Final Report

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Chalara – lessons learned

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Contents

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2. Short project report

2.1 Executive summary

Ash dieback has become a continent-wide problem in a relatively short period of time which has generated a significant amount of research within and across countries. To consider what lessons have been learned, this project convened a workshop of researchers and government and non-governmental representatives from 10 EU countries to describe the impact of the disease, research undertaken and underway, and management responses. From the workshop and following work, it was identified that whilst there was much ongoing research which had the potential to deliver long term benefits, a lack of immediately useable information for land managers risks ash being lost from the landscape before long-term research outputs are available for use. The Awareness, Planning, Action and Recovery framework developed with Defra funding (and subsequently published, Stokes and Jones, 2019[1]) was used to explore this issue.

Given the research backgrounds of the attendees there was a strong emphasis on the search for resistant or tolerant species. This line of research, by its nature, is uncertain and long term. There appeared to be a number of potential interesting options but none of them were particularly close to offering a solution to the large-scale loss of ash from the landscape. Outputs of resistance/tolerance research (resistant/tolerant ash) will most likely be available after then period of high impact and mortality of ash dieback has passed. As such, this research may be more pertinent to the post invasion stage of Ash dieback. Land managers may demonstrate low acceptance/uptake of resistant/tolerant ash if they are unsupported during the high mortality phase of ash dieback. In the short term, adopting planting strategies to maintain/increase high genetic diversity may offer more immediate solutions for land managers and may also have a positive effect across multiple threats.

Research into more immediate response options (e.g. silviculture) were mentioned. However, there was limited discussion of how the outputs of this research have been, or should be, translated practical/usable solutions for those responsible for management at a local level. The creation of a toolkit for local authority managers in the UK was an example of an attempt to achieve this. The creation of a toolkit reflected the need to get information to those who have to manage the impacts of the disease whilst the longer-term research is ongoing.

The time for different strands of research to provide useable outputs to land managers emerged as a key theme. It has been documented that responses in plant health can lag outbreaks (Ward, 2016[2]), resulting in missed opportunities to limit the total impact of an outbreak. This problem can be understood by considering the behaviour of local managers. The Awareness, Planning, Action and Recovery framework sets out four phases which local managers need to oversee for a successful outcome. The research described at the workshop was more focussed upon the latter phases of action and recovery. Overlooking the earlier phases risks local managers being unsupported during the early period of an outbreak and

[1] Stokes. J., and Jones, G. (2019). Ash Dieback: An Action Plan Toolkit.Tree Council Publication. Tree Council, London.
[2] Ward, M (2016). Action against pest spread—the case for retrospective analysis with a focus on timing. Food Security 8, pp77–81

risks slow uptake of the outputs of long term research. This situation may be worsened where local managers have had a poor, unsupported experience of managing ash which results in a reluctance to plant resistant/tolerant material.

Two options are to address this issue are: 1) to provide local managers with more immediate solutions and engagement; and 2) to take a pre-emptive approach to long term research, beginning before the threat arrives (as per New Zealand's pre-emptive licensing of biological control agents for brown marmorated stink bug[3]).

2.2 Project aims

The general aim of the project was to produce a European review of the lessons that can be learnt from the Ash dieback outbreak. The consortium focused on:

- Assessment of the Chalara outbreaks regarding: the initial outbreak, efforts on containment / eradication; official reaction / responses, public reaction and the current situation in UK, Ireland, Norway, Estonia, Lithuania, Germany, Sweden and Italy;
- Assessment of impacts in urban and rural environments and on forest and other stakeholders (including health and safety and management considerations);
- Review of Ash dieback research (map current projects) to identify knowledge gaps – to include what we know about what can be done to increase resilience and mitigate impact. This will include a short review (or list) of present resistance breeding programs in Europe and assessment of their expediency.

2.3 Description of the main activities

Given available resources, the centrepiece of the project was a short workshop hosted by DAFM in Dublin. The partners changed and grew considerably from the limited initial set, thanks to intervention from the Euphresco coordinator and the willingness of Defra to finance the travel of additional experts. In addition, several observers attended from DAFM and Defra. For a full attendance list see Appendix 1

The presentations covered the view from 10 countries (UK, Ireland, Austria, Italy, Germany, Sweden, Norway, Estonia, Latvia, Lithuania) and were provided by a mix of national plant health authorities, academic researchers, as well as one UK charity involved in tree issues for over 30 years. See Table 1 for the key points of these presentations.

