(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 Countryside 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.

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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

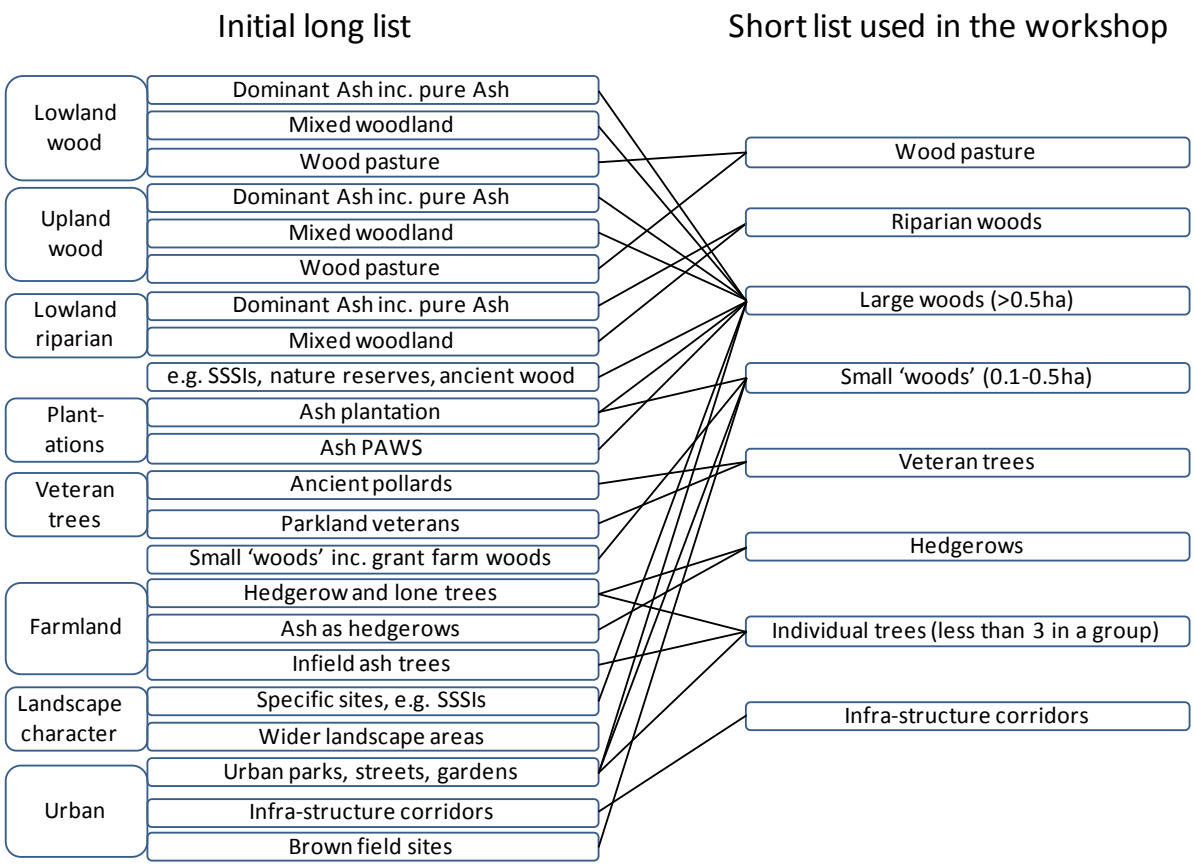

Figure 10.1. The full list of contexts (on the left) and their mapping on to the shortened list of contexts (on the right) as used in the workshop.

