations/policy

- To inform statutory and legal reporting requirements, for example concerning plant health, The Habitats Directive, various International Conventions.
- To inform all aspects of environmental/biodiversity policy.
- To inform biosecurity policy.

ii. Science – ecology

- Knowledge of the biodiversity impacts, including changes to ecological processes.

- Knowledge of impacts on designated sites and protected species.

- Increase in ecological knowledge of perturbations and resilience of woodlands and wooded landscapes.
- Knowledge for nature conservation and ecosystem services.

iii. Management
- Knowledge to inform management decisions and management policy.
- Knowledge of the impacts of management responses to the disease.

iv. Advice
- To provide advice and information to landowners, managers, policy advisors.
- To provide advice on monitoring the disease and its impacts.

v. The public
- To explore the contribution of citizen science.
- Societal impacts and public understanding of impacts.

vi. Other
- Cross-applicability of monitoring, etc., to other tree diseases (present, emerging, future).
- Integration with European monitoring.

Note: Cost was acknowledged as a significant factor by all contributors

2 Workshop preparation and activity

2.1 Workshop preparation

Prior to the workshop, the following actions were completed.

- A list of possible receptors (i.e. the factors or processes which will be affected by ash dieback) was compiled by CEH, circulated to all workshop delegates and edited in response to comments received to produce a second version (Appendix 3). This second list was then summarised under a shorter list of headings (Appendix 3) to facilitate use in assessing ash dieback impacts across the range of identified contexts (see below) and for discussion at the workshop.
- A list of contexts within which ash occurs in the UK (e.g. woodlands, hedgerows, individual trees, etc.) was compiled by CEH, circulated to all workshop delegates and edited in response to comments received to produce a second version (Appendix 3) for discussion at the workshop.
- All workshop delegates were requested to send CEH a list of their organisations' reasons and/or their requirements for monitoring ash dieback impacts (Section 1.3.1).
- Agency delegates were requested to provide a summary of policy relevant to ash dieback for presentation at the workshop.
- A questionnaire, designed to capture the essential attributes of existing surveys, was drawn up by CEH, tested independently on a number of schemes and edited according to feedback to produce a final version (Appendix 4).
- Organisations and persons responsible for, or with knowledge of, existing surveys, monitoring schemes or data-sets with relevance for ash dieback impacts were requested (by CEH by e-mail, Appendix 4) to fill in a questionnaire or questionnaires and to return it/them to CEH.
- A list of surveys, etc., and of organisations or persons to contact was drawn up by consultation within CEH and with prospective workshop delegates and their organisations/agencies.

2.2 Workshop activity – summary of proceedings

The following Section summarises the proceedings of the workshop. The key outputs are listed in Section 2.3 with explanatory notes.

2.2.1 Day 1

Reasons and/or requirements for monitoring ash dieback were reviewed. Policy relevant to ash dieback was reviewed. Reasons and requirements were re-iterated at several points throughout the workshop to maintain focus.

The list of receptors was reviewed. The rationale behind the production of the shorter list of receptors was discussed. A few additional receptors were added to the list, but with the exception of 'invertebrates – using ash' and 'invertebrates – using the woodland environment (Section 2.3.1), the list was found to be generally acceptable. Several participants recognised that these two categories were too broad, since invertebrates will be sampled via many different methods, but no specific recommendation for succinctly addressing this variation was proposed. We therefore noted that 'invertebrates' are a diverse group, requiring diverse ways of sampling, and for convenience these two categories of invertebrate receptors were accepted to facilitate progress.

The list of contexts was reviewed with the intention of reducing the number from 22 to something more manageable. However, the ensuing discussion highlighted the diversity of viewpoints, and it was not possible to agree on changes to the list at this time. One major difficulty was regional differences in the contexts within which ash occurs and comprises an important constituent of the countryside. In particular, the value of individual trees, hedgerow trees, ash as a structural component of hedges and ash in small woods (<0.5ha) was contentious (Section 2.3.2).

The receptors and contexts were combined into a grid and, working within four groups, the delegates attempted to identify those receptors which were unimportant within each context. Although each group agreed on a list of unimportant receptor × contexts, there was little agreement between the groups (Appendix 5).

2.2.2 Day 2

Following overnight discussions, a reduced list of eight contexts (Appendix 3) were presented to the workshop and, after much discussion and some minor adjustments, were agreed. The list of receptors was then combined with this smaller list of contexts to produce a second receptors × contexts grid (Appendix 6).

We had details on the essential attributes of 65 surveys, monitoring schemes and data-sets via the returned questionnaires (Appendix 7) (note that 69 questionnaires were returned, but some were for the same surveys). The workshop participants worked in five groups to score these surveys according to the 'receptors × contexts' for which they could be used. A separate receptors × contexts grid was filled in for each survey. Surveys were scored as a 'tick' (✓) if suitable for a given receptor within a given context, or as a 'tick+' (✓+) if the survey could be suitable after some minor modification. Any such minor modifications were noted on the back of the receptors × contexts grid sheet (Appendix 6).

Information concerning some additional data sources (Appendix 8) that were not suitable for the questionnaire format (e.g. a list of the data-sets available through the NBN Gateway, a database of insects and their food plants, potential future Welsh data-sets, etc.) were also available for general information. Of these, a proposal from a consortium led by BSBI and CEH to monitor the effects of ash dieback on woodland epiphytes and ground flora (Appendix 8) was included in the scoring procedure due to its high relevance and suitability for inclusion.

The results from the separate assessments of the surveys were aggregated onto two receptors × contexts grids using a show of hands to count up the number of potentially relevant surveys, if any, for each cell of the grid. The original intention was to combine results onto a single grid, but following discussion it was identified that the recording scale of a survey was highly relevant (i.e. that surveys with national, GB or UK coverage differed fundamentally in terms of relevance for a UK-wide ash dieback monitoring scheme from those with more restricted coverage) (Section 2.3.3). Thus, two receptors × contexts grids were filled in: one for large-scale coverage surveys, and one for more restricted or local-scale surveys. However, it was concluded that large-scale surveys had by far the most immediate direct relevance for a UK-wide ash dieback monitoring scheme, and these formed the basis of most of the on-going work. It was noted that, at a large-scale, there were surprisingly few complete gaps in the receptors × contexts grid, but that some receptors were not well-covered in some contexts (Section 2.3.4). It was also noted as a general point that restricted or local-scale surveys could have the potential to be extended to a larger scale.

Once complete, the large-scale receptors × contexts grid was colour-coded to indicate the potential level of coverage within each cell (Appendix 9). After the workshop, large-scale receptors × contexts grids were also filled in, showing the identification numbers of which surveys were considered suitable ('suitable', 'suitable with modification', or 'possibly suitable') for each receptor × context cell (Appendix 10).

Whilst filling the grids, the delegates were asked to bear the following four questions in mind.

Q1. What are the most useful, or potentially most useful, current surveys?
Q2. What are the most important gaps in current capability?
Q3. At a high-level, what are the key elements/components/requirements for monitoring ash dieback?
Q4. What modifications/new ideas are there for collecting ash-dieback-relevant data (e.g. for filling the important gaps), and what other potential new initiatives?

Before moving on to consider these questions, Peter Carey (Bodsey Ecology) presented interim results from a report by Dr S. Parnell (Rothamsted Research) provided by Dr N. Cunniffe (The Mathematical Biology and Theoretical and Computational Epidemiology Group, University of Cambridge) looking at optimal sampling strategies to detect *Chalara*. This study showed that initial risk of infection was greatest in the wooded regions of south-eastern England. These interim results were interpreted by the workshop participants as indicative of a relatively slow rate of spread, but subsequent discussion with Dr N. Cunniffe revealed this interpretation to be incorrect. Other modelling work in progress suggests that the spread of *Chalara* in Britain is more likely to be rapid (Dr M. Castle, Prof. C. Gilligan & Dr N. Cunniffe, University of Cambridge, work in prep.). Given the large degree of uncertainty in the likely incidence and rate of spread of the disease, rapid access to the final reports of these and other modelling studies is essential to inform spatial considerations, and the speed at which monitoring of the impacts of ash dieback needs to be implemented.

Michael Pocock (CEH) then gave a brief summary of CEH attempts to identify European studies of ash dieback impacts on biodiversity. This is summarised later (see Section 5), but overall there appears to be little active biodiversity monitoring – most efforts are currently directed at genetic studies to identify resistance, and epidemiology.

Following discussion of the likely spread of the disease and the European perspective, the workshop divided into five groups to consider the four questions listed above. The groups reported back on Q1 and Q2 together, and on Q3 and Q4 separately.

This process generated much discussion, but little consensus beyond identifying large-scale surveys as the best basis for a UK-wide ash dieback monitoring scheme. However, it was also recognised that smaller-scale and/or site-based surveys could have the potential to be extended to wider geographical areas, and that sites surveyed in the past (e.g. the network of sites in the Bunce Woodland Survey) could be revisited if infection occurs, or to update the original pre-infection baseline data. The four questions were revisited on Friday, following overnight discussion to determine the best way forward.

2.2.3 Day 3

Following overnight discussion of the most effective and constructive means of pulling together the wide-ranging discussions of Day 2, it was determined to:

- Present a potential scenario for a draft strategy to monitor ash dieback impacts on biodiversity in the UK, based on the Day 2 discussions.

- Discuss the attributes of the surveys proposed to comprise the core of the draft strategy and to delete or add to them according to consensus.
- Discuss the necessity, strengths and weakness of achieving co-occurrence of survey squares or sites across the core surveys.
- Consider the integration of data across surveys (including within the core surveys, and between the core and 'other' surveys).
- Consider gaps in current core survey capability.
- Consider means by which core survey capability for monitoring ash dieback could be improved.
- Consider improvements, in relation to ash dieback, to 'other' surveys.
- Consider potential costs.

The above outline for Day 3 was presented to the workshop and addressed by a combination of rapid 'ideas generating' sessions using four small groups, followed by whole group discussion. This process included answering Q1 from Day 2 (i.e. identifying the potentially most useful surveys), and revisiting the essential elements of Day 2's Q2, Q3 and Q4 (i.e. (Q2) the most important gaps; (Q3) the key high-level considerations of an ash dieback monitoring strategy; and (Q4) new initiatives/ideas, e.g. to fill gaps, including the use of modifications to existing surveys). The answers to these questions were prioritised in some cases (by a show of hands) on a scale of 1 to 3, with 1 being considered essential, 2 important if possible, and 3 a good idea, but that might not be feasible. These various answers, with their priorities where available, are summarised in Section 3. The essential features of the discussion are summarised below. The day was completed by each delegate independently estimating 'ball park' costs of an ash dieback monitoring strategy based on three broad scenarios – the details of this exercise are reported in Appendix 11. A broader discussion of areas where costs may arise is given in Section 6.

The draft outline strategy for monitoring ash dieback impacts on biodiversity in the UK is presented below in Section 4 (see also Section 2.3.5). This includes the list of core surveys (see also Section 2.3.6). This outline was agreed as a basis for a draft monitoring strategy, but several key groups and areas were identified as gaps (Section 2.3.7), in particular, invertebrates and management action in response to infection with ash dieback. It was recognised that there would be scope to expand recording (in terms of both new data and greater/different detail for existing data) by professional surveys (Section 2.3.8), but that this would need to be cost-effective and might entail replacement of the types of data collected rather than just addition. It was also noted that there was a risk of volunteer overload if data collection requirements were expanded and/or changed too much or too frequently (Section 2.3.9).

In addition to the agreed core surveys, there was discussion about the use of Common Standards Monitoring of designated sites (e.g. SSSIs). One of the advantages of reporting the impact of ash dieback on the condition of designated sites (which probably cover much of the best condition woodland in the country) and on designated species, is that there is a legal obligation to undertake this assessment. Our proposed monitoring strategy would partially support these aims. Alternatively, given that this monitoring is going on, it could (or should) feed into the long-term monitoring of the impact of ash dieback on biodiversity. However, there was some concern that reporting against the features for which a site was notified would be too variable to provide consistent monitoring of the impacts. (It was also noted that, in practice, Common Standards Monitoring was carried out differently in the different UK countries.)

The necessity, strengths and weaknesses of co-occurrence (i.e. the use of the same sites or sample squares across different surveys) were discussed and it was concluded that the potential to achieve co-occurrence across sites used by the core surveys should be assessed and thus merited further study (Section 2.3.10). The possibility of using a subset of core survey sites to set up a new network of co-occurring sites (targeted at areas with a high risk of infection) was suggested as one means of maximising the benefits of co-occurrence, including the collection of pre-infection baseline data (Section 2.3.11). The underlying rationale of the discussion of co-occurrence was that data collection would continue more-or-less as usual, or with some relatively minor modifications to better target the effects of ash dieback (see below), and that added benefit would accrue from parallel data collection from the same sites. This would also mean that modifications targeting ash dieback would not necessarily need to be adopted by every core survey – recording activity at each site could be co-ordinated to maximise recorder time and cost-effectiveness. However, it was noted that addition of non-random sites to randomised, systematic surveys could alter their statistical design. Some participants felt that the benefit of 'sacrificing' a small proportion of random sites to co-occur with other surveys would be worth the benefits of a richer data-set, but others were not fully convinced. Alternatively, establishment of additional sites shared across surveys would mitigate this concern, but would require funding (or recruitment of additional expert volunteer surveyors), and it would be important to undertake an assessment of the number of sites needed for statistical rigour.

One of the suggestions arising from consideration of the four questions at the end of Day 2 was that existing sites with a history of long-term data collection located in areas at high risk of early infection could be used for in-depth studies of the impacts of ash dieback (Section 2.3.12; and see Section 2.4 below). These sites would complement data collection by the core surveys, and would have the potential to be integrated with the new network of co-occurring sites to inform on the likely impacts (including the time-scale of the progression of effects) as infection spreads. It was also suggested that such in-depth studies could include a focus on higher-level ecological processes such as ecosystem services, ecosystem resilience, trophic network effects, and community-level processes.

Within all these discussions it was noted that integration of data and information exchange between core surveys, between the main body of 'other' surveys and the core surveys, and across networks of co-occurrence sites would be an essential component of a monitoring system for ash dieback (Section 2.3.13). Various possibilities for where such an integrating function might be located were raised, such as within the core surveys and/or with existing bodies already collating data across multiple surveys, some sort of new structure, or combinations thereof. However it was to be done, it was concluded that information integration and exchange would be essential and required further attention.

The possibility of modifying existing surveys (both 'core' and the main body of 'other' surveys) to better target ash dieback effects was discussed (Section 2.3.14), and the main conclusion was the 'obvious' one of directly recording the presence and extent of infection. As mentioned above, it was noted that excessive extension could lead to volunteer overload (especially if an ash dieback scheme were to be extended to other tree diseases) and to the need to replace certain elements of currently collected data with new elements targeting ash dieback effects (to maintain recorder time/effort and cost-effectiveness). The possibility of extending the geographical coverage of local or relatively restricted site-based recording and of repeating certain site-based surveys was also noted as an important option worthy of further consideration (Section 2.3.15). It should also be noted that the implicit expectation is that data analysis would be conducted by the organisation overseeing the survey. Therefore, clear expectations for the sharing of data and results, and the expected statistical power of the analyses, should be established in advance of such modifications being agreed.

The value of citizen science was noted and discussed (Section 2.3.16). It was recognised that mass-participation citizen science was distinct from the activities of regular expert volunteer recorders within such schemes as the BTO Breeding Birds Survey, not least because the costs of running a mass-participation event would be additional to the 'business as usual' recording activity within existing surveys. It was concluded that mass-participation citizen science should be regarded as a tool that could be applied within surveys, or *de novo*, rather than as a 'survey' in its own right. Similarly, remote sensing was also recognised as a valuable tool (Section 2.3.17), and the distinction between the resolution of data collection by satellite versus airborne was noted. To have most value, remote-sensing data should be integrated with ground-survey work. The availability of pre-infection (i.e. baseline) airborne data for various sites, including some at high risk of infection, was noted.