Table 1: Summary of the presentations

Speaker	
Glyn Jones (Fera, UK)	**Research presented**: Presented a conceptual view of the tree health problem and proposed a proactive, rather than reactive plant health response
Cathal Ryan (DAFM, Ireland)	**National status of ash**: An important component of Irish native woodlands - economically, environmentally, culturally important. **ADB history**: Found Oct 2012 **Policy**: Originally eradication policy but spread continued. Move to focus on resilience from 2017 to reduce impact

[3] https://www.plantandfood.co.nz/page/news/research/update/assessing-the-biosafety-of-the-samurai-wasp-as-a-biocontrol-agent-for-the-brown-marmorated-stink-bug/

Thomas Kirisits (BOKU, Austria)	**ADB history:** Monitoring 2008-2016 (indicating chronic disease development. Continuing damage assessments in existing field trials and monitoring plots **Research presented**: conservation and resistance breeding for *excelsior* and *angustifolia*, susceptibility of non-native ash species to ash dieback, virulence of *Hymenoscyphus fraxineus, and* studies on the (infection) biology of *H. fraxineus*
Lucio Montecchio (UNIPD, Italy)	**ADB history:** First report in 2009. **Research presented:** Discussed possible synergistic interaction between *Diplodia fraxini* and *Hymenoscyphus fraxineus*
Rasmus Enderle (JKI, Germany)	**ADB history**: ADB present since 2000. Ash tree density varies from 0.3% to almost 5% in different states. Baden-Wurttemberg (SW corner) survey 2015 – c1/4 with up to 25% defoliation, 34% with 26-60% and 39% more than 61% defoliation. **Policy history:** No official ADB policy between 2000-2008. Monitoring started in 2009. Advice not to plant ash in some states from 2009. First newspaper reports in 2011. ADB considered as a traffic safety issue since 2013. **Research presented:** Seed plantation to create resistant clones, biological control, FNR call (https://forst.fnr.de/forst/eschentriebsterben/?__mstto=en).
Rimvydas Vasaitis (SLU, Sweden)	**Research presented:** Provided an update on the spread of EAB from Russia. Some promising parasitoids plus some signs of resistance. Testing for resistance to ADB in Gotland (selection in 2013 and planted 2015 and 2017).
Ari Hietala (NIBIO, Norway)	**National status of ash:** Northernmost stand of all attendees **ADB history:** ADB spread north along Atlantic coast from 2007. More severe crown impact in SE compared to west. **Policy history:** Monitoring programme since 2009. Ash stand management - silvicultural measures to promote tree vitality, mixed stands to reduce infection pressure, maintenance of high genetic variation to meet disease and other selection pressures
Rein Drenkhan (EMU, Estonia)	**National status of ash:** *F. excelsior* covers only 0.33% (7630 ha) of the total forested area. **ADB history:** ADB 1st record of *H. fraxineus* in 1997 but symptom-based observation not detected until 2003. Forest ash worst conditions in west. No single solution – ash trees near open areas and also having long crowns seem more resistant. **Policy history:** No specific management policy for ash. Future priorities – monitoring and detection of new threats, genetic resistance/breeding, education (to avoid imports), biological control and integrated management
Gerry Douglas (TEAGASC, Ireland)	**Research:** Find tolerant genotypes and propagate, develop molecular markers, introgression of Asiatic resistance genes. Collaborations with Lithuania, Belgium, UK, France and Germany
Baiba Ievina and Kristine Paruma (VAAD, Latvia)	**National status of ash**: C0.4% of total forest area – studied ash **Policy history:** Monitored stand health since 2005. Survey in 2015 – 36 samples collected, 21 tested with molecular methods, 18 positive. Natural regeneration now occurring – 75% of 2-6 year old are healthy, 10% dead, less susceptible in mixed stands and dry sites

Willem Roelofs (Defra, UK)	**ADB history:** First UK detection in Feb 2012 in trade – confirmed much wider soon after. Huge media interest. **Policy history:** Initial response - import restrictions, expert panel, management plan (to slow rate of spread, develop resistance and resilience) and large scale R&D. Many knowledge gaps remain. Current and future policy objectives: maintain ash as part of landscape, manage the impact
Jon Stokes (Tree Council, UK)	**Research:** Considered the needs of local (municipal) managers - a process for managers to assess and respond (include replace) to the impact of ADB. Includes a guide for managers of when to act based on canopy cover
Daiva Burokienė (NRC, LT)	**ADB history**: Symptoms of dieback on common ash (*F. excelsior*) was first observed in 1995–1996 in Lithuania. The health of ash stands contunues decline. It is considered that the disease is in its chronic phase, Since the beginning of the decline sanitary fellings are applied. Damage assessment in natural forests and in field trials are performed (monitoring by now). **Research:** Resistance breeding for *F. excelsior* (working on genotypes from Lithuania and other Europe countries). Studies on virulence and genetic diversity of *H. fraxineus*; biological control of *H. fraxineus*.