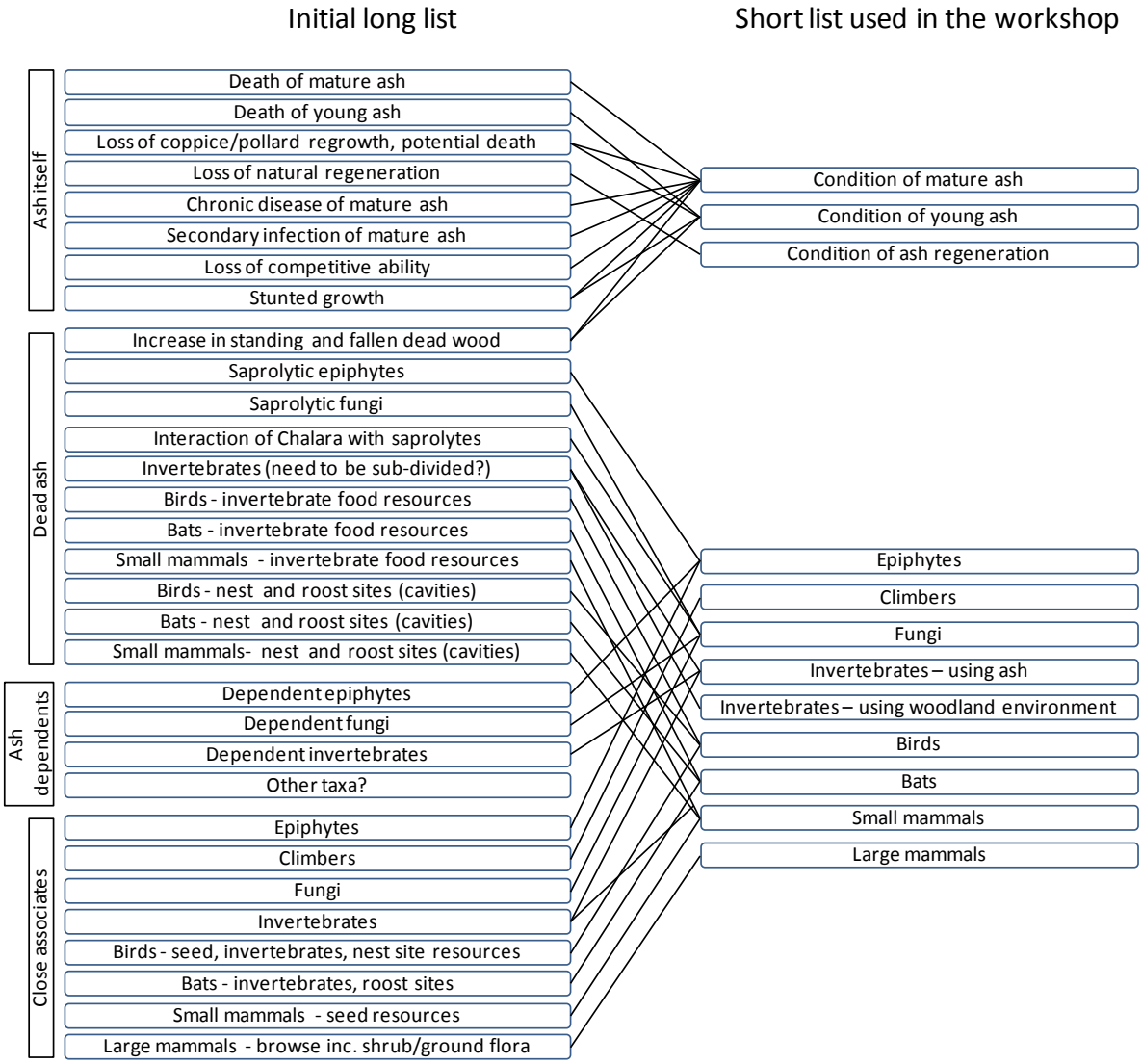

Figure 10.2a. The full list of receptors and their mapping on to the shorter list of receptors, as used in the workshop. Shown in two parts: (a) on this page; and (b) on the following page).