From the information about the likely rate of spread of the disease arising from the Cambridge University epidemiological modelling and the current lack of information concerning the incidence of infection in mature ash, it was concluded that the summer of 2013 would be vital in the assessment of the location and extent of infection. Should the rate of spread be relatively slow, at least in the short-term (i.e. over the next one to three years), and if the effects on individual mature trees do not cause rapid mortality, then there should be time to construct an effective strategy, and to modify it as information becomes available from infected sites. However, should spread and mortality progress rapidly, an equally rapid response (in terms of data acquisition and dissemination of information and advice) will be required.

2.3 Summary of workshop outputs and discussion points

2.3.1 Invertebrates

It was concluded that assessing impacts on invertebrates would be difficult because of the large numbers of species concerned, the wide range of niches occupied, and the complexity of the ash-specific and wider woodland environment resources involved. Monitoring impacts of ash dieback would have to take this into account. Surveying for multiple groups of invertebrates by different surveyors at a number of core sites (analogous to the BSBI/CEH draft proposals for monitoring woodland epiphytes and ground flora) could be a way forward. Alternatively, if there are good 'indicators' of the abundance or richness of guilds of invertebrates (e.g. the amount of deadwood), these could be used as surrogates to provide simple assessments of importance for invertebrates.

2.3.2 Small woods, spinneys, copses, clumps and rows of trees, individual trees

It was concluded that ash as individual trees and within small woods, spinneys, copses, clumps and rows of trees (i.e. individually small, but numerous, widespread and often loosely connected landscape elements), were important contexts of ash in the countryside. It was also noted that the importance of this diffuse, but frequent, occurrence of ash in the countryside was likely to increase across mainland UK from east to west.

2.3.3 Large-scale coverage

It was concluded that large-scale surveys had by far the most immediate direct relevance for a UK-wide ash dieback monitoring scheme. It was also noted that site-based surveys at a more local scale had potential for expansion.

2.3.4 Few complete gaps in large-scale survey coverage of receptors within contexts

Despite the relative lack of complete gaps, it was noted that some receptors were not well-covered in some contexts, especially invertebrates (including soil invertebrates) and fungi (including mycorrhizae and endophytes), and various receptors in small woods. Although plants are covered by many surveys, the systematic, well-designed plant surveillance survey (BSBI/CEH project) currently being piloted could be very valuable in assessing changes in plant composition. Also, ecosystem functions were monitored by relatively few surveys, although those that did monitor some (e.g. Countryside Survey) did so in a robust way at national scales.

2.3.5 Potential structure for an overall strategy

A structure for a scheme monitoring the impacts of ash dieback on biodiversity in the UK is described in detail in Section 4.

2.3.6 Set of core surveys

The core surveys of the draft monitoring scheme were identified as: (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; (f) designated sites monitoring (such as Common Standards Monitoring); (g) National Forest Inventory; and (h) National Bat Monitoring Programme. See Section 4.

2.3.7 Identified key gaps in core surveys

Key gaps in the eight core surveys were identified as invertebrates, fungi, small woods (and in particular, plant health in small woods – but see Section 4 with regards to the potential, given funding, for the Small Woods Survey to complement the National Forest Inventory), and management. Management effects were distinguished as those carried out in direct response to infection, those carried out to mitigate the effects of infection, and ‘business as usual’. The first category (direct response to infection) was seen as having the greatest potential for rapid and large-scale impacts on biodiversity, especially in an urban and infrastructure context, in relation to perceived public safety issues.

2.3.8 Potential to expand professional surveys

It was noted that there was potential to increase the information collected by professional surveys as long as this was done in a constructive, practical and cost-effective manner (which might require replacement of some part of existing data collection rather than just addition). It would also be possible to adjust the way, or the detail, in which current information is collected to make it more informative for ash dieback effects.

2.3.9 Potential problem of volunteer overload

It was acknowledged that volunteer schemes would need to take care not to make excessive demands on their participants, nor to be frequently adding/changing the information to be recorded (to avoid volunteer overload/confusion).

2.3.10 Potential for co-occurrence monitoring – merits further study

It was concluded that collecting data across different core surveys from the same locations could have great benefits in terms of both information synergy and maximising cost-efficiency of survey effort. It was also noted that efforts should be made to maximise co-occurrence when setting up new survey work, such as the BSBI/CEH proposal. Although co-occurrence might conflict with randomised survey design, it was identified as meriting further consideration and study.

2.3.11 New network of co-occurring sites across a range of contexts

One suggestion to build on the concept of co-occurrence was to identify a subset of core survey sites with maximum co-occurrence to provide pre-infection data which could then act as a baseline following infection. If the potentially rapid rate of spread of ash dieback is realised, it will be important to include sites from a range of contexts over a wide geographical area to have as much pre-infection data as possible. It could also include new survey work.

2.3.12 Identify sites for in-depth studies – target locations at high risk of infection

It was concluded that a number of existing sites and areas, many with existing long-term data-sets, should be used for in-depths studies. These studies should include ‘higher-level’ concerns, such as mechanisms, ecological processes, and network/trophic-level effects. Results could be used to model impacts in order to inform data gathering and management responses as infection spreads to other sites. It would be particularly valuable to have experimental treatments of different forms of management in response to ash dieback. To achieve this advantage of improving future responses, these sites should be selected in the first instance to lie in areas at high risk of infection. Candidate sites are given in Section 2.4.

2.3.13 Data/information exchange – merits further study

The exchange of information between both core surveys and between the main body of ‘other’ surveys and the core surveys was recognised as essential for efficient collection of ash-dieback-related data, and for its compilation, assimilation and use. Where an ash dieback data or information integration function would lie needs to be determined; for example, as an extra action within existing survey procedures, or with a new body within an existing organisation or some combination of the two (plus other possibilities). We recognise that this collation of data and results, and the provision of recommendations is a substantial, and therefore potentially costly, role. The availability of data collected by one organisation’s surveyors (whether paid or volunteer) to other organisations would also need to be established.

2.3.14 Modification of existing surveys

There is potential to modify both core surveys and the main body of ‘other’ surveys to improve their collection of ash-dieback-related data. The most obvious modification would be to add assessment of, for example, the presence, extent, and impact (in whatever format) of ash dieback, but this would have to be done with care in the light of the risk identified above of professional (Section 2.3.8) or volunteer surveyor overload (Section 2.3.9). Such problems of overload (and perhaps also confusion) would be exacerbated if an ash dieback monitoring scheme was extended to other tree diseases on a regular basis. If there was an important question that needed addressing during one year, then potentially this could be applied as a one-off question to surveys with many surveyors, whether volunteer (e.g. Breeding Bird Survey) or paid (e.g. National Forest Inventory).

2.3.15 Extension or repetition of existing local or small-scale site-based surveys

Almost any small-scale survey would have the potential to be extended to increase its geographical range, but the major obstacles to this would be time and cost considerations. It would be possible to bear this option in mind during further study of co-occurrence (Section 2.3.10). Repetition of previous 'one-off' or infrequent site-based surveys could offer a more cost-effective means of targeting ash dieback effects, especially for sites located in areas at high risk of infection. Such sites might be of value within a new network of co-occurring sites (Section 2.3.10) and have potential as in-depth study sites (Section 2.3.12).

2.3.16 Citizen science

Mass participation citizen science was recognised as a method which has the potential to be applied alongside existing surveys (as well as for a new initiative or event) in response to specific needs when this approach is appropriate for those needs. It was distinguished from regular participation by expert volunteers in existing surveys.

2.3.17 Application of airborne remote sensing

Airborne remote sensing was identified as suitable for site-level monitoring of changes in composition, structure and condition – as distinct from satellite-based platforms which may have a larger geographical remit but usually have lower resolution. Airborne remote-sensed data, supplying pre-infection baselines, are available for many of the sites identified below as being suitable for in-depth studies. Note that collection of airborne data includes the potential to use equipment flown on small unmanned vehicles (AUVs), as well as aircraft-based acquisition. Ground-truthing of remote-sensed data allows the interpolation of impacts to wider areas where only remote-sensed data are available.

2.4 Sites with potential for in-depth studies

Workshop delegates identified the following as potential in-depth study sites. Some of these are in areas with a high risk of early infection (e.g. Norfolk, Suffolk and Cambridgeshire), but given the current uncertainty over the incidence and spread of the disease, identifying a range of sites is valuable. Sites with a lower risk of imminent infection would also have more time to implement ash dieback specific studies to complement existing baseline data.

- Bradfield Woods NNR (Suffolk)
- Swanton Novers NNR (Norfolk)
- Monks Wood NNR (Cambridgeshire)
- Hayley Wood (Cambridgeshire)
- Gamlingay Wood (Cambridgeshire)
- Sheephouse Wood (Buckinghamshire)
- Rushbeds Wood (Buckinghamshire)
- Wytham Wood (Oxfordshire)
- Alice Holt Forest (Hampshire)
- Lady Park Wood NNR (Gloucestershire)

Highly visited woods such Rydal Wood near Ambleside in Cumbria were also suggested as having potential for citizen science monitoring.

Although the list of named sites above are all woodlands, certain surveys such as those concerned with ancient and veteran trees would supply information for non-woodland contexts. Landscape-scale studies were also suggested, with potential sites including Ennerdale, Cumbria (http://www.wildennerdale.co.uk/aboutus.html) and the Carrifran Wildwood (http://www.carrifran.org.uk/) in the Moffat Hills, Scottish Southern Uplands. It was also suggested that Special Areas of Conservation (SAC) in the Peak District Dales could offer an upland context with a significant presence of ash (which might be less well-represented in the cases of Ennerdale and Carrifran).

Sites within the The Bunce Woodland Survey may also have potential as in-depth study sites. This survey was conducted in 1971 and 2002, and covered 103 sites in England, Wales and Scotland (including good representation of Ancient Woodlands and SSSIs). It collected information about tree and understory species composition, size, and age-structure, plus soil data. However, it lacks data on epiphytes and has no representation in Northern Ireland.

Woodlands that are currently under active management for timber production could provide experimental sites for testing management responses to infection (in terms of both containment and mitigation). This would be especially useful where treatments might involve extensive felling and/or replanting, or other activities incompatible with the ethos and management of nature reserves and other protected areas.

3 Summary of question responses

Q1. What are the most useful, or potentially most useful, current surveys?
Q2. What are the most important gaps in current capability?
Q3. At a high-level, what are the key elements/components/requirements for monitoring ash dieback?
Q4. What modifications/new ideas are there for collecting ash-dieback-relevant data (e.g. for filling the important gaps), and what other potential new initiatives?

Priority is indicated as:

- ESS (essential);
- IMP (important);
- VAL (valid but non-essential).

If no indication is given, then priority was not established. Some points appear under more than one list as is appropriate. List number order is not significant.

These questions were addressed at the workshop (Day 2) and the answers compiled from whole-group discussions. Priority, where determined, was by a show of hands.

3.1 Q1. What are the most useful, or potentially most useful, current surveys?

The most useful, or potentially most useful current (or prospective) surveys are discussed in Section 4 (including the currently unfunded FC Small Woods Survey and the BSBI/CEH epiphytes and ground flora proposal). It was also noted that certain previous 'one-off' or infrequent surveys could have the potential to be repeated. The Bunce Woodland Survey was of particular note in this respect. It was conducted in 1971 and 2002, and covered 103 sites in England, Wales and Scotland (including good representation of Ancient Woodlands and SSSIs). As well as having potential for repetition in its own right, it could also contribute sites for coverage by other surveys and when considering co-occurrence. It collected information about tree and understory species composition, size, and age-structure, plus soil data. However, it lacks data on epiphytes and has no representation in Northern Ireland.

3.2 Q2. What are the most important gaps in current capability?

1. Recording impacts on invertebrates, including soil invertebrates and consideration of functional groups, functional roles and priority species (ESS).
2. Recording impacts on epiphytes and fungi (ESS). These fungi include 'toadstools' (fruiting bodies of saprophytes and some mycorrhizae), but also micro-fungi (including mycorrhizae and endophytic fungi), which are more challenging to monitor but important for ecosystem function.
3. Taxonomic expertise – presumably most important in relation to invertebrates, fungi and epiphytes.
4. Small woods (0.5ha) – concern included tree health (ESS). Concern also extended to small urban woods and to ash in other small features of the countryside, such as small spinneys and copses, rows of trees, hedgerows and lone trees.
5. Management information and activity including actions taken in response to infection and lack of information on felling licences about reasons for felling. Need more information about management activities and the reasons behind them (ESS).
6. Grazing/browsing impacts – these are well covered in current NFI recording plots, but may be less well-covered in other contexts.
7. Monitoring of small mammals (VAL).

8. Monitoring of ash regeneration, including coppice (this might also be extended to other species where ash is replaced due to a lack of regeneration).
9. Non-co-occurrence of different surveys, including differences in permitted access, comprises a barrier to 'joined-up' monitoring.
10. Understanding of *Chalara* impacts for use as feedback into the monitoring process.
11. Ecology and distribution of ash, especially outside of woodland.
12. Seasonal changes and/or differences between seasons are not well-covered by most surveys (VAL).
13. Information on higher-level processes such as ecosystem services, and how they may be affected.
14. Annual monitoring of tree infection. Some coverage probably available via the NFI rolling programme, but not in small woods and others contexts. For PAWS, monitoring spread of diseases is a condition of restoration.
15. Remote sensing of the extent of infection (baseline data are available for some sites).
16. Epidemiology and spatial rate of spread of the disease – these aspects are probably covered by other studies and are probably not within the direct remit of this report.

3.3 Q3. At a high-level, what are the key elements/components/ requirements for monitoring ash dieback?

1. Funding – availability and continuity.
2. Leveraging alternative/private sources of funding.
3. Cost-effectiveness.
4. Awareness of 'volunteer capital'.
5. Clear objectives; based on good science; producing good science; (evolutionary approach)?
6. Sustainable, long-term strategic monitoring – future proof.
7. Ability to track change over time and geographical space.
8. Evaluate levels of uncertainty.
9. Relevant to statutory drivers.
10. Transferable to other tree diseases.
11. Determine the relevance of *Chalara* impacts to society.
12. Determine the extent, if any, to which the disease and its impacts can be managed.
13. Monitor key ecosystem elements to evaluate *Chalara* impacts within the context of a changing global environment.
14. Ability to disentangle *Chalara* effects from other drivers.
15. Capture ecosystem processes, measures and mechanisms underlying impacts.
16. Co-occurrence of sites and information integration across surveys.
17. Co-occurrence at the level of recording methodology – taxa specific.
18. Use of NFI as a core of a co-occurrence approach.
19. Cost/benefit analysis of joint co-occurrence/in-depth study site approach.
20. Integration with European work (e.g. modelling forest growth and implications for loss of forest stock).

3.4 Q4. What modifications/new ideas are there for collecting ash-dieback-relevant data (e.g. for filling the important gaps), and what other potential new initiatives?

3.4.1 New initiatives

1. Structured survey for invertebrates.
2. Test sites for understanding regeneration issues.

3. Expand suite of intensively monitored sites.
4. Expand the NFI to small woods.
5. BSBI/CEH survey of woodland epiphytes and ground flora.
6. ObservaTree.
7. Other new/proposed *Chalara*-targeted surveys or extensions?
8. LWEC Tree Health call.
9. EU call on non-native invasive species.