2.4 Broad themes discussed

In responding to a tree pest or disease, responsible authorities and stakeholders need to go through a process of Awareness, Planning, Action and Recovery[1, 2]. These processes occur at different speeds and to different extents across different stakeholders. This may be due to resource availability and/or levels of interest in tree health. Stakeholders with a higher pre-existing interest in tree health and/or with more resource available for tree health issues are generally more willing and more able to prepare and respond to threats for example by producing and baseline data to scope the scale of the issue and to make the case for resources required to address the issue.

From the presentations, it was clear that the importance of ash is not equal across countries, with ash being a minor species in some countries and much more plentiful in others. Of the countries represented at the workshop, this percentage varied from less than 0.5% (e.g. Latvia and Estonia total forest area) to over 12% of British broadleaves. Differences in perceptions regarding the importance of ash were illustrated in the language used to describe the impacts of the decline in the ash populations. Environmental and cultural values were highlighted more by UK and Ireland delegates (with respect to their roles in the environment e.g. hedgerows and connectivity (GB), as well as linked to cultural activities such as hurling (Ireland)). The UK is also seeking to maintain ash in the landscape. There was limited discussion across all presentations of the possible landscape impacts, the effects on ecosystem services, or the requirements for local land managers to respond to ash dieback. Clearly, this does not mean that such impacts are not felt in these countries.

A number of key research themes emerged from the presentations. We consider these in relation to the framework from Stokes and Jones (2019) that highlights a cycle of Awareness, Planning, Action and Recovery:

- **Understanding the causal agent (Awareness)**: Decision makers need to be aware of the underlying biology of the threat of interest to be able to produce robust plans for policy responses. Considerable scientific research effort has been expended across Europe to understand the biology of the causal agent *Hymenoscyphus fraxineus*. This included (but is not limited to):
    - Understanding virulence of *Hymenoscyphus fraxineus, and* studies on the (infection) biology of *H. fraxineus (Austria)*
    - Developing molecular markers (Ireland)
    - Understanding virulence and genetic diversity of *H. fraxineus* and the biological control of *H. fraxineus* (Lithuania)
- **Spread (Awareness):** Knowledge of the area affected, and the rate of spread is also required to plan a response. Considerable research effort around Europe focused on the speed and spread of the disease within the individual countries. This work was undertaken to establish national timeframes, to understand when 'impacts' of the disease would be felt and planned for.
- **Impact (Awareness, Planning, Action and Recovery):** Response actions should reflect the potential impact of the threat. Impact assessments were continuing in a number of countries with the aims of: 1) monitoring continued spread and development and 2) identifying resistant/tolerant individuals. Other studies looked at the practices surrounding:
    - Health and safety impacts (UK), traffic safety (Germany)
    - Sanitation felling (Lithuania)
    - Alternative silvicultural management strategies including self-regeneration of ash trees following sanitation felling (Germany) and maintenance of high genetic variation to meet disease and other selection pressure (Norway)
    - The harvest of valuable timber before deterioration of wood quality (Germany)
    - The communities of fungi in declining ash trees; (Latvia)
    - Transfer of knowledge: provide information to practitioners, policy makers and the general public (Germany and the UK)

  However, there were very few examples of the scale of the expected impacts from which a commensurate response could be assessed.
- **Resistance and tolerance trials (Action and Recovery):** These are generally instigated after a threat materialises, often as the threat is known about and seen to be moving closer to the area of interest. Resistance and tolerance trials were often linked across the EU (and further) to consider, for example, the performance of locally adapted Fraxinus genotypes. These trials represent long term research efforts. Countries at an earlier stage of spread were interested in finding local tolerance in low disease pressure locations and to see if this translated to tolerance in high disease pressure locations. There was also considerable concern over whether the virulence and genetic diversity of *Hymenoscyphus fraxineus* would overcome the natural resistance variability of *Fraxinus*, especially if new introductions of *H. fraxineus* occured

from Asia. Studies around Europe focussed on different elements of resistance including:
    - Disease resistant ash planting stocks (Lithuania)
    - Tree genetics and breeding: selection and conservation of tolerant trees; resistance mechanisms and influencing factors; development of laboratory methods; breeding (Germany)
    - Enhancing resistance of ash trees through the harvest (Estonia)
    - Conservation and resistance breeding for *excelsior* and *angustifolia* (Austria)
- **Supply of tolerant germplasm (Recovery)**: This reflects the need for planning the actions and recovery phases, since the availability and acceptability of such germplasm will outline what recovery pathways are possible. Whilst there were discussions about the capacity to produce sufficient amounts of tolerant germplasm, there was no consideration of the demand for such material.
- **Other strategies:** Other strategies mentioned include:
    - Biological control of *H. fraxineus* was mentioned in presntations by two countrys (Germany, Estonia)
    - Maintenance of high genetic variation – for ADB and other selection pressures (Estonia and others)
    - Natural regeneration (Latvia)