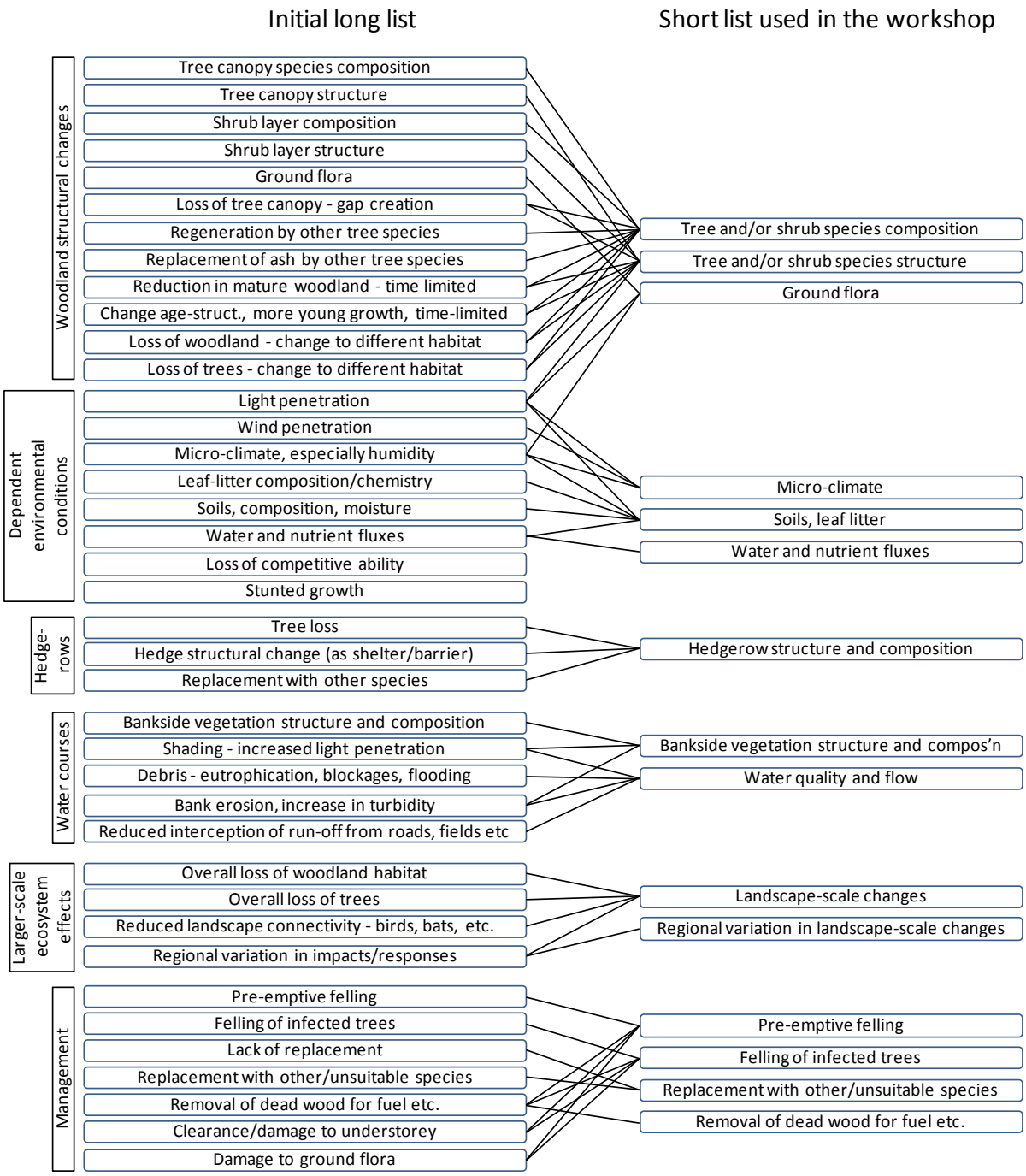

Figure 10.2b. The full list of receptors and their mapping on to the shorter list of receptors, as used in the workshop. Shown in two parts: (b) on this page; and (a) on the previous page.

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 >0.5 ha in size	small woods 0.5ha-0.1ha in size	hedge- rows woody linear features	wood pasture (scattered trees)	individual trees no more than 3 (roughly)	'veteran' trees	infra-structure corridors long thin lines of trees bordering roads/railways etc.	riparian woods 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).

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.