3.4.2 Modifications/ideas

1. *Chalara*-specific recording (e.g. add a few simple questions to existing surveys) (ESS).
2. Capture data on other tree pathogens.
3. Some contexts should be well covered due to passion/dedication of volunteer recorders (e.g. veteran trees).
4. Ensure soil sampling is targeted at key specific sites (ESS).
5. Increase integration of sites (co-occurrence) and adapt methodology across surveys (ESS), for example, include counts of trees, especially young trees, in Countryside Survey (CS) and agri-environment monitoring. Could include increasing numbers of sites or changing sites to increase co-occurrence.
6. Test sites for understanding regeneration issues (use in-depth study sites?).
7. Apply the use of citizen science to existing surveys (ESS), including the use of Apps.
8. Include reasons for felling on felling licenses (i.e. to identify responses to infection/disease).
9. Integrate evidence streams from felling and biodiversity sources.
10. Exploit the NFI resource base to collect more data.
11. Use a GIS approach to overlay locations of remote-sensed data on locations of existing surveys as an aid to co-occurrence.

4 Outline strategy for monitoring the effects of ash dieback on biodiversity

The main elements of the outline strategy are shown below in Figure 4.1. For ease of use, this figure is presented in a format that allows it to be copied as a 'stand-alone' diagram.

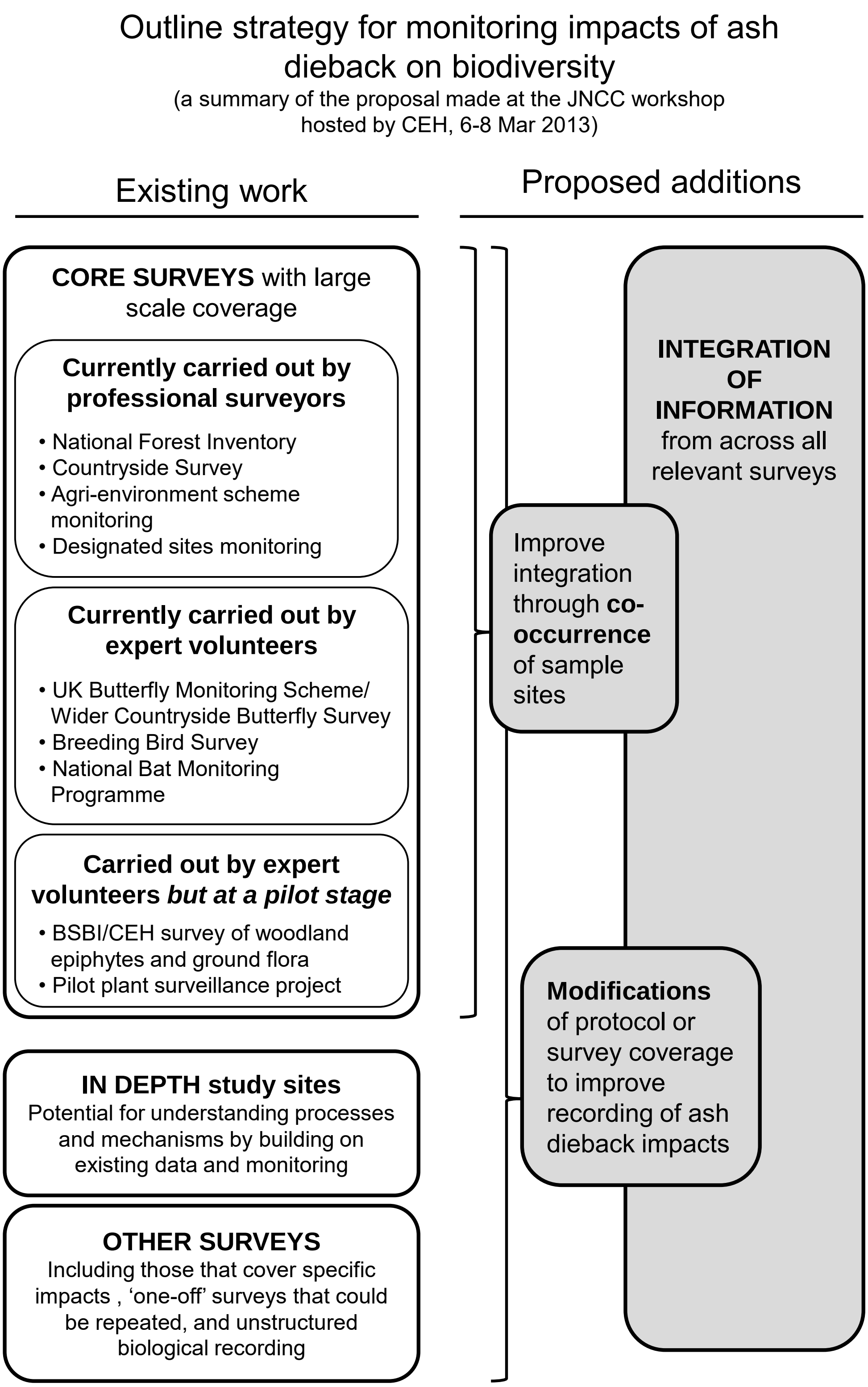


Figure 4.1. For caption see overleaf.

4.1 Outline description

The proposed strategy is based on a core of eight existing surveys (see Section 4.1.1 below), which were selected for their large-scale coverage and to provide monitoring of essential taxa and contexts. These core surveys would be supported by additional information supplied by the main body of 'other' surveys. Core surveys, and the most relevant 'other' surveys would also have the potential to be modified or extended to improve collection of ash-dieback-specific data. At a minimum, the presence and extent of infection (i.e. visible symptoms of ash dieback) at survey sites would be desirable.

All survey activity (core and 'other') would be informed by results collected from a number of sites where in-depth studies of ash dieback impacts on a range of taxa and higher-level habitat, community and ecological processes are (or have been in the past) conducted (see Section 2.4). These sites would be selected as being already infected or with a high risk of infection (in order to provide information ahead of the main spread of infection, if possible) and ideally would have an established (and preferably on-going) long-term history of relevant ecological research and hence pre-infection baseline data.

Information exchange across core surveys and between the core and 'other' surveys would be essential and would need to include an integration function to collate, analyse and disseminate ash-dieback-relevant information. Some of this work could be done within core surveys and/or by an overseeing body, either new or based on existing data collation centres such as the Biological Records Centre. Results from the in-depths studies would also need to feed into this integration function. How to achieve effective integration requires further study.

The effectiveness and efficiency of data collection would be enhanced if different surveys collected data from the same sites (i.e. if co-occurrence between survey sites could be maximised). It would also be possible to establish a new network of co-occurring sites (based on a subset of core and possibly most relevant 'other' surveys sites), targeted within areas on the boundaries of known locations of infection. This would enable collection of pre-infection baseline data, but its effectiveness would be dependent on the rate of spread of infection and the speed of impacts at individual sites (e.g. rapid spread and fast impacts could over-run such sites before useful baselines were established). Investigation of how to achieve cost-effective co-occurrence requires further study.

◄**Figure 4.1.** Proposed structure of draft outline strategy for monitoring ash dieback impacts in the UK. Core surveys offer large-scale coverage with potential to increase co-occurrence of sites across surveys to improve efficiency of data collection and information integration. All surveys have potential for modification to improve recording of ash dieback impacts. In-depth study sites will inform monitoring and science needs and supply ecological and management information/advice. Effective information integration across core and 'other' surveys, and with the in-depth study sites will be required to enable data collation and analysis and for dissemination of results and advice. Note that full funding is not yet assured for all the core surveys in the future, and in particular, for the two BSBI/CEH pilot projects and Countryside Survey. This is discussed further below.

4.1.1 Core surveys

Eight core surveys were identified as detailed below. The Forestry Commission Small Woods Survey (companion survey to the NFI) also 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. The last Small Woods Survey was published in 2003, and a total of seven surveys were conducted between 1924 and 1979–82 (B. Ditchburn pers comm). The next Small Woods Survey is planned for 2014–2016, but is currently unfunded (see Section 6). It also lacks coverage in Northern Ireland. The Countryside Survey also monitors 'small woodlands' amongst other 'wider countryside' habitats, but it too is currently unfunded.

Most of the eight core surveys have UK-wide coverage, the exceptions being agri-environment monitoring, the NFI and the BSBI/CEH epiphytes and ground flora proposals. The first of these is considered ineffective in Scotland for ash dieback, and the latter two do not include Northern Ireland. However, although the current pilot studies for the BSBI/CEH proposal do not include Northern Ireland, this gap could be addressed within the full survey should funding be secured. Six of the eight surveys (and agri-environment monitoring in Wales) have a stratified random design which should ensure adequate coverage within their overall scope. Designated sites monitoring is by definition site-based, and any bias within coverage should be off-set by the large number of sites (and their relative importance for biodiversity). Agri-environment monitoring in England will also benefit from a large number of sites – and any potential bias towards lowland arable areas will coincide with areas in the east and south-east where major disease impacts are mostly likely to occur first.

(a) Agri-environment monitoring (collectively across different country schemes; for example Higher Level Stewardship monitoring in England, and Axis II monitoring in Wales) (AES)

Coverage:	England, Wales (Northern Ireland?)
Recording frequency:	Annual over 7 years
Sample design:	Stratified random in Wales; elsewhere targeted at scheme participants
Sample size:	*c*60–90 1km squares; 300–500 farms
Site access:	Permission; contractual
Main gaps:	No effective agri-environment monitoring in Scotland; not woodland

(b) Breeding Bird Survey (BBS)

Coverage:	England, Wales, Scotland, Northern Ireland
Recording frequency:	Annual
Sample design:	Stratified random
Sample size:	*c*2,500 1km squares
Site access:	Public
Main gaps:	Not woodland

(c) UK Butterfly Monitoring Scheme/Wider Countryside Butterfly Survey (UKBMS/WCBS)

Coverage:	England, Wales, Scotland, Northern Ireland
Recording frequency:	Annual
Sample design:	Stratified random
Sample size:	*c*750 + 1,000 sites
Site access:	Public
Main gaps:	Only butterflies, no other invertebrates

(d) BSBI/CEH pilot proposals for monitoring woodland epiphytes and ground flora comprise two separate, but linked, projects. The first is a plant surveillance project as described below, the second is a pilot project for cross-taxon sampling of ground flora and fungi, and epiphytic bryophytes and lichens. This second project exemplifies co-occurrence of survey locations which are sampled by different volunteer experts. The locations for the ground flora and epiphyte survey are randomly selected ash-rich sites.

Coverage:	England, Wales, Scotland. Full survey (subject to funding) may include extension to Northern Ireland
Recording frequency:	5-year cycle
Sample design:	Stratified random
Sample size:	*c*200 1km squares
Site access:	Public
Main gaps:	No urban, infrastructure or plantation coverage; currently unfunded beyond pilot stage

(e) Countryside Survey (CS)

Coverage:	England, Wales, Scotland, Northern Ireland
Recording frequency:	7–8 years (but has potential to become a rolling programme)
Sample design:	Stratified random
Sample size:	*c*591 1km squares
Site access:	Permission (confidential)
Main gaps:	No urban coverage; no seasonal data; infrequent

(f) Designated sites monitoring (DSM)

Coverage:	England, Wales, Scotland, Northern Ireland
Recording frequency:	6–8-year cycle
Sample design:	Site-based
Sample size:	Large numbers of sites
Site access:	Permission
Main gaps:	Data collected (and collection frequency) varies across sites and countries; data collected within each cycle can vary with perceived risks/needs

(g) National Forest Inventory (NFI)

Coverage:	England, Wales, Scotland
Recording frequency:	Annual
Sample design:	Stratified random
Sample size:	*c*15,000 plots
Site access:	Permission
Main gaps:	No small woods; no wider countryside data; currently does not include Northern Ireland

(h) National Bat Monitoring Programme (NBMP)

Coverage:	England, Wales, Scotland, Northern Ireland
Recording frequency:	Annual
Sample design:	Stratified random + sites
Sample size:	*c*6,885 squares plus sites
Site access:	Public/permission
Main gaps:	Degree of coverage varies geographically within countries; does not target tree-roosting bats; potentially difficult to attribute effects directly to ash dieback

4.2 Main conclusions and recommendations

(i) The most cost-effective approach for monitoring ash dieback effects on biodiversity in the UK is to build on a 'core' of existing, and mostly well-established, surveys. These surveys are 'extensive' (i.e. they cover a large number of sites). Candidate core surveys are identified. They include those that are undertaken by paid professionals and volunteer experts.

(ii) There are many 'other' surveys in the UK which also have the potential to contribute additional knowledge about the impacts of ash dieback on biodiversity, especially in specific places, specific contexts of ash (e.g. veteran trees), or specific aspects of biodiversity.

(iii) Core and other surveys have the potential to be modified to better target impacts of ash dieback, although we identify several caveats to this recommendation.

(iv) The integration of information across the core surveys and between the core and other surveys, with respect to the impacts of ash dieback, will be essential to achieve an overview of UK-wide effects and to enable the dissemination of results and advice.

(v) The robustness of the results regarding the impacts of ash dieback and its mitigation would be enhanced by the use of common sites across different surveys (i.e. by maximising co-occurrence of sites).

(vi) Monitoring work (in both core and other surveys) needs to be supported by more in-depth studies of the consequences of ash dieback for habitats, communities and ecosystems. Such studies are viewed as 'intensive' (i.e. concentrating on changes to mechanisms and processes underlying ecological structure and function). Candidate in-depth study sites are identified.

(vii) The value of the data and cost-effectiveness of in-depth studies will be enhanced by selecting sites with existing long-term data and, where possible, also on-going research programmes.

(viii) Locating in-depth study sites in areas at high risk of imminent infection could provide 'early' information on ash dieback impacts of value for planning management responses in areas likely to be less rapidly exposed, but the effectiveness of such planning will be dependent on the actual rate at which the disease spreads.

(iv) Commercial woodlands (if available with substantial areas of ash) could be used to test the effectiveness of management options in response to infection. This would be especially valuable where such activity in semi-natural woodlands would be incompatible with conservation objectives.

(x) Future funding issues for currently unfunded candidate core surveys need to be resolved (i.e. established surveys for which future funding is uncertain, and surveys currently being piloted).

4.2.1 Recommendations for future work

- Investigation of the means of achieving information integration and exchange across core (and other) surveys to produce a coherent and accessible body of information. This should include a means of accessing information to provide a basis for advice.
- Investigation of how to achieve maximal co-occurrence of sites across different surveys, and the cost-benefit of changing or adding sites to existing surveys to achieve this aim.
- Investigation of how to effectively monitor potential receptors that are not well-monitored, especially invertebrates, fungi and aspects of ecosystem function.
- Investigation of how best to assess impacts – this should be informed by the results of the companion project to this one (i.e. JNCC Report No. 483: *Ash dieback: impacts on other species and understanding the ecology of Ash*).

5 European perspectives on biodiversity monitoring of ash dieback impacts

One of the challenges of monitoring the impacts of ash dieback on biodiversity is that it is difficult to know which receptors are likely to be impacted most. Therefore, we contacted researchers elsewhere in Europe in order to learn from their experience. However, in summary, we found little research activity on the impacts of ash dieback on biodiversity elsewhere in Europe. This is somewhat surprising giving the severity of the disease and the length of time it has been present in eastern Europe. The FRAXBACK EU Cost Action project appears mostly focussed on understanding the genetics of resistance, and appears to be most focussed on arboriculture/silviculture and forestry. The wider impacts of the loss of ash trees falls outside of the remit of this EU project.

We pursued correspondence with the following people, and asked each of them for any further contacts who may be able to provide experience about ash dieback impacts on biodiversity.