The presentations focussed upon national-level longer term science projects relating to resistance and tolerance. The speed of onset of the disease and the provision of immediate solutions to end-users was not directly addressed. There was discussion of the need to be able to provide sufficient germplasm, but the rate of decline of local ash populations has meant that local decision makers need solutions at a faster rate than parts of the science is able to provide. There was little emphasis placed upon the solutions that science can provide more immediately to decision makers (e.g. those relating to silvicultural management responses). The presentations did not include the status of social science disciplines in the research. Social science may be expected to consider issues such as the adoption of any research into management practices, as well as more fundamental issues of what society wants its landscape to look like. UK social scientists were interested in the provision or supply of resistant/tolerant trees.

Given the high ash mortality due to Chalara, as well as other impending threats to ash (e.g. Emerald Ash Borer), the demand for ash in the future may be negatively impacted. Where there is uncertainty regarding the degree to which “future” ash is fully resistant, land managers might not be willing to take the risk, instead replacing lost ash with a wide range of species. As a result, the benefits of long-term efforts to produce resistant/tolerant ash depends not only on the scientific outputs of the research, but also on engagement with and understanding of local managers responsible for making decisions about managing and planting ash. It is likely that any restocking of ash will not recreate the historic abundance and distribution of ash and a worst-case scenario could see research producing tolerant ash material for which there is neither a market nor social acceptance.

2.5 Conclusions and recommendations for policy makers

The progress of ADB across Europe provides some interesting insights into the prioritisation, coordination and response to tree health threats at different scales (local, national and international). These insights are valuable lessons for the control of invasive alien species (IAS) more broadly. Ward's (2016) framework looks at a classic biological invasion approach with reactive decision makers and their lagged awareness. Stokes & Jones (2019) start from the perspective of local decision makers, acknowledging their limited resources and the need for increased Awareness in order to make suitable responses. Combining these two approaches highlights the need to minimise the lag at the local level, as actors complete the Awareness, Planning and Action stages, particularly early in an outbreak.

When considering IAS, most interested parties agree that it is better to attempt to prevent their introduction rather than react to them through eradication and control attempts. This because IAS, like the causative fungus of ash dieback, typically have a high reproduction rate. Consequently, once they become locally established and start spreading outside the area of introduction, their eradication is very challenging. Whilst these statements may appear self-evident, it is helpful to consider these within the Awareness, Planning and Action and Recovery framework. Early local eradication requires the Awareness, Planning and Action stages to be completed rapidly at the local level. Early, local interventions have the potential to reduce the total impact of a pest at the local, national and potentially international scales.

2.5.1: Prioritisation

Whilst an important component of forests and woodlands in Europe, ash comprises less than 1% of the total wooded area (Hemery, 2008). Regionally or locally it can occupy a much higher proportion in, for example, the United Kingdom, France, Germany and Austria. Thus, representatives from each country may view the issue differently, reflecting the local economic, social/cultural, and environmental importance. However, it should be possible to identify areas that are likely to have similar priorities, and which are therefore more interested in understanding the possibilities of response options that include resistant/tolerant varieties.

For any tree health threat, decision makers need to consider the physical impact of the pest/disease on the host and whether the costs these systems generate. ADB highlighted the need to consider if costs of a pest or disease fall disproportionately on one set or more sets of stakeholders. In the case of ADB, the health and safety implications (risk of falling branches or trees) emerged as the most significant cost and fell on a narrow group of stakeholders – local authorities, highways and homeowners. The decision making of these stakeholders must be understood. For example, for these stakeholders, tolerant trees need to be "tolerant enough" so that they are deemed sufficiently safe for the responsible risk manager in specific planting locations.

2.5.2: Coordination

Many countries have been undertaking work on resistance/tolerance of Fraxinus. This effort is often, but not always coordinated across Europe, and funding is beginning to decline. There is debate as to when/if this line of research will provide useful outcomes in the short/medium term. The search for disease tolerance/resistance is also likely to be an area of continued interest across many species and threats. It might therefore be useful to consider how such research could be prioritised across pests and diseases.

For research and action to be effective at the local, national and international scale, there needs to be an appropriate understanding of the potential damage that can be caused by an IAS. To achieve this, widespread and available assessments and information of the potential impacts of an IAS have to be available to the appropriate people[4]. The UK Plant Health Risk Register represents an attempt to collate and share such assessments. However, this information is generally available to researchers, and not available to local managers of trees. As a result, local managers may be unaware of any potential threat or suitable response.

2.5.3: Demand

The future demand for Chalara-resistant/tolerant species is currently unknown, and may be partially dependent upon other threats (such as emerald ash borer). The way that resistant/tolerant species are discovered may be perceived negatively and not viewed as socially acceptable (n.b. compare to perceptions of GMO's, particularly in Europe[5] . In this sense, uptake of resistant/tolerant germplasm may require some incentive for end-users, an area requiring further research.

There is considerable variability in the acceptability of resistant trees, depending upon how the tree has been produced - from those stakeholders who would only consider naturally selected trees to be the source of a replanting programme – to those who are prepared to embark on using trees with resistance which have been derived through cisgenetic and transgenetic manipulation. This public tolerance of the 'range of acceptability' should influence research programme development in future and the interplay between the social science and technical aspects of tree resistance should be more closely studied. This will allow researcher to asses if there ss a risk of the host species becoming perceived as a liability, rather than an asset, by landowners.

Tree species often face multiple pest and disease threats as well as other biotic and abiotic pressures. Thus, there are a number of traits to trade off when considering which species to plant. Identifying which traits and trade-offs should be studied and researched is a topic which needs closer consideration. Similarly, if acceptable resistant/tolerant trees are discovered, mass produced and widely planted in the landscape, the implications for the resilience of the new landscape need to be considered. These issues highlight the need for a degree of planning in the replanting of the new trees to ensure future problems are not being created.

2.5.2 Coordinating Planning and Action

According to the Awareness, Planning, Action and Recovery framework[1], local decision makers with responsibilities for the landscape need to be provided with the 'resources' and 'tools' to 1) become aware of the spread of an IAS, 2) to be alerted to the potential

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[4] For example, currently across western Europe, an IAS called *Favolaschia calocera (Orange Ping Pong Fungus) from Madagascar* is spreading in trees, now for example found in 6 sites in England (Field Mycology 16: 113 (2015)). Little is known about its potential impact of this IAS and national pest and disease portals like the UK's Plant Health Portal, having little bar the name of the organism

[5] Bonny, S. (2003). Why are most Europeans opposed to GMOs? Factors explaining rejection in France and Europe. Journal of Biotechnology Vol. 6 No. 1, Issue of April 15, 2003

consequences of the IAS and then to 3) to plan/action their responses (including the plan for post invasion recovery).

At the outset (or in advance of) of a damaging tree pest/disease incursion, for example, it seems reasonable to gain an understanding of which trees are resistant or tolerant and to understand the underpinning of this resistance or tolerance. In the future, this (often expensive) research may benefit from being fine-tuned by considering the following questions;

- What is the role and scale of the host species in providing benefits to society? If this varies across locations/ nations, how will the demand for a solution vary?
- What is the acceptability of resistant trees?
- What is the impact of the pest/disease on the reputation/perception of the host species?
- Where and on whom do the impacts fall?
- If acceptable resistant/tolerant trees are discovered, mass produced and widely planted in the landscape, what are the implications for the resilience of the new landscape?
- Which traits should research focus upon?

Thus, the objectives for research into pest and disease resistance/tolerance funded by the public purse should reflect those of wider society and not particular sectors (in the absence of market failure). The research should reflect what stakeholders need and provide it over the appropriate timescale.

Overall, the research landscape around Chalara seems to support a variant of the hypothesis put forward by Ward (2016)[2]: that measures to prevent or slow the spread of new pests are not implemented as quickly as they should be. An evaluation of the plant health regime in the European Union (EU) concluded that "*In emergency situations, the limited support and lengthy decision-making process results in measures being taken too slowly, too late*."[6] This begs the question as to the role of longer-term research programmes that obtain funding as the awareness and concern about the pest has peaked

[6] European Union. (2010). Evaluation of the community plant health regime. Food Chain Evaluation Consortium. https://ec.europa.eu/food/sites/food/files/plant/docs/ph_biosec_rules_final_report_eval_en.pdf. Accessed 2 Dec 2019