Prof. Erik Kraer, Forest & Landscape, University of Copenhagen, Denmark
Dr Vaidotas Lygis, Institute of Botany, Vilnius, Lithuania
Prof. Tadeusz Kowalski, University of Krakow, Poland
Dr Āris Jansons, LVMI Silava, Salaspils, Latvia
Dr Wojciech Gil, Forest Research Institute, Poland
Dr Tomasz Oszako, Instytut Badawczy Leśnictwa, Poland
Dr Talis Gaitnieks, LVMI Silava, Salaspils, Latvia

In summary, we found no evidence that there is monitoring of the impacts of ash dieback on biodiversity, although even if monitoring were occurring it would be very difficult to disentangle the impacts of ash dieback itself with the impacts of the resulting changes in woodland management.

5.1 Email correspondence with Prof. Erik Kraer, Forest & Landscape, University of Copenhagen, Denmark

There is active research on *Chalara fraxinea* and ash dieback in Denmark (summarised at http://sl.life.ku.dk/English/research/recent_findings/Ash.aspx). Despite the appalling statistics about the prevalence of the disease in Denmark about the infestation of Denmarks' ash trees, causing losses of 60–90% (http://www.forestry.gov.uk/forestry/infd-8w9euv), there has been little work done, so far, on the impacts of ash dieback on biodiversity. However baseline monitoring on the flora was begun in Suserup Forest in 2012 and it is expected that this will provide some indication of the impacts of ash dieback.

5.2 Email correspondence with Dr Vaidotas Lygis, Institute of Botany, Vilnius, Lithuania

Some systematic work is being undertaken on the impacts of ash dieback, based on forest regeneration following clear-felling of ash-dieback-affected *Fraxinus excelsior*. Sampling was undertaken in 20 clear-cuts and regeneration of trees was assessed. Ash regeneration was scarce (0–21% prevalence in clear-cut stands that had been 40–100% ash). Of the ash that were observed just over half were diseased and only 30% were visibly healthy. The conclusion is that ash regeneration is poor, leading to a shift in species composition towards understorey shrubs (hazel, willows, etc.; which results in sites being unproductive for forestry) and early successional species (alder, birch and aspen). The initial work is submitted for publication. According to permanent monitoring plots established in pure ash stands, about 10% of ash trees are lost every year and condition of the remaining trees is continuously deteriorating.

There is no systematic monitoring of the impacts of ash dieback on biodiversity. Dr Lygis says that "*we can only presume that loss of ash-dominated habitats is definitely causing a certain impact on inhabiting floral and faunal communities.*" Clearly the management of the infected ash woods by clear-cutting to enhance productivity for forestry confounds the direct impact of the disease on woodland composition.

Dr Lygis provided information on the Latvian monitoring plots:
They established 20 plots in 2005–2006 all over the territory of Latvia and surveyed them in 2011. Three of the plots have been clear-felled so they are no longer available for comparative analysis. All permanent monitoring plots were approximately circular, with a radius of 15m (covering area of 706.5m^2). Characteristics of all monitoring plots were recorded according to established forestry research methods (Sarma 1948; Greig-Smith 1964; Kershaw 1964; Dierschke 1994; Anon, 1993a, 1998). All trees higher than 5m were numbered in each monitoring plot.

Stand characteristics:

1. Measurements: tree diameter, tree height, individual azimuth and distance from the monitoring plot centre were measured.
2. Assessment of tree growth: wood samples were taken from all ash trees using increment borer and widths of annual rings were measured.
3. Tree mortality: snags (species, diameter and length), wind-fallen trees (species, diameter and stage of decay in three classes) and stumps (species, diameter, length and stage of decay in three classes) were surveyed and their parameters recorded.
4. Assessment of tree crown condition: crown density, crown dieback, crown transparency and defoliation, as well as amount and density of epicormic shoots (Gillespie *et al* 1993; Millers *et al* 1993; Anon 1993).
5. Stand regeneration (all trees and shrubs with height less than 5m): three smaller plots with a radius of 5m were established (7m from the centre of the monitoring plot; azimuths 0°, 120° and 240°) in each permanent monitoring plot. Height and position were recorded for every woody plant in every small plot.
6. Stand composition: inventory of all tree species in all layers of the stand (tree layer (E_3), shrub layer (E_2), grass layer (E_1) and moss layer (E_0)) was made and stand composition estimated using Braun–Blanquet method in each permanent monitoring plot (Braun-Blanquet 1964; Dierschke 1994).
7. Soil characteristics: soil profile was analyzed up to 1.2m depth, its horizons were described. Soil samples have been taken from different soil horizons and their physical and chemical analyses were made in each permanent monitoring plot.

We have not been able to establish whether the initial results of these analyses are available, or from whom.

5.3 Email correspondence with Prof. Tadeusz Kowalski, University of Krakow, Poland

Currently there are severe levels of infestation of ash trees with ash dieback, although there appears to be no systematic, repeated monitoring of the impacts. However, Prof. Kowalski provided very useful descriptions of the advance of the disease and its symptoms.

Ash (*Fraxinus excelsior*) is a minor component of Polish woods (<1% of the area, mainly in mixed stands). Trees of all age classes are infected, but trees about 3–20 years old are most susceptible. The overground parts of infected young trees die quickly, but they grow secondary shoots from the root collar, which subsequently become infected and die. In old ash trees the advance of the disease is slower. The most common symptoms are the death of whole branches or their apices (*c*25% of trees), tree-top dieback (13% of trees), defoliation of crowns (98%) and epicormic shoots growing from trunks and along the bases of living branches (60%), as well as local necroses on the trunks and twigs (Kowalski *et al* 2012; Kowalski and Czekaj 2010). Such weakened trees often become infected with *Armillaria*, which causes root rot and felling by the wind during storms. In newly established experimental plots only one-half to two-thirds of ash seedlings showed no signs of the disease (Kowalski *et al* 2012). Disease symptoms occurred more often in artificially regenerated stands than naturally-regenerated ones (Kowalski and Czekaj 2010).

Once ash trees have died or have been blown over, plots are artificially planted with other trees and natural regeneration (especially by alder) occurs. There is no specific evidence about the impact of ash dieback on biodiversity.

Note: Most of the references cited in this Section were supplied via e-mail simply as citations (i.e. lacking the full reference). In the time available we have not been able to unearth the full references (many may not be in English) but, given that some of this cited work may be of interest, we have left them rather than taking the tidier route of deletion.

6 Funding issues

Funding issues were raised in a number of areas, which are summarised below. As an exercise at the workshop, participants were requested to consider three broad scenarios for monitoring ash dieback and to make independent estimates of their likely costs. The results of this exercise are reported in Appendix 11, but it should be noted that some participants had concerns about their inclusion in this report due to their likely inaccuracies.

- Repetition and continuation of the core surveys. Although future funding can never be guaranteed, continuation of four of the core surveys (i.e. BBS, UKBMS/WCBS, NFI and NBMP) currently appears to be stable. Of the remaining four, support for agri-environment monitoring may not be stable in the long term, and repetition (and content and frequency) of designated site monitoring may be constrained by national/agency budgets. The next round of Countyside Survey (CS) is currently unfunded, as are the full projects of the BSBI/CEH proposals – see below.
- Repetition and continuation of 'other' surveys. The Forestry Commission Small Woods Survey (companion survey to the NFI) is highly notable in this respect. The Small Woods Survey 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. The last Small Woods survey was published in 2003. Previous surveys were conducted in 1979–82, 1965–67, 1957, 1947–49, 1939, 1930 and 1924. The 1957 survey also included all hedgerows and 'Parkland trees'. The next Small Woods Survey is planned for 2014–2016, but is currently unfunded. The Countryside Survey also covers 'small woodlands' as they occur in sample squares, but it too is currently unfunded. There is potential to consider these two surveys in conjunction to ensure that data are compatible.
- New proposals – for example the BSBI/CEH draft proposal for monitoring woodland epiphytes and ground flora, and the pilot plant surveillance project currently only have support for a limited field trial in 2013 as part of a Defra-funded project to trial more systematic approaches for monitoring biodiversity by volunteers. Other new projects with large potential with respect to ash dieback impacts (and those of other tree diseases) include the Woodland Trust project 'ObservaTree'.
- Extension of the coverage of core surveys, or something analogous, to areas where they are currently lacking. This might include the addition of new sites or sample squares, the adaptation of alternative surveys to fill gaps or the setting up of new work. Northern Ireland might be at a particular disadvantage in this respect because, for example, it is not included within the NFI (nor the National Inventory of Woodland Trees) or the BSBI/CEH proposal.
- Investigation of how to best integrate information exchange across the core surveys and between the core and 'other' surveys. An investigation would probably incur relatively modest costs, but would need to precede funding of the actual process of integration. Some of the cost of actual integration could probably be absorbed within the surveys (or at least most of them), but there might be additional costs associated with higher-level integration and reporting. Such costs may increase with time as infection spreads and might also expand to include direct advice on management responses as information on biodiversity impacts becomes available.
- Support for further research work and monitoring at selected in-depth study sites. Some such costs could probably be borne by the organisations actively involved at given sites, but substantial new work would require additional funding. Research on mechanisms and the pathways leading to impacts on biodiversity could form research grant proposals. Costs would also apply to work at sites with existing information, but no current activity. Future collection of remote-sensed data to monitor change from existing pre-infection baseline data would need additional

funding and/or success within the grant application route. Aircraft-based collection of remote-sensed data at a landscape-scale has costs in the ten to tens of thousands (e.g. for summer plus winter acquisition of LiDAR and hyperspectral data for *c*60km^2 of Cambridgeshire the cost is in the region of £15,000 per season), whereas drone-based collection for smaller areas (e.g. 1km^2) or sites is in the region of one to a few thousand pounds. Data processing costs are usually additional.

- Investigation of how to maximise the benefits of co-occurrence. This, combined with the suggestion below for a new network, would require additional work including spatial analyses of site/sample square locations, the possible instigation of new sites/survey work and consideration of sampling frequency and site access (e.g. public versus restricted).
- Investigation into a new network of maximally co-occurring sites targeting a buffer zone at the boundary of areas at high risk of infection. The practicality of this will depend on the rate of spread of infection; if it is rapid, sites could be over-run before good baseline data, within the context of the new network, can be established.
- Increased frequency of monitoring within a rolling programme scenario plus the costs of analyses and reporting.
- Information gathering in relation to management activity in response to ash dieback. This would be necessary to separate the effects of management from those of the disease *per se*.

6.1 Summary

(i) Repetition and continuation of the core surveys (e.g. CS and support for agri-environment and designated sites monitoring).
(ii) Repetition and continuation of 'other' surveys – highly notable in this respect being the Small Woods Survey (companion survey to the NFI).
(iii) New proposals (e.g. the BSBI/CEH pilot projects for monitoring woodland epiphytes and ground flora; ObservaTree).
(iv) Extension of core surveys, or something analogous, to areas where they are currently lacking.
(v) Investigation of how to best integrate information exchange across the core surveys and between the core and 'other' surveys.
(vi) Support for further research work and monitoring at selected in-depth study sites.
(vii) Iinvestigation of how to maximise the benefits of co-occurrence of sites across surveys.
(viii) Investigation into a new network of co-occurring sites targeting a buffer zone within the boundary of areas at high risk of infection.
(ix) Increased frequency of monitoring within a rolling programme scenario plus the costs of analyses and reporting.
(x) Information gathering in relation to management activity in response to ash dieback.

7 References

KOWALSKI, T. & CZEKAJ, A. 2010. Disease symptoms and fungi on dying ash trees (*Fraxinus excelsior* L.) in Staszów Forest District stands. *Forest Research Papers*, **71**, 357–368.

KOWALSKI, T., KRAJ, W. & SZESZYCKI, T. 2012. The studies on ash decline in Rokita Forest District stands. *Acta Agraria et Silvestria. Series Silvestria*, **50**, 3–22.

SUTHERLAND, W. ET AL. 2006. The identification of 100 ecological questions of high policy relevance in the UK. *Journal of Applied Ecology*, **43**, 617–27.

SUTHERLAND, W.J., FLEISHMAN, E., MASCIA, M.B., PRETTY, J. & RUDD, M.A. 2011. Methods for collaboratively identifying research priorities and emerging issues in science and policy. *Methods in Ecology and Evolution*, **2**, 238–47.

(See note in Section 5 regarding references in relation to European work.)

8 Appendix 1: List of workshop participants

Workshop participants	Days at workshop
CEH	
Shelley Hinsley	All
Michael Pocock	All
Owen Mountford	Wed, Thurs
Chris Preston	Wed
Rob Rose	All
Simon Smart	All
Lindsay Maskell	All
David Roy	All
Helen Roy	All
Marc Botham	Wed, part Thurs/Fri
Jodey Peyton	All
Sarah Turner	All
Anita Weatherby	Wed
Nick Jackson	Thurs, Fri
Collaborators	
Andy Musgrove, British Trust for Ornithology	All
Kevin Walker, Botanical Society of the British Isles	Thurs, Fri
Mike Townsend, Woodland Trust	All
Sue Benham, Forest Research	All
Ross Hill, Bournemouth University	All
Peter Carey, Bodsey Ecology	All
Agencies	
Jeanette Hall, Scottish Natural Heritage	All
Hilary Miller, Countryside Council for Wales	All
Emma Goldberg, Natural England	Wed, Thurs
Keith Porter, Natural England	Thurs, Fri
Ben Ditchburn, Forestry Commission	All
Vicky Morgan, Joint Nature Conservation Committee	All
Lynn Heeley, Joint Nature Conservation Committee	All
John Farren, Northern Ireland Environment Agency	All
Bobbie Hamill, Northern Ireland Environment Agency	All
Andy Stott, Defra	Fri

9 Appendix 2: Reasons for monitoring – JNCC desired outcomes, reported in full

9.1 Impacts of the disease

Outcome: *We know about the impacts of the disease on UK biodiversity because we have been alert and measure relevant changes – there are no nasty surprises lurking undiscovered. We understand the ecological processes which have been disrupted by the disease to cause the impacts [many already disrupted by other pressures]. We have enough relevant information about the impact on UK biodiversity of ash dieback, to allow us to:*

- *assess and forecast ongoing impacts;*
- *identify and implement actions and policies to minimise, offset or compensate for the impacts, while there is still time to act.*

In the event that there is no realistic way to avoid or manage the impacts, we have the knowledge to recognise and explain this, and to assess the implications.

Notes:

(a) This is a medium- to long-term outcome.
(b) It is high priority.
(c) Useful to estimate the extent to which we can do this using existing surveys.
(d) Useful to plan how responsive the monitoring strategy will need to be, as impacts are identified.
(e) Understanding the ecological processes is arguably less important as an outcome of monitoring cf. detecting the impacts – because the ecological understanding can come from other research spend.
(f) However, where it is affordable to include measures which can elucidate impacts on functions and mechanisms, this should be considered. What are they? They could be, for example, measures of deadwood, grazing impacts, saprophytes, or regeneration (by species, health, cover, etc.).
(g) Any extra spend should be evaluated to see if it also delivers for the other outcomes.
(h) The main specialisms required to carry out the monitoring are ecological and taxonomic?
(i) It would be useful to capture expert views on which measurements are suitable to be carried out by volunteers.
(j) Relevant to the following sectors: biodiversity and nature conservation (including site management); access and recreation; plant health; valuing natural capital and services.

9.2 Impacts of management responses

Outcome: *We have enough relevant information about the impact on UK biodiversity of human responses to the disease (including actions driven by policy, governments and individuals), to allow us to assess and forecast their potential impacts, and to advise on the best overall options for biodiversity.*

Notes:

(a) This may include short-term as well as medium- to long-term impacts, as responses develop to the disease.
(b) It is high priority.
(c) Notes c, d, g, i above apply.
(d) The main specialisms required to carry out the monitoring are ecological, taxonomic and land-management expertise. To interpret and direct the monitoring, socio-economic expertise may also be relevant.

(e) Relevant to the following sectors: biodiversity and nature conservation (including site management); forestry and silviculture; access and recreation; plant health; valuing natural capital and services.