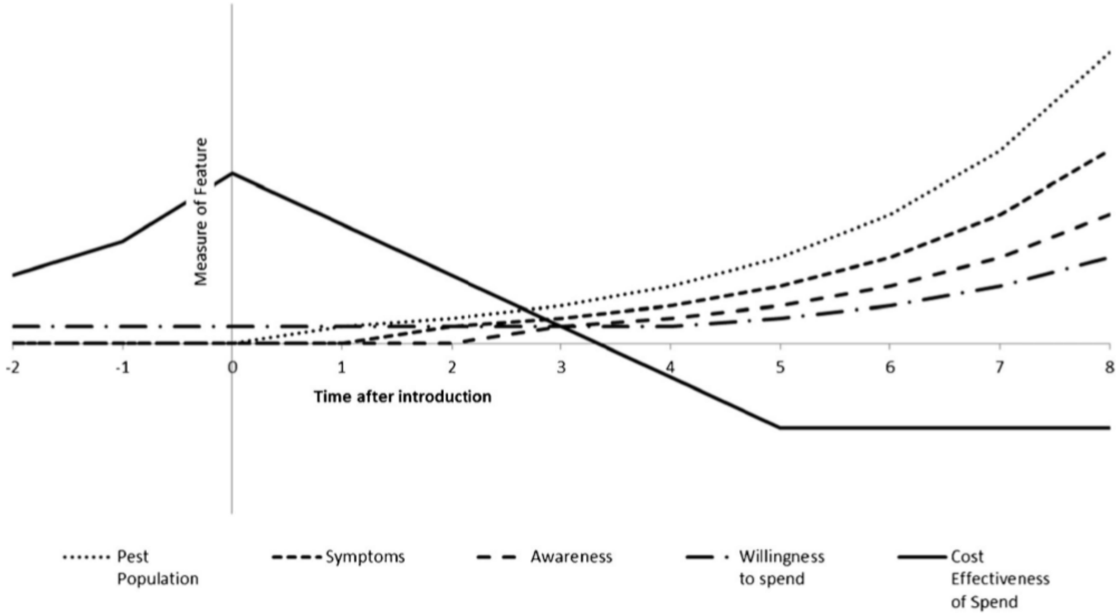


Figure 1: Typical features in a standard outbreak of a plant pest

Ward's view is expressed in Figure 1 that illustrates the time lags between pest population, symptoms, awareness and willingness to spend, alongside cost effectiveness of spend. Much of the country spending was initiated post domestic invasion. Many of the shorter-term science outputs (e.g. silviculture) can be rapidly deployed and longer-term resilience measures (e.g. enhance/maintain genetic diversity) can be deployed now to mitigate the impacts of future pest and disease.

Perhaps what is required a clearer picture of the strategic and tactical objectives of the research that reflects the different objectives at both a national level as well as at a local level. Considerations at a local level should account for those who implement the recommendations and outputs of the science and their experience of the Awareness, Planning, Action and Recovery process.

Forward looking collaboration between countries should also be encouraged so that research builds across Europe or between nations for current and future threats and not just for threats we are already trying to manage. For example, the work in EU countries on ADB should be of interest to the US and Canada, as the US lessons on Emerald Ash Borer are in the other direction. Although research collaboration already exists, it does not focus on timely sharing of information or the practical management of pests and diseases. Therefore, it would be worth establishing a European convening organisation such as a 'European Tree Council' that would allow researchers, local municipalities and non-governmental organisations to share concerns about pests and disease long before they reach the thresholds for serious landscape damage. Through this process, research could be prioritised and developed ahead of time, instead of being commissioned behind the 'disease front'.

From the social science perspective, questions around 'how to assess the characteristics of resistance/tolerance' need researching although they are difficult given that the "payback" is many years in the future. Whilst the benefit of maintaining the ecosystem services from trees, woodlands and forests are obvious and clear, these could also suffer from a lack of research funding as they are difficult to value in monetary terms. However, if we accept that the 'tree resource' is worth maintaining and improving, then allocating research resources to learning more about resistance/tolerance characteristics should take a long view and consider future large-scale pest and disease threats, now. It will also be vital to understand the importance of identifying and protecting tolerant trees in the wider environment – how can we incentivise landowners to leave healthy looking trees alone and/or collect genetic material from them?

2.6 Benefits from trans-national cooperation

The workshop attracted a much larger audience that initially anticipated as a result of the EUPHRESCO coordinator and Defra funding additional participants.