9.3 Applicability for other tree diseases

Outcome: *Long-term monitoring delivers the above outcomes for a range of tree diseases, not just* Chalara *ash dieback.*

Notes:
(a) This is a medium- to long-term outcome, depending on the disease.
(b) It is high priority.
(c) It would be useful to assess the scope that the *Chalara* monitoring strategy could cover impacts of a range of other known or potential diseases, and to compare the costs of options.
(d) Other options might include proposals to monitor for impacts of *Chalara* using methods which could later be adapted for other diseases if needed (i.e. avoiding narrowly restricted methods looking just at ash trees), even if at first the methods are applied only in ash habitats.
(e) Relevant to the following sectors: biodiversity and nature conservation; forestry and silviculture; plant health.

9.4 Integration with monitoring in neighbouring countries (cross-cutting outcome)

Outcome: *Where possible, measurements made in UK are compatible with those in other countries with the infection, or with other parts of the British Isles.*

Notes:
(a) This is lower priority or 'nice to do', but obvious wins should be identified.
(b) Some monitoring for birds, butterflies is already joined-up across parts of Europe – it would make sense at least to capture the lessons learned (benefits, costs, pitfalls) from these schemes.

9.5 Increasing theoretical or 'pure' ecological knowledge (cross-cutting outcome)

Outcome: *The results of the monitoring are deep, wide or repeated enough to answer, or contribute to answers about, questions of underlying ecological or evolutionary drivers such as resilience, stability, adaptation, rare extreme events or tipping points.*

Notes:
(a) This is a long-term outcome.
(b) We are discussing spend which is ear-marked for monitoring rather than research.
(c) A high priority is to ensure that opportunities to design monitoring to facilitate this outcome are considered, and built in wherever possible without inflating the cost. It is not a high priority to expand costs significantly in order to achieve this outcome.
(d) Obvious wins should be identified, and it makes sense to make sure we do not preclude wider (and potentially very important) gains if they can be designed in at low cost. After all, it is hard or impossible for pure research projects, which are usually short, to collect the long-term data which are often important for understanding.

10. Appendix 3: Receptors and contexts

During consultation prior to the workshop, we developed a long list of contexts and receptors. These were then shortened, as described in the main text, to provide a useful framework for our discussions. Firstly, the authors constructed a list of likely contexts and receptors (note that in pre-workshop documents, 'receptors' were called 'impacts'). This was distributed for comment to a small group of people, and the final revised list was distributed around all contributors (Table 10.1).

For the workshop, a slightly smaller list of contexts was presented, based on feedback from the participants. During discussion at the workshop, it became clear that the contexts were too repetitive and overlapping. A proposal was made to reduce these to eight contexts and after a short discussion, the final list was agreed. The mapping of the longer list onto the shorter list is shown in Figure 10.1.

The long list of receptors was reduced to a shorter number in advance of the workshop, and this was agreed by all participants. The mapping of the long list to the shorter list is shown in Figure 10.2a and b.

Table 10.1. The full list of contexts and impacts, as distributed to the workshop participants. This is included here for completeness, and not as a final statement on the best categorisation of contexts. It was adapted by participants during the workshop.

POTENTIAL CONTEXTS AND IMPACTS (compiled by: Shelley Hinsley, Owen Mountford, Michael Pocock, Chris Preston and Simon Smart)

Instructions:
Below are the different contexts (p.1) for ash in Britain, and a list of impacts (p.2) of ash dieback which have potential to be monitored. Please add to this document (using 'track changes') to fill in anything that we have missed. If you think that a 'context' or 'impact' is entirely unimportant and not worth considering, then please note this as well. Similarly, these are long lists which will be prioritised both before, and finally, at the Workshop – for now, please indicate which 'contexts' and 'impacts' you consider to have the highest priorities.

CONTEXTS

1. **Woodland**
    - **Mixed lowland woods** (especially NVC type W8 *Fraxinus excelsior-Acer campestre-Mercurialis perennis*, and also W12, but including W10-16, especially when there is a strong calcareous component)
    - **Lowland riparian woods** (e.g. W7 *Alnus glutinosa-Fraxinus excelsior-Lysimachia nemorum* woodland along watercourses)
    - **Mixed upland ash woods, sometimes ash dominated** (W9 *Fraxinus excelsior-Sorbus aucuparia-Mercurialis perennis* woodland, especially on limestone)
    - **Ash-dominated lowland woods** (probably very rare)
    - **Ash plantations**
2. **Farmland** (e.g. as recorded in farm environment plans)
    - **Ash structural in hedgerows**
    - **Ash as hedgerow trees**
    - **Individual infield trees**
3. **Veteran trees**
    - **Ancient pollards** (formerly managed as part of the farmed landscape, e.g. in the Yorkshire Dales)
    - **Parkland veteran trees**
4. **Urban and suburban and infrastructure**
    - **Planted in urban parks** (though be aware of other *Fraxinus* species)

- **Planted** (e.g. as street trees & new housing and retail developments)
- **Gardens**
- **Brownfield sites** (often seedlings of native ash)
- **Along roads, railways and canals** (e.g. forming woodland corridors)

5. **Wider context**
   - **'Landscape character'** (ash will cited as important within some of the National Character Areas)
   - **Specific sites of importance (e.g. SSSIs, NNRs, LNRs)**

IMPACTS

Note: we will be working out precisely which impacts are relevant to which contexts as time goes on – in this list we just want to think of all the possible/relevant impacts, hence not all entries are mutually exclusive.

1. For ash itself

- Chronic disease of mature ash
- Secondary infection of *Chalara* infected ash
- Death of mature ash
- Death of young ash
- Crippling of young ash (i.e. stunted growing point)
- Loss of regeneration of ash

2. On species depending on ash

a) on species depending on live ash directly (feeding on, growing on ash)

- Epiphytes confined to ash
- Epiphytes and climbers closely associated with ash
- Epiphytes and climbers associated with ash (as well as other trees)
- Invertebrates, fungi and other taxa entirely dependent on ash
- Invertebrates, fungi and other taxa closely associated with ash (feeding and non-feeding interactions)
- Invertebrates, fungi and other taxa associated with ash (as well as other trees)
- Loss of invertebrate food resources for birds (and bats?)
- Loss of ash seed food resources for birds and mammals
- Loss of nest sites for birds (see also 2b) below)

b) on species depending on dead ash directly

- Increase in standing dead and fallen wood – likely to have a complex phenology dependent on the rate of spread of the disease, infection rates, mortality rates and management.
- Increase in habitat for bryophyte specialists of dead wood
- Increase in food resources for some invertebrates species in relation to dead wood
- Increase in food resources for some species of fungi in relation to dead wood
- Increase in food resources for some bird species in relation to dead wood (and bats?)
- Increase in cavities for nesting and roosting for bats and birds in relation to dead wood

3. On conditions and functions dependant on ash

a) on environmental conditions

- Changes in light penetration
- Changes in micro-climate (especially relative humidity)
- Changes in exposure to the wind
- Changes in leaf litter composition and chemistry
- Changes in soils (e.g. organic and mineral content)
- Changes in water and nutrient fluxes

b) on woodland structure and composition

- Changes in tree canopy composition (e.g. succession after loss of ash)
- Changes in structure and composition of shrub layer (including bramble)
- Changes in ground flora composition (higher plants and bryophytes)

- Replacement of ash woodland with other habitat types (probably minor)
- Opening of canopy gaps
- Increased opportunities for tree seedling recruitment
- Long-term increase in variation in age/size distribution of trees

c) on hedgerow structure

- Changes in hedgerow structure and composition
- Loss of structural integrity of hedgerows
- Loss of trees
- Replacement with other species

d) on water courses and related features

a. Impact of debris and deadwood from dying ash in rivers on water flow and flood risk
b. Impact of gap creation and tree death on interception of enriched run-off in riparian buffer zones
c. Changes in shading of river channels

4. Indirect effects on species through changes in structure and composition

- Overall loss of woodland habitat for e.g. birds, bats and butterflies
- Changes in woodland structure (including knock-on impacts on food sources) for e.g. birds, bats and butterflies
- Loss of landscape connectivity
- Impacts on small mammals due to changes in habitat structure
- Impacts on large mammals due to changes in landscape connectivity, changes in availability of cover, changes in availability of forage, browse, etc.

5. On ecosystem functions in general (maybe a bit too vague? And/or covered by other points?)

- Impacts on water-regime, drainage, soil-moisture
- Impacts on nutrient cycling
- Impacts on erosion

6. On human health and well-being

- Potential risks to the public from dead/decaying trees – also applies to rural locations
- Potential risks to infrastructure routes from dead/decaying trees
- Loss of environmental quality due to tree loss from urban locations and gardens
- Affect of such changes on adjacent human usage (e.g. light regime on roads, etc.)
- Also, should aspects of woodland livelihoods and economies come in here? Or is that beyond the scope of 'biodiversity impacts'?

7. On other aspects

- Consideration of impacts on woodland and tree management?
- Consequences for biodiversity of management responses to the threat of the disease
- Consequences for biodiversity of management responses to the actual presence of the disease

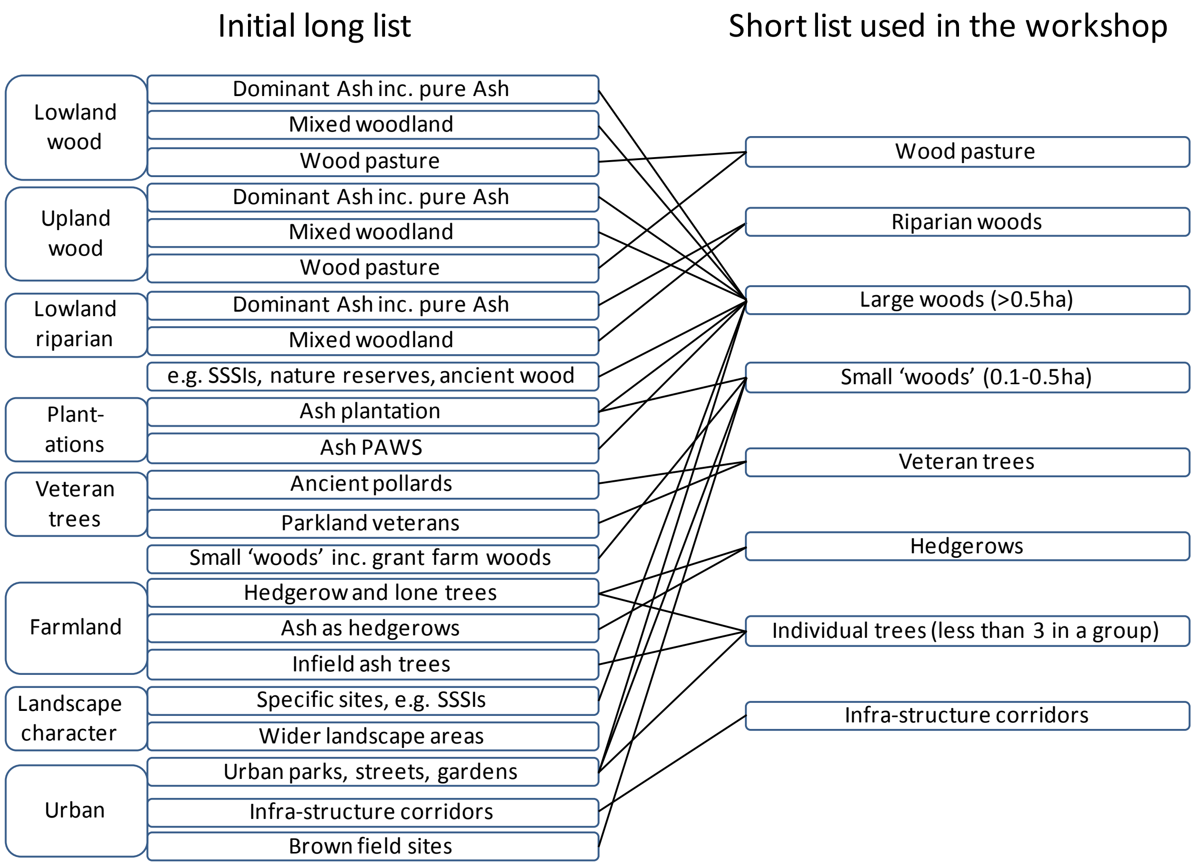


Figure 10.1. The full list of contexts (on the left) and their mapping on to the shortened list of contexts (on the right) as used in the workshop.

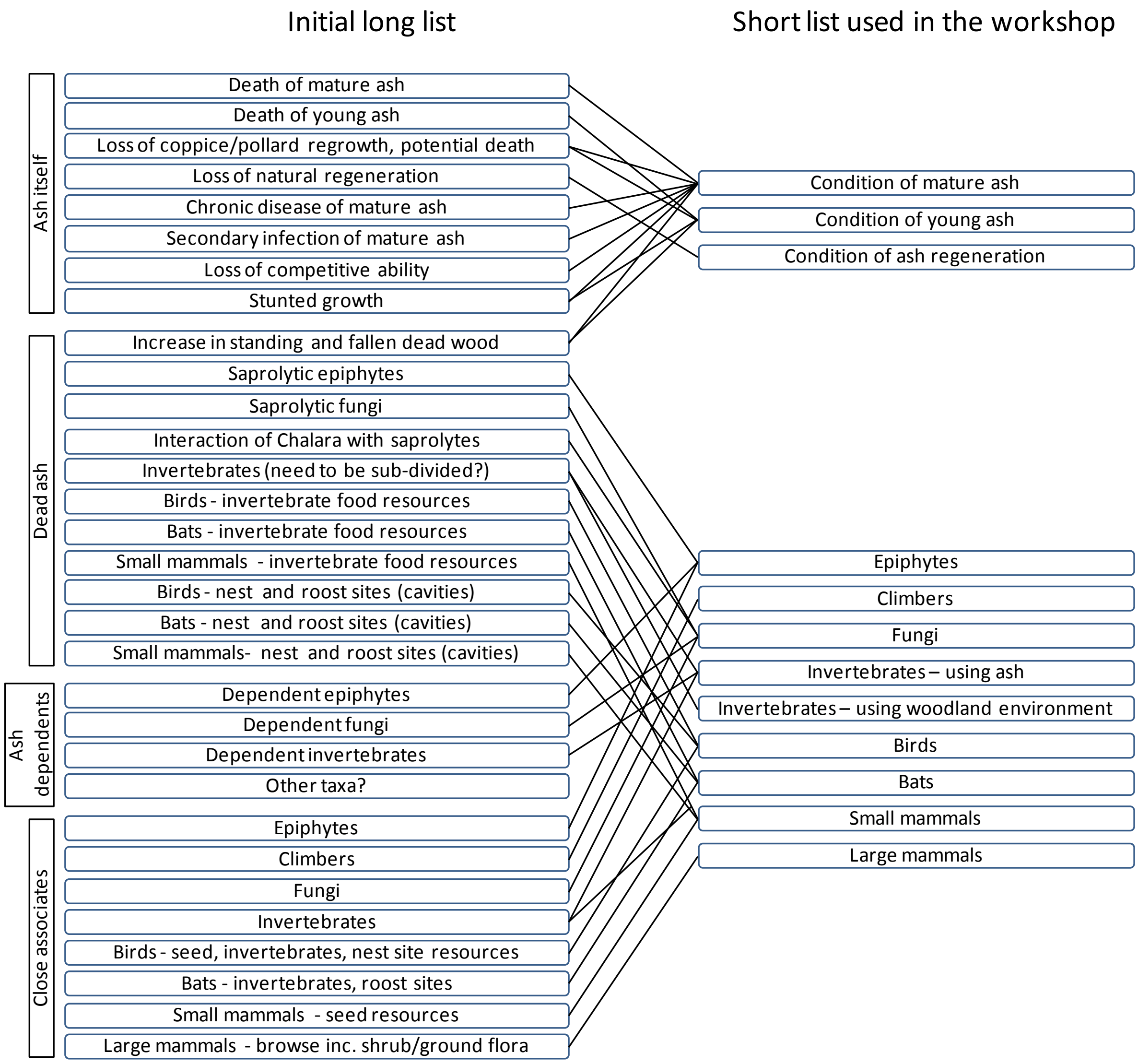


Figure 10.2a. The full list of receptors and their mapping on to the shorter list of receptors, as used in the workshop. Shown in two parts: (a) on this page; and (b) on the following page).