This project has shown that there is research, knowledge and expertise across Europe, but the information is often difficult to find from other countries and often does not benefit the wider plant health community[7]. National funders of plant health research should therefore take a more strategic national and transnational approach to plant health research, as promoted by Euphresco. Research should aim to identify risks before they become a problem and provide decision makers at national and local level with the information needed to undertake practical and effective disease/ pest reductions. Thus, the flow of information to decision makers is not just horizontally between national level organisations, but also vertically to ensure that lessons from science can be rapidly translated into tools for timely and consistent local implementation. It is not clear if at present such routes to implementation at local scales is optimal.

The thinking expressed above is therefore being translated into a COST Action application as well as an H2020 bid. That is, the consortia will think about preparedness for a system given multiple threats. Thus, this needs to include the social science part of the analysis – how do we move from a mostly reactive system to a more pro-active one? This project will consider the requirements of coordinating surveillance activities across scales: provide guidance to local managers and a reporting framework so that everyone is using the same approach and they can learn from each other around Health & Safety threats, diseases progression, environmental factors, etc.

On the UK side, this project has developed close links with the EUPHRESCO Prepsys team (some of whom will also participate in the H2020 bid discussed above). The Chalara workshop attendees have expressed the desire to create a paper out of the conclusions presented above and in addition we are in discussion with the Prepsys leader to consider a joint paper on lessons learned across Chalara and Emerald Ash Borer.

[7] Giovanni, B. et al (2016). The Gold Mine of Nationally funded Project. Universal Journal of Agricultural Research 4(5): 198-203, 2016 http://www.hrpub.org/download/20160930/UJAR5-10407286.pdf

3. Publications

3.1. Article(s) for publication in the EPPO Bulletin

None.

3.2. Article for publication in the EPPO Reporting Service

None.

3.3. Article(s) for publication in other journals

None.

4. Open Euphresco data

None.

Appendix 1: Attendance list

	First Name	Surname	Institute
1	Anne-Marie	Dillon	DAFM, Ireland
2	Barry	Delany	DAFM, Ireland
3	Cathal	Ryan	DAFM, Ireland
4	Tom	McDonald	DAFM, Ireland
5	Louise	Farrell	DAFM, Ireland
6	Rachel	Wisdom	DAFM, Ireland
7	Marialaura	Destefanis	DAFM, Ireland
8	Eamon	Nolan	DAFM, Ireland
9	Sinéad	Kelly	DAFM, Ireland
10	Richard	O'Hanlon	AFBI, Northern Ireland
11	Ari	Hietala	NIBIO, Norway
12	Jon	Stokes	Tree Council, United Kingdom
13	Willem	Roelofs	DEFRA, United Kingdom
14	Rasmus	Enderle	JKI, Germany
15	Clovis	Douanla-Meli	JKI, Germany
16	Kristine	Paruma	NPL, Latvia
17	Baiba	Ievina	NPL VAAD, Latvia
18	Lucio	Montecchio	UNIPD, Italy
19	Daiva	Burokienė	NRC, Lithuania
20	Rimvys	Vasaitis	SLU, Sweden
21	Thomas	Kirisits	BOKU, Austria
22	Kalev	Adamson	EMU, Estonia
23	Rein	Drenkhan	EMU, Estonia
24	Rebecca	Mcilhiney	DEFRA, United Kingdom
25	Laura	Stevens	DEFRA, United Kingdom
26	Miguel	Nemesio Gorriz	Teagasc, Ireland
27	Gerry	Douglas	Teagasc, Ireland
28	Glyn	Jones	Fera Science, United Kingdom
29	Sheila	Nolan	DAFM, Ireland

Workshop Agenda
Day 1: Monday 26th February, DAFM Backweston

12:30 Meet/Greet and lunch
13:30 Outline of the project – Glyn Jones
Welcome to Ireland – Sheila Nolan
13:45 Introductions and science presentations

14:00-14:20	Thomas Kirisits (BOKU, Austria)
14:25-14:45	Lucio Montecchio (UNIPD, Italy)
14:50-15:10	Rasmus Enderle (JKI, Germany)
15:15-15:35	Rimvydas Vasaitis (SLU, Sweden)
15:40-16:00	Ari Hietala (NIBIO, Finland)

Fifteen-minute break	
16:15-16:35	Rein Drenkhan and Kalev Adamson (EMU, Estonia)
16:40-17:00	Gerry Douglas (TEAGASC, Ireland)
17:05-17:25	Baiba Ievina and Kristine Paruma (VAAD, Latvia)

17:30 Discussions and key points

Day 2: Tuesday 27th February

08:30 View from Government and practitioner
09:30 Discussion on key research areas including prioritisation/justification
10:30 Coffee
11:00 Outputs: Reporting requirements, who will provide what, ideas for joint papers/dissemination
12:30 Lunch
13:45 End of meeting