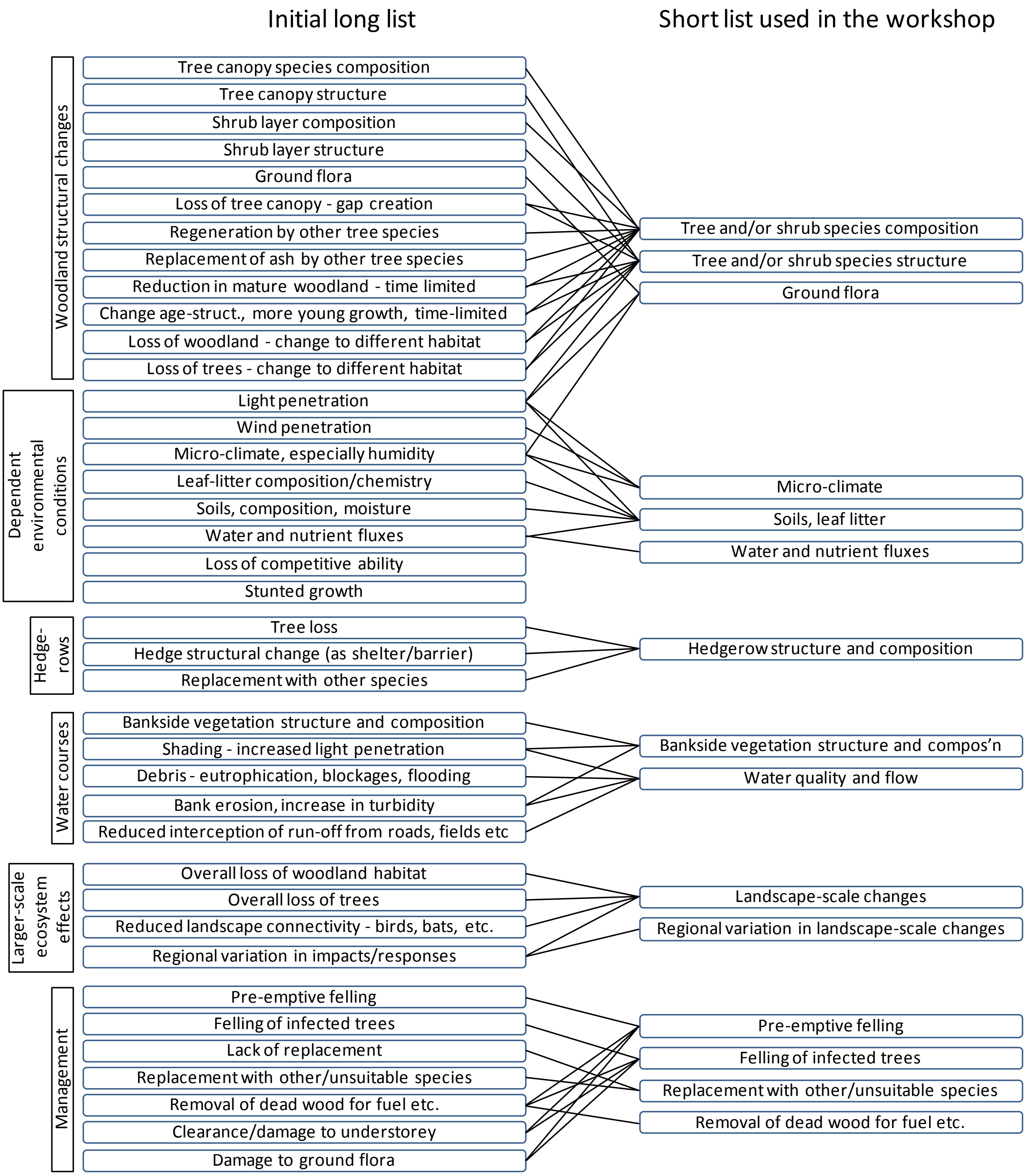


Figure 10.2b. The full list of receptors and their mapping on to the shorter list of receptors, as used in the workshop. Shown in two parts: (b) on this page; and (a) on the previous page.

11 Appendix 4: Survey questionnaire (blank) and pro-forma e-mail request for information

E-mail request – general format, edited according to information being requested.

Dear …………….,

My name is Shelley Hinsley and I work for the Centre for Ecology and Hydrology (CEH) based at Wallingford. We are currently involved in some work that is investigating the options for long-term monitoring of the potential impacts of ash dieback on biodiversity in the UK.

As part of this work, we are collating information about current surveys and monitoring schemes, and existing datasets, that might be useful in the future (with or without some extension or modification) for monitoring ash dieback impacts. We are hoping to discuss this information at a Workshop Meeting at Wallingford in early March (6-8th).

I am therefore writing to ask if you could fill in a questionnaire (file attached) for each of the …………….relevant survey(s) name(s)…………….so that we can include these in the meeting. The requested information is about the overall attributes of the survey/data, and shouldn't take too long to fill in. I have also sent an example questionnaire filled in for Countryside Survey. We intend to include the questionnaires as part of the report to JNCC and all contributions will be acknowledged. We will also send you a summary of our conclusions when these become available.

Don't feel too constrained by the format of the questionnaire – the important thing is to get the relevant information into it. Unfortunately (as ever), the time-scale for this work is very short so I would be very grateful if you could return the questionnaires to me by Thurs. 28th next week.

Please get back to me if you need any further information,

Many thanks for your help, and apologies for the indecent haste,

Shelley

Dr. Shelley A. Hinsley
CEH Wallingford

- **Questionnaire**

Project: Ash Dieback: Scoping Long-term Monitoring Options for Impacts on Biodiversity
Summary of the attributes of existing surveys, monitoring methods or datasets useful to monitor the impacts of ash dieback on biodiversity in the UK. We intend that these will be submitted as part of the final report with no further editing – please note if you have any concerns with this (see "Notes on use in final report").

Name of survey, monitoring method or dataset			
Author		Affiliation	
Notes on use in final report (e.g. other parties needing to sign it off?)			

ATTRIBUTES		DETAILS			
Main target of survey	e.g. taxon, species, community, habitat or site etc.				
Location of target, i.e. specific habitat or general countryside	A specific habitat (e.g. woodland, parks etc.)				
	Wider countryside				
Other or minor target species, taxa etc.					
Organising or Responsible Body					
Survey organisation (can be one or both)	Professional				
	Amateur/volunteer				
Data collection (can be any combination)	Paid surveyor				
	Expert amateur				
	Non-expert volunteer				
Country	England			Scotland	
	Wales			Northern Ireland	
	Other				
Spatial extent of coverage	National				
	Regional (specify)				
	County (specify)				
	Site(s) (and location)				
	Other				
Broad habitat types covered (can be more than one, e.g. lowland farmland)	Lowland				
	Upland				
	Farmland				
	Urban				
	Other				
Time period covered	Year started				
	Year ended or on-going				
	Particular years				
Survey design, e.g. stratified random sample, random sample, particular site(s) etc.					
Scale of recording	Area-based (e.g. 1-km sq etc.)				
	Site-based, whole area				
	Site-based, quadrats				
	Site-based, transect(s)				
	Other				
If site-based, give site area or size range					

Sample size	e.g. no. of squares, sites etc.	
Overall recording frequency	e.g. annual, monthly etc.	
Number of visits/recording sessions within each main recording event		
Data recorded for main target of survey	Presence/absence	
	Abundance	
	Breeding success	
	% cover	
	Vegetation density	
	Habitat composition	
	Habitat structure	
	Habitat condition	
	Land use	
	Other	
If applicable, what additional habitat data is collected?		
Data recorded for other or minor survey targets		
How common is ash in the survey samples, sites, habitats etc?		
Is any ash-specific data recorded? If so, please specify (e.g. health, age classes, associated species etc.)		
Data storage format	Paper records	
	Spreadsheet	
	Database	
	Other	
Data availability	Public	
	Free	
	Restricted	
Any further information on ease of use of the dataset		

OVERALL SUMMARY					
Briefly describe its suitability for monitoring the impacts of ash die back					
Any disadvantages for monitoring the impacts of ash die back?					
Could it be adapted/ extended to make it more useful for monitoring impacts of ash die back? (Give any specific details of reasonable changes)					
Overall suitability for monitoring ash dieback impacts		HIGH	MEDIUM	LOW	NONE
Would it be suitable for monitoring impacts of other tree diseases? (Give any specific details)					

FURTHER INFORMATION: Any relevant links or publications?

12 Appendix 5: Receptors × contexts grid and summary of five independent groups' attempts to identify receptors that were unimportant within a given context

During the workshop, we sought to reduce the number of cells in the receptors × contexts grid, in order to allow a more efficient assessment of the fit of each survey to the monitoring needs. One approach that we used was to ask people in groups to identify which cells in the grid were unimportant. In total, five groups undertook this task, though one group only completed the first half and one group only completed the last half of the grid. Each cell could therefore be regarded as unimportant by four groups. These results are collated in Table 12.1. Very few of the cells were unanimously regarded as unimportant when considering the monitoring of the impacts of ash dieback on biodiversity; indeed there appeared to be very little consistency in the opinions of the four groups, despite feedback that groups tended to be unanimous within the group in their decisions for each cell. We noted that few groups were prepared to comment on lines 22 to 26 because these were descriptions of changes in management rather than receptors *per se*. In the light of these results, we changed our intended approach and reduced the size of the grid, by aggregating the 'contexts' (as described in the text and in Appendix 3) for subsequent discussions.

Table 12.1 (on following page). For each cell, the number of groups (up to a maximum of four) which thought that the cell in question was unimportant in the context of monitoring the impacts of ash dieback. Blank cells indicate all groups thought that cell was important (i.e. no group thought it was unimportant)

	LOWLAND WOOD Dominant Ash inc. pure Ash	LOWLAND WOOD Mixed woodland	LOWLAND WOOD Wood pasture	UPLAND WOOD Dominant Ash inc. pure Ash	UPLAND WOOD Mixed woodland	UPLAND WOOD Wood pasture	LOWLAND RIPARIAN Dominant Ash inc. pure Ash	LOWLAND RIPARIAN Mixed wood	SPECIAL WOOLAND SITES e.g. SSSIs, nature reserves etc.,ancient semi-nat	PLANTATIONS Ash plantation	PLANTATIONS Ash PAWS	VETERAN TREES Ancient pollards	VETERAN TREES Parkland veterans	COPSES / SHELTER-BELTS Small 'woods' inc. Farm woodland grant woods	FARMLAND Hedgerow and lone trees	FARMLAND Ash as hedgerows	FARMLAND Infield ash trees	LANDSCAPE CHARACTER Specific sites e.g. SSSIs etc.	LANDSCAPE CHARACTER Wider landscape areas	URBAN Urban parks, streets, gardens	URBAN Infra-structure corridors	URBAN Brown field sites
1 (Infections + condition of) mature ash	0																	1	1			
2 (Infections + condition of) young ash												1	1				1	1	1			
3 Condition of ash regeneration										1		2	2				1	1	1	1		
4 Dead wood																1		1	1	2	1	
5 Epiphytes	1	1					1	1		1				1		1		1	1	1		
6 Climbers	1	2	2	1	2	2	1	2	1	2	1	1	1	1	2	2		2	3	2	2	2
7 Fungi																1		1	1			
8 Invertebrates - using ash																		1	1			
9 Invertebrates - using the woodland environment													1		2	1	2	1	1	1		
10 Birds																	1	1	1		1	
11 Bats																		1	1			
12 Small mammals	1	1	2	1	1	2	1	1		1	2	2	2	1	2	1	2	1	2	2	2	2
13 Large mammals (pressures)	1	1	2	1	1	2			1	2	1	4	4	1	3	2	3	2	2	3	3	2
14 Tree and/or shrub species composition												2	2		2		3	1	1			
15 Tree and/or shrub species structure										1		2	2	1	2		3	1	1			
16 Ground flora										1		3	3		1	1	3	1	1	1	1	1
17 Micro-climate										1		2	2	1	1	1	2	1	2	1	1	1
18 Soils, leaf litter										1		3	2		3	1	3	1	2	1	1	1
19 Water and nutrient fluxes												4	4		2	1	4	1	2	1	1	
20 Bankside vegetation structure and composition	2	2	2	2	2	2			2	3	2	3	3	1	3	3	3	1	1	3	3	3
21 Water quality and flow + bankside erosion	1	1	1	1	1	1			1	2	1	2	2		2	2	2	1	1	2	1	2
22 Landscape-scale changes																		1	1			
23 Regional variation in landscape-scale changes																		1	1			
24 Pre-emptive felling										1								1	1			
25 Felling of infected trees										1								1	1			
26 Replacement with other/unsuitable species										1								1	1			
27 Removal of dead wood for fuel etc.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1
28 Grazing			1			1				2		2	2	1	3	3	3	1	2	4	4	4

13 Appendix 6: Receptors × contexts grids – summary and details of full records

During the workshop, we asked the participants to work in groups in order to assess the suitability of each survey to assess the impacts of ash dieback on the different receptors. In order to achieve this efficiently we provided a grid for them to fill in (Table 13.1). The full results for the scoring of each survey have been archived as PDF files.

Table 13.1. The grid used by participants to score the suitability of projects for assessing the impacts of ash dieback on biodiversity.

	large woods	small woods	hedge- rows	wood pasture	individual trees	'veteran' trees	infra-structure corridors	riparian woods
	>0.5 ha in size	0.5ha-0.1ha in size	woody linear features	(scattered trees)	no more than 3 (roughly)		long thin lines of trees bordering roads/railways etc.	long thin lines of trees bordering water courses
(Infections + condition of) mature ash								
(Infections + condition of) young ash								
Condition of ash regeneration								
Dead wood								
Epiphytes								
Fungi								
Invertebrates - using ash								
Invertebrates - using the woodland environment								
Birds								
Bats								
Small mammals								
Large mammals								
Tree and/or shrub species composition								
Tree and/or shrub species structure								
Ground flora								
Micro-climate								
Soils/leaf litter								
Water and nutrient fluxes								
Bankside vegetation structure and composition								
Water quality and flow + bankside erosion								
Connectivity (landscapes-scale changes)								
grazing + browsing								

14 Appendix 7: List of surveys (with i.d. numbers and the names of the authors of the questionnaire information) described in the returned questionnaires

Electronic copies of the questionnaires will be supplied if/when permission is confirmed from all parties associated with each surveys. The process of confirming permissions is in progress.

I.D. No.	Survey	Contact
1	National Amphibian & Reptile Recording Scheme	John W. Wilkinson
2	National Bat Monitoring Programme	Philip Briggs
3	Airborne remote sensing survey of Monks Wood & surrounding area	Ross Hill
4	Airborne remote sensing survey of additional sites	Ross Hill
5	Effects of Woodland Structure on Bird Populations	Rob Fuller
6	Bradfield Woods NNR vegetation and birds measurements	Rob Fuller
7	Sheephouse & Rushbeds Woods vegetation and birds measurements	Rob Fuller
8	BirdTrack	Andy Musgrove
9	BTO Garden BirdWatch	Mike Toms
10	Wetland Bird Survey	Andy Musgrove
11	Heronries Census	Andy Musgrove
12	Breeding Bird Survey	Andy Musgrove
13	Marsh Tits, Cambs woods	Richard K Broughton
14	Breeding birds in Cambs woods	Shelley Hinsley
15	Long-term reproductive success (great tits, blue tits), Cambs woods	Shelley Hinsley
16	Woodland structure and birds	Paul Bellamy
17	Repeat Woodland Bird Survey	Paul Bellamy
18	Waterways Breeding Bird Survey	Andy Musgrove
19	Monitoring the effects of ash dieback on the ground flora and epiphytes of woodland	K.J. Walker
19a	UK Plant Surveillance Scheme	K.J. Walker
20	BSBI Distribution Database (incorporating the BRC VPD)	K.J. Walker
21	BSBI Local Change (Monitoring Scheme)	K.J. Walker
22	BBS Epiphyte Survey	C.D. Preston
23	Records for Bryophytes Flora of Cambridgeshire, 2000 onwards	C.D. Preston
24	Records for Mosses & Liverworts of Carmarthenshire and Pembrokeshire, and bryophyte records from Monmouthshire 2000 onwards	C.D. Preston
25	Wildflowers Count	Sue Southway
26	Ronald Good Vegetation Plots	James Bullock
27	Long term vegetation plots at Wytham Woods and Warburg Reserves, Oxfordshire	Keith Kirby
28	Miscellaneous site surveys and quadrat records from *c*1980 onward held by Natural England (and other agencies)	Keith Kirby

29	The Tree Register of the British Isles (TROBI)	David Alderman
30	Ancient Tree Hunt	Mike Townsend?
31	'Bunce Surveys' – long-term vegetation change in 103 woods 1971–2001	Keith Kirby
31a	Bunce Woodland survey 1971 and 2002	
32	UK Butterfly Monitoring Scheme	David Roy
33	Wider Countryside Butterfly Survey (WCBS)	David Roy
34	Butterflies for the New Millenium (BNM)	Marc Botham
35	Butterflies for the New Millennium – national butterfly recording scheme for Britain and Ireland	Richard Fox
36	National Moth Recording Scheme (NMRS)	Marc Botham
37	National Moth Recording Scheme	Richard Fox
38	Rothamsted Insect Survey (RIS) See also Rothamsted light trap data	Marc Botham
39	Rothamsted Insect Survey Light Trap Network	Chris Shortall
40	Biosoil (woodland soils)	Sue Benham Peter Crow
41	ICP Forests Level 2 (including Futmon)	Sue Benham
42	Lady Park Wood	George Peterken Ed Mountford
43	Ash Die back monitoring	Paul Rutter
44	East Midlands woodland grant scheme monitoring	Paul Bellamy
45	Countryside Survey	Lindsay Maskell
46	Environmental Change Network (ECN)	Rob Rose
47	HLS Monitoring Survey	Owen Mountford
48	Monitoring of biodiversity on new native woodland sites owned by Woodland Trust	Sian Akinson
49	Monitoring of biodiversity in plantations on ancient woodland sites (PAWS) owned by Woodland Trust	Tim Hodges
50	Scottish Ancient Woodland Inventory	Jeanette Hall
51	Native Woodland Survey for Scotland	Jeanette Hall
52	Site Condition Monitoring – Scotland	Jeanette Hall
53	Common Standards Monitoring/Integrated Site Assessments	Keith Porter
54	Long term monitoring network (England)	Keith Porter
55	Ancient Woodland Inventory – revised version for Wales	FCW/CCW
56	NVC survey of woodlands in Wales	Jim Latham
57	Habitat Survey of Wales, Phase 1	CCW
58	Designated Sites (SAC, SSSI) monitoring and condition assessment, Wales	CCW
59	National Forest Inventory	Ben Ditchburn
60	Common Standards Monitoring (+Scotland/Northern Ireland)	Bobbie Hamill
60a	Woodlands Survey 1971–2001	
61	National Biodiversity Network: NBN Gateway	Lynn Heeley
62	Opportunistic biological recording (e.g. supported by BRC and the NBN)	David Roy

62a	Mass participation citizen science – spread of ash dieback (summary of options including apps (Ashtag, TreeAlert, etc.) and websites (Biological Records Centre, Treezilla, etc.)	Michael Pocock
63	Nature’s Calendar (UK Phenology Network)	Kate Lewthwaite
64	Observatree	Kate Lewthwaite
65	Ash Site Yield	Miriam White

15 Appendix 8: Additional data sources

A number of additional data sources were mentioned, including: information from the BSBI/CEH draft proposal for monitoring woodland epiphytes and ground flora; an additional data source from SNH which scores availability of survey information and level of threat for each species, and combines these scores to produce a 'risk' category to prioritise urgency of survey; a potential future data source from Wales considering updates on the Phase 1 map using satellite imagery; and additional data sources available on the NBN Gateway, including information from local records centres. In addition, information about the 'Database of Insects and Their Food Plants' (NBN, CEH, JNCC) is available at: http://www.brc.ac.uk/DBIF/homepage.aspx

The most immediately relevant additional source is the draft proposal of BSBI/CEH (in collaboration with the British Bryological Society, British Mycological Society and British Lichen Society) for monitoring the effects of ash dieback on the ground flora and epiphytes of woodland. This proposal is actually two separate, but linked, projects. The first is a plant surveillance project, based on a stratified random sample of *c*200 1km squares. The second is a pilot project for cross-taxon sampling of ground flora and fungi, and epiphytic bryophytes and lichens. The locations for the ground flora and epiphyte survey are randomly selected ash-rich sites. These proposals are currently unfunded beyond a limited field trial (which does not include Northern Ireland) in 2013 as part of a Defra-funded project to pilot more systematic approaches for monitoring biodiversity by volunteers.

16 Appendix 9: Colour-coded 'heat map' of potential level of large-scale survey coverage available for each receptor within each context

During the workshop, after groups of participants had scored individual projects for their suitability for monitoring the impacts of ash dieback on biodiversity, the participants felt it would be useful to have an assessment of the numbers of projects that were relevant to 'national' monitoring of the receptor in each context. We achieved this summary by a 'show of hands' from participants in the workshop, each participant giving feedback on several projects to ensure representation of all the projects that had been scored. These summary results are shown in Table 16.1 (with the full details in Appendix 10).

This summary (in Table 16.1) gives no indication of the coverage (there was debate as to whether 'national' meant UK, but it was taken heuristically to mean 'wide scale'), frequency of repeat visits, how systematic the surveys are, or whether they are pilot or established surveys.

However, despite the caution needed in interpreting the table, we believe that it clearly shows that most biodiversity could be reasonably well monitored (though in this context we purposely do not define 'well') by existing surveys. Ash trees and plants (including other woody plants) appear to be monitored by many different projects. Fungi, some invertebrates, epiphytes and vertebrates have fewer relevant monitoring schemes, and we note that current monitoring is unsystematic and unstructured for fungi and many invertebrate groups (e.g. through expert recorders as in the records collated through the Biological Records Centre). Also, ecosystem functions are monitored by few projects (although relevant projects, such as Countryside Survey or National Forest Inventory, are structured, systematic and large-scale, making their results likely to be statistically robust).

Table 16.1. The number of surveys which could currently monitor wide-scale (= 'national'), long-term impacts of ash dieback on biodiversity, as collated via a 'show of hands' from participants at the workshop. For clarity, cells are coloured according to the numbers of surveys, with red being highest numbers and blue the lowest.

LARGE-SCALE MONITORING	large woods >0.5 ha in size	small woods 0.5ha-0.1ha in size	hedgerows woody linear features	wood pasture (scattered trees)	individual trees no more than 3 (roughly)	'veteran' trees	infra-struct. corridors long thin lines of trees bordering roads/railways etc.	riparian woods long thin lines of trees bordering water courses	TOTALS
(Infections + condition of) mature ash	10	6	3	6	4	7	5	8	**49**
(Infections + condition of) young ash	9	5	2	4	3	4	4	7	**38**
Condition of ash regeneration	12	8	4	5	3	6	4	8	**50**
Dead wood	10	6	1	5	2	8	2	7	**41**
Epiphytes	5	5	5	6	5	7	3	5	**41**
Fungi	2	2	1	3	2	3	1	2	**16**
Invertebrates - using ash	5	5	4	5	2	3	4	5	**33**
Invertebrates - using the woodland environment	11	8	7	8	5	3	7	8	**57**
Birds	8	8	5	6	5	5	5	8	**50**
Bats	2	3	3	3	3	3	3	3	**23**
Small mammals	2	2	1	2	2	2	2	3	**16**
Large mammals	3	3	2	3	3	3	3	4	**24**
Tree and/or shrub species composition	17	13	6	9	7	10	4	14	**80**
Tree and/or shrub species structure	16	12	5	8	3	9	3	11	**67**
Ground flora	16	13	7	8	4	7	5	13	**73**
Micro-climate	2	0	0	2	0	1	1	1	**7**
Soils/leaf litter	7	2	0	2	0	1	1	4	**17**
Water and nutrient fluxes	1	1	0	1	1	1	0	1	**7**
Bankside vegetation structure and composition	5	4	1	3	1	3	1	6	**24**
Water quality and flow + bankside erosion	0	0	0	0	0	X	0	2	**2**
Connectivity (landscapes-scale changes)	2	1	1	2	1	3	3	2	**15**
grazing + browsing	8	4	1	3	1	4	1	3	**25**
TOTALS	**153**	**111**	**60**	**94**	**57**	**93**	**62**	**125**	**755**

17 Appendix 10: Individual surveys considered suitable (with and/or without modification) for each receptor within each context

During the workshop, groups of participants scored individual surveys for their suitability for monitoring the impacts of ash dieback on biodiversity, as described in the main text. For each survey, each cell was marked to show whether the receptor × context was currently monitored (✓), could be monitored by easy survey modification (✓+), or might possibly be currently monitored (✓?). These results were summarised to provide details of which particular surveys were regarded as contributing, or potentially contributing, to the monitoring of the impacts of ash dieback (Table 17.1).

Table 17.1 (On the next page.) The surveys which were considered to be relevant in monitoring the impacts of ash dieback on biodiversity. These surveys are separated as those which currently monitor (✓), could be easily modified to monitor (✓+), or might possibly currently monitor (✓?) these receptors/impacts in each context. Each survey is indicated by a unique number, and the name of each numbered survey is listed at the end of the table. The numbers from 66 to 71 refer to additional data sources (see Appendix 8) and those from 102 to 105 were surveys known to workshop participants and scored on the day in the absence of a previously completed questionnaire.

		1	2	3	4	5	6	7	8
IMPACTS ON ASH		large woods	small woods	hedge-rows	wood pasture	individual trees	veteran trees	infra-struc. corridors	riparian woods
Mature ash	✓	**3, 4, 5+16, 6, 7, 13, 41, 42, 44, 49, 59, 62a, 63, 65, 71, 104**	**3, 4, 41, 49, 62a, 63, 71**	**3, 4, 62a, 63, 71**	**3, 4, 59, 62a, 63, 71**	**3, 4, 62a, 63, 71**	**3, 4, 6, 30, 62a, 63**	**3, 4, 62a, 63**	**4, 49, 62a, 63, 71**
	✓+	***8, 11, 14, 15, 17, 25, 32+33, 46, 48, 53+58, 54, 62, 102, 105***	***8, 11, 15, 17, 25, 32+33, 46, 48, 53+58, 59, 62, 102, 105***	***8, 32+33, 59, 62, 102, 105***	***8, 32+33, 53+58, 54, 62, 102, 105***	***8, 10, 32+33, 62, 102, 103, 105***	***8, 10, 32+33, 53+58, 62, 102, 103, 105***	***8, 32+33, 59, 62, 103, 105***	***8, 10, 11, 18, 32+33, 48, 53+58, 59, 62, 102, 105***
	✓?			*25*	*11, 25, 30*	*11, 25*	*11, 13, 18, 40, 41*	*11, 25*	*25*
Young ash	✓	**5+16, 6, 7, 13, 41, 42, 44, 49, 59, 62a, 65, 71, 104**	**41, 49, 62a, 71**	**62a, 71**	**59, 62a, 71**	**62a, 71**	**6, 59, 62a**	**59, 62a**	**49, 59, 62a, 71**
	✓+	***8, 11, 14, 15, 17, 22, 23, 24, 25, 32+33, 46, 48, 53+58, 54, 62, 102, 105***	***8, 11, 15, 17, 22, 23, 24, 25, 32+33, 46, 48, 53+58, 59, 62, 102, 105***	***8, 22, 23, 24, 32+33, 59, 62, 102, 105***	***8, 22, 23, 24, 32+33, 53+58, 54, 62, 102, 105***	***8, 10, 22, 23, 24, 32+33, 59, 62, 102, 103, 105***	***8, 10, 22, 23, 24, 32+33, 53+58, 62, 102, 103, 105***	***8, 22, 23, 24, 32+33, 62, 103, 105***	***8, 10, 11, 18, 22, 23, 24, 32+33, 48, 53+58, 62, 102, 105***
	✓?	*3, 4*	*3, 4*	*3, 4*	*3, 4, 11*	*3, 4, 11*	*3, 4, 11, 18*	*3, 4, 11*	*4*
Ash regeneration	✓	**5+16, 6, 7, 13, 41, 42, 44, 49, 59, 71, 104**	**41, 49, 71**	**71**	**59, 71**	**71**	**6, 59**	**59**	**49, 59, 71**
	✓+	***11, 14, 15, 17, 22, 23, 24, 32+33, 46, 48, 53+58, 54, 62, 102, 105***	***11, 15, 17, 22, 23, 24, 32+33, 46, 48, 53+58, 59, 62, 102, 105***	***22, 23, 24, 32+33, 59, 62, 102, 105***	***22, 23, 24, 32+33, 53+58, 54, 62, 102, 105***	***10, 22, 23, 24, 32+33, 59, 62, 102, 103, 105***	***10, 22, 23, 24, 32+33, 53+58, 62, 102, 103, 105***	***22, 23, 24, 32+33, 62, 103, 105***	***10, 11, 18, 22, 23, 24, 32+33, 48, 53+58, 62, 102, 105***
	✓?				*5+16, 11*	*11*	*5+16, 11, 18*	*11*	*5+16*
Dead wood	✓	**13, 17, 40, 41, 42, 49, 53+58, 54, 59, 62, 104**	**17, 41, 49, 53+58, 62**	**62**	**53+58, 54, 59, 62**	**62**	**30, 53+58, 59, 62**	**59, 62**	**40, 49, 53+58, 59, 62**
	✓+	***14, 15, 22, 23, 24, 32+33, 46, 71, 102, 105***	***15, 22, 23, 24, 32+33, 46, 59, 71, 102***	***22, 23, 24, 32+33, 59, 102, 105***	***22, 23, 24, 32+33, 102***	***22, 23, 24, 32+33, 44, 59, 102, 105***	***22, 23, 24, 32+33, 44, 102, 105***	***22, 23, 24, 32+33***	***22, 23, 24, 32+33, 48, 102***
	✓?	*3, 4, 6, 44*	*3, 4*	*3, 4*	*3, 4, 30*	*3, 4*	*3, 4, 6, 18*	*3, 4*	*4*

		1	2	3	4	5	6	7	8
IMPACTS ON BIODIVERSITY 1		large woods	small woods	hedge-rows	wood pasture	individual trees	veteran trees	infra-struc. corridors	riparian woods
Epiphytes	✓	**22, 23, 24, 41, 42, 61, 62, 71**	**22, 23, 24, 41, 61, 62, 71**	**22, 23, 24, 61, 62, 71**	**22, 23, 24, 61, 62, 71**	**22, 23, 24, 61, 62**	**22, 23, 24, 30, 61, 62**	**22, 23, 24, 61, 62, 71**	**22, 23, 24, 61, 62, 71**
	✓+	***48, 49, 59***	***48, 49, 59***	***59, 105***	***59***	***59***	***59, 105***	***59***	***49, 59***
	✓?	*40, 53+58*	*53+58*		*30, 53+58*		*18, 53+58*		*53+58*
Fungi	✓	**42, 61, 62, 71**	**61, 62, 71**	**61, 62**	**61, 62**	**61, 62**	**30, 61, 62**	**61, 62**	**2, 61, 62**
	✓+	***41, 48, 59***	***41, 48, 59***	***59***	***59***	***59***	***59***	***59***	***48, 59***
	✓?	*40, 53+58*	*53+58*		*30, 53+58*		*18, 53+58*		*53+58*
Invertebrates - using ash	✓	**37, 39, 62**	**37, 39, 62**	**37, 39, 62**	**37, 39, 62**	**9, 62**	**9, 30, 62**	**37, 39, 62**	**37, 39, 62**
	✓+	***32+33, 35, 41, 48, 49, 54, 59, 61***	***32+33, 35, 41, 48, 49, 59, 61***	***32+33, 35, 59, 61***	***32+33, 35, 54, 59, 61***	***32+33, 59, 61***	***32+33, 59, 61***	***32+33, 35, 59, 61***	***18, 32+33, 35, 48, 49, 59, 61***
	✓?	*53+58*	*53+58*		*30, 53+58*		*18, 53+58*		*53+58*
Invertebrates - using woodland environment	✓	**32+33, 35, 37, 39, 41, 46, 54, 62**	**32+33, 35, 37, 39, 41, 46, 62**	**32+33, 35, 37, 39, 62, 105**	**32+33, 35, 37, 39, 54, 62**	**9, 32+33, 62**	**9, 30, 62**	**32+33, 35, 37, 39, 62**	**32+33, 35, 37, 39, 62**
	✓+	***48, 49, 59, 61, 105***	***48, 49, 59, 61, 105***	***59, 61***	***59, 61***	***59, 61***	***32+33, 59, 61***	***59, 61***	***18, 48, 49, 59, 61, 105***
	✓?	*53+58*	*53+58*		*30, 53+58*		*18, 53+58*		*53+58*
Birds	✓	**5+16, 6, 7, 8, 11, 14, 15, 17, 41, 44, 46, 48, 54, 61, 62, 105**	**8, 11, 15, 17, 41, 46, 48, 61, 62, 105**	**8, 61, 62, 105**	**8, 54, 61, 62, 105**	**8, 9, 61, 62, 105**	**5+16, 6, 8, 9, 13, 61, 62, 105**	**8, 61, 62, 105**	**8, 11, 18, 48, 61, 62, 105**
	✓+	***49, 59***	***49***		***59***	***10, 59, 103***	***10, 59, 103***	***59, 103***	***10, 49, 59***
	✓?	*53+58*	*53+58*		*53+58*	*11*	*18, 53+58*	*11*	*53+58*
Bats	✓	**13, 41, 46, 61, 62**	**41, 46, 61, 62**	**2, 61, 62**	**2, 61, 62**	**2, 61, 62**	**2, 61, 62**	**2, 61, 62**	**2, 61, 62**
	✓+	***2, 48, 49, 59***	***2, 48, 49***		***59***	***59***	***59***	***59***	***48, 49, 59***
	✓?	*53+58*	*53+58*		*53+58*		*18, 53+58*		*53+58*

		1	2	3	4	5	6	7	8
IMPACTS ON FUNCTION		large woods	small woods	hedge-rows	wood pasture	individual trees	veteran trees	infra-struc. corridors	riparian woods
Replacement with other/unsuitable species	✓	**53+58, 59, 105**	**53+58, 59, 105**	**105**	**53+58, 59, 105**	**9, 105**	**9, 53+58, 59, 105**	**59, 105**	**53+58, 59, 105**
	✓+	***14, 41, 44, 48, 49, 65, 71, 102***	***41, 48, 49, 71, 102***	***59, 102***	***102***	***59, 102***	***102***	***103***	***49, 102***
	✓?						*18*		
Water and nutrient fluxes	✓	**41, 105**	**41, 105**	**105**	**105**	**-**	**-**	**-**	**-**
	✓+	***59, 62***	***59, 62***	***59, 62***	***59, 62***	***59, 62***	***59, 62***	***59, 62***	***59, 62***
	✓?						*18*		
Bankside vegetation strucutre and composition	✓	**48, 53+58, 59**	**48, 53+58, 59**	**-**	**53+58, 59**	**-**	**53+58, 59**	**59**	**48, 53+58, 59, 105**
	✓+	***62***	***62***	***59, 62***	***62***	***10, 59, 62***	***10, 62***	***62***	***10, 18, 62***
	✓?	*71*	*71*				*18*		
Water quality and flow + bankside erosion	✓	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**105**
	✓+	***59, 62***	***59, 62***	***59, 62***	***59, 62***	***59, 62***	***59, 62***	***59, 62***	***59, 62***
	✓?						*18*		
Connectivity (landscape-scale changes)	✓	**3, 4, 15, 59, 105**	**3, 4, 15, 59, 105**	**3, 4, 105**	**3, 4, 59, 105**	**3, 4**	**3, 4, 30, 59**	**3, 4, 59, 105**	**4, 59, 105**
	✓+	***2, 13, 14, 32+33, 35, 37, 39, 61, 62***	***2, 32+33, 35, 37, 39, 61, 62***	***2, 32+33, 35, 37, 39, 59, 62***	***2, 32+33, 35, 37, 39, 61, 62***	***2, 32+33, 59, 61, 62***	***2, 32+33, 61, 62***	***2, 32+33, 35, 37, 39, 62***	***32+33, 35, 37, 39, 62***
	✓?				*30*		*18*		
Special sites	✓	**2, 7, 32+33, 35, 37, 39, 42, 53+58, 59, 104**	**2, 32+33, 35, 37, 39, 53+58, 59**	**2, 32+33, 35, 37, 39**	**2, 32+33, 35, 37, 39, 53+58, 59**	**2, 32+33**	**2, 32+33, 53+58, 59**	**2, 32+33, 35, 37, 39, 59**	**2, 32+33, 35, 37, 39, 53+58, 59**
	✓+	***11, 49***	***11, 49***	***59***		***10, 59***	***10***		***10, 11, 49***
	✓?				*11*	*11*	*11, 18*	*11*	

		1	2	3	4	5	6	7	8
MANAGEMENT AND PRESSURES		large woods	small woods	hedge-rows	wood pasture	individual trees	veteran trees	infra-struc. corridors	riparian woods
Pre-emptive felling	✓	**53+58**	**53+58**	**-**	**53+58**	**-**	**30, 53+58**	**-**	**53+58**
	✓+	***14, 41, 44, 48, 49, 59, 65, 71, 102***	***41, 48, 49, 59, 71, 102***	***59, 102***	***59, 102***	***9, 10, 59, 102***	***9, 10, 59, 102***	***59, 103***	***10, 49, 59, 102***
	✓?	*3, 4*	*3, 4*	*3, 4*	*3, 4, 30*	*3, 4*	*3, 4, 18*	*3, 4*	*4*
Felling of infected trees	✓	**53+58**	**53+58**	**-**	**53+58**	**-**	**30, 53+58**	**-**	**53+58**
	✓+	***14, 41, 44, 48, 49, 59, 65, 71, 102***	***41, 48, 49, 59, 71, 102***	***59, 102***	***59, 102***	***9, 10, 59, 102***	***9, 10, 59, 102***	***59, 103***	***10, 49, 59, 102***
	✓?	*3, 4*	*3, 4*	*3, 4*	*3, 4, 30*	*3, 4*	*3, 4, 18*	*3, 4*	*4*
Replacement with other/unsuitable species	✓	**53+58, 59, 105**	**53+58, 59, 105**	**105**	**53+58, 59, 105**	**9, 105**	**9, 53+58, 59, 105**	**59, 105**	**53+58, 59, 105**
	✓+	***14, 41, 44, 48, 49, 65, 71, 102***	***41, 48, 49, 71, 102***	***59, 102***	***102***	***59, 102***	***102***	***103***	***49, 102***
	✓?						*18*		
Removal of dead wood for fuel etc.	✓	**53+58, 59**	**53+58, 59**	**-**	**53+58, 59**	**9**	**9, 53+58, 59**	**59**	**53+58, 59**
	✓+	***41, 44, 48, 49, 65, 71, 102***	***41, 48, 49, 71, 102***	***59, 102***	***102***	***59, 102***	***102***		***49, 102***
	✓?						*18*		
Grazing/browsing	✓	**5+16, 6, 46, 53+58, 59, 104, 105**	**46, 53+58, 59, 105**	**-**	**53+58, 59**	**-**	**5+16, 6, 53+58, 59**	**59**	**53+58, 59**
	✓+	***13, 41, 44, 48, 49, 54, 102***	***41, 48, 49, 102***	***59, 102***	***54, 102***	***59, 102***	***102***	***103***	***15, 49, 102***
	✓?						*15*		

1 National Amphibian & Reptile Recording Scheme
2 National Bat Monitoring Programme
3 Airborne remote sensing survey of Monks Wood & surrounding area
4 Airborne remote sensing survey of additional sites
5 Effects of Woodland Structure on Bird Populations
6 Bradfield Woods NNR vegetation and birds measurements
7 Sheephouse & Rushbeds Woods vegetation and birds measurements
8 BirdTrack
9 BTO Garden BirdWatch
10 Wetland Bird Survey
11 Heronries Census
12 Breeding Bird Survey
13 Marsh Tits, Cambs woods
14 Breeding birds in Cambs woods
15 Long-term reproductive success (great tits, blue tits), Cambs woods
16 Woodland structure and birds
17 Repeat Woodland Bird Survey
18 Waterways Breeding Bird Survey
19 Monitoring effects of ash dieback on woodland ground flora and epiphytes
19a UK Plant Surveillance Scheme
20 BSBI Distribution Database (incorporating the BRC VPD)
21 BSBI Local Change (Monitoring Scheme)
22 BBS Epiphyte Survey
23 Records for Bryophytes Flora of Cambridgeshire, 2000 onwards
24 Records for Mosses & Liverworts of Carmarthenshire and Pembrokeshire, and bryophyte records from Monmouthshire 2000 onwards
25 Wildflowers Count
26 Ronald Good Vegetation Plots
27 Long term vegetation plots at Wytham Woods and Warburg Reserves, Oxon
28 Miscellaneous site surveys and quadrat records from c1980 onward held by Natural England (and other agencies)
29 The Tree Register of the British Isles (TROBI)
30 Ancient Tree Hunt
31 'Bunce Surveys' – long-term vegetation change in 103 woods 1971–2001
31a Bunce Woodland survey 1971 and 2002
32 UK Butterfly Monitoring Scheme
33 Wider Countryside Butterfly Survey (WCBS)
34 Butterflies for the New Millenium (BNM)
35 Butterflies for the New Millennium – national butterfly recording scheme for Britain and Ireland
36 National Moth Recording Scheme (NMRS)
37 National Moth Recording Scheme
38 Rothamsted Insect Survey (RIS) See also Rothamsted light trap data
39 Rothamsted Insect Survey Light Trap Network
40 Biosoil (woodland soils)
41 ICP Forests Level 2 (including Futmon)
42 Lady Park Wood
43 Ash Die back monitoring
44 East Midlands woodland grant scheme monitoring
45 Countryside Survey
46 Environmental Change Network (ECN)
47 HLS Monitoring Survey
48 Monitoring of biodiversity on new native woodland sites owned by Woodland Trust
49 Monitoring of biodiversity in plantations on ancient woodland sites (PAWS) owned by Woodland Trust
50 Scottish Ancient Woodland Inventory
51 Native Woodland Survey for Scotland
52 Site Condition Monitoring – Scotland
53 Common Standards Monitoring/Integrated Site Assessments
54 Long term monitoring network (England)
55 Ancient Woodland Inventory – revised version for Wales
56 NVC survey of woodlands in Wales
57 Habitat Survey of Wales, Phase 1.
58 Designated Sites (SAC, SSSI) monitoring and condition assessment, Wales
59 National Forest Inventory
60 Common Standards Monitoring (+Scotland/Northern Ireland)
60a Woodlands Survey 1971–2001
61 National Biodiversity Network: NBN Gateway
62 Opportunistic biological recording, e.g. supported by BRC and the NBN
62a Mass participation citizen science (summary of options including apps (Ashtag, TreeAlert etc.) and websites (Biological Records Centre, Treezilla))
63 Nature's Calendar (UK Phenology Network)
64 Observatree
65 Ash Site Yield
66 DATA SOURCES AVAILABLE ON NBN GATEWAY
67 POTENTIAL FUTURE WELSH DATA
68 Monitoring the effects of ash die-back on the ground flora and epiphytes of woodlands
69 ADDITIONAL SNH DATA SOURCE
70 Database of Insects and their Food Plants
71 BSBI Ash Monitoring – VM,JF, RR
102 Farmer Attitudes survey – Pete Carey
103 British Rail Survey – Owen Mountford
104 NNR and CWS Woodland Long Term Monitoring
105 Axis II – Glas Tir Wales Monitoring

18 Appendix 11: Estimates of costs

Workshop delegates were requested to consider the following three options as potential funding scenarios and then to estimate independently an overall cost for each option. ‘Core’ refers to the eight surveys identified as those most suitable to form the basis of a UK-wide monitoring strategy for ash dieback (see Section 4). ‘Extensive’ refers to the normal monitoring operations of these surveys across their large numbers of survey sites. ‘Site-based intensive studies’ refers to detailed ecological work undertaken at a small number of sites as part of existing (and usually on-going) research that has potential to inform a deeper understanding of the consequences of the disease for habitats, communities, ecological processes and ecosystems.

Option 1. Core (extensive) surveys + site-based intensive (i.e. in-depth) studies

Option 2. Core (extensive) surveys + site-based intensive studies + additional modifications (including co-occurrence) to core surveys

Option 3. Core (extensive) + site-based intensive studies + additional modifications (including co-occurrence) to core surveys + new initiatives

Responses fell into three distinct groups based on the sizes of the estimates. The results, in millions, are given as the mean ± SD and the range.

	Group 1 (n = 7)	**Group 2 (n = 4)**	**Group 3 (n = 5)**
Option 1	4.6 ± 2.1	11.3 ± 1.0	33.5 ± 12.4
	1.4 to 7.0	10.0 to 12.0	20.0 to 50.0
Option 2	5.1 ± 2.3	13.1 ± 1.3	38.7 ± 14.3
	1.5 to 7.5	12.0 to 15.0	23.0 to 55.0
Option 3	6.6 ± 3.2	17.4 ± 2.8	46.9 ± 19.4
	1.8 to 10.0	13.5 to 20	24.5 to 70.0

Although the guess-timates varied substantially between the three groups, the proportional increase from Option 1 to Option 2 and from Option 1 to Option 3 were very consistent. Specifically, people estimated a 15% increase in costs (11 to 16%, across the three groups) from Option 1 to Option 2, and a 46% increase in costs (40 to 54%, across the three groups) from Option 1 to Option 3.

The current cost of Option 1 was estimated by those with experience of the core surveys to be approximately £9.5 million per year, so taking the participants estimates, the estimated potential cost of Option 2 would be about £10.8 million per year, and Option 3 would be about £13.9 million per year. A full ecosystem service evaluation could be carried out to calculate the economic cost-benefit of the Options, especially given the potential for the information from these surveys to assist in the discovery of management to ameliorate the impacts of ash dieback on biodiversity and to allow effective reporting of the change in condition of protected habitats and species.