Appendix 2: Workshop presentation abstracts

Cathal Ryan (DAFM, Ireland)

Forest cover in Ireland is approximately 731,650ha or 10.5% (National Forest Inventory data 2012). 20610ha or 3.2% of stocked forest area is ash. *Fraxinus excelsior* is the only indigenous species of ash in Ireland. Ash was a significant component of the Forest Service grant aided planting programme until the finding of *H. fraxineus* but its planting is no longer grant aided. Ash is an important component of Irish native woodlands and one of our most common hedgerow trees and is significant economically, environmentally and culturally. Ash wood is in demand to produce hurley sticks for our national sport. The ash resource in Irish forests is largely in young, even aged, monocultural plantations.

Forest Service, Department of Agriculture, Food and the Marine (DAFM) is the regulatory authority for forestry in Ireland. DAFM is the National Plant Protection Organisation and the Forest Service is responsible for the forestry aspects of the Plant Health Directive (EU Council Directive 2000/29/EC). The NPPO has a number of obligations under the EU Plant Health Regime. These include import controls and eradication measures where required.

Ireland's forest health status overall is very good, being recognised at EU level as a Protected Zone (PZ) for 13 forestry harmful organisms. Annual official surveys are carried out for these PZ pests and other regulated and non-regulated pests.

The first finding of ash dieback disease was in October 2012 at an afforestation site in Co. Leitrim. The finding was associated with plants imported from continental Europe in 2009. DAFM introduced national legislation in November 2012 (SI No. 431 of 2012) restricting movement of ash applying to plants, seeds and wood. All initial findings were associated with imported plants. A policy of eradication was adopted by DAFM and by DAERA (the plant health authorities in Northern Ireland) on the island of Ireland and an All Ireland Chalara Control Strategy was published in 2013.

The first wider environment findings were in autumn 2013 in hedgerow trees in close proximity to cleared infected sites. A marked increase in the incidence of the disease was observed in 2016 and 2017.

Current policy aims to reduce the potential impact of the disease on the island as a whole. DAFM continues close collaboration with DAERA Northern Ireland. A review of 2013 All Ireland Chalara Control Strategy is being carried out.

Research has an important place in DAFM's response to Chalara. DAFM has funded projects on breeding for resistance and modelling the spread of ash dieback in Ireland. DAFM has also part funded early mass screening trials in UK by Forest Research which included 14000 Irish ash trees.

DAFM is conscious of new threats to ash notably *Agrilus planipennis*. Specific surveys for *A. planipennis* will be carried out in 2018 and pest specific contingency plans will be developed under the incoming Plant Health Regulation (2016/2031). The new regulation also requires increased stakeholder engagement and consultation and takes a more risk-based approach with a focus on contingency planning. DAFM will increase the profile of and encourage greater stakeholder and general public engagement in plant health ahead of the International Year of Plant Health in 2020.

Rasmus Enderle (JKI, Germany)

F. excelsior, which is the only ash species of relevance in German forests, accounts for 2.4 % (about 250.000 ha) of the total forest area of Germany. According to present knowledge, ash dieback reached Germany in 2000. In 2002, symptoms were observed and documented in three different north-eastern federal states. In 2006, symptoms were present in south-eastern and south-western Germany. By 2009, the pathogen was present throughout the country. Trade and transportation of ash plant material was not restricted and undoubtedly contributed to the fast spread of the pathogen within Germany.

Despite of various scattered, independent monitoring plots, there is no data of the severity of ash dieback that is representative for whole Germany. The most comprehensive data is available from south-western Germany, where about 40 % of trees (DBH > 7 cm) were strongly defoliated, 24 % were infected at the root collar and 14 % were in sound condition in 2015. Between 2012 and 2015, 11 % of ash trees either were harvested or died in this region.

In 2008, first German forest research institutes officially advised against the planting of ash trees. The serious magnitude of this new epidemic was perceived by many in 2009, when forest authorities were informed intensively about the pathogen and the symptoms. At this time, various monitoring plots were established independently from each other by different research organisations. Any discussions about the containment of the fungus where silenced by the presumed identification of the teleomorph as a long-know native leaf decomposer. Triggered by the Danish paper about the presence of genetic resistance in some ash trees in 2011, forest owners were advised not to cut healthy trees. A nationwide compilation of recommendations for the management of the disease was published in 2013. These strategies focused mainly on traffic safety, preservation of tolerant trees and the harvest of valuable timber before deterioration of wood quality. These main aims of ash dieback management formed the foundation for more sophisticated concepts, but generally remain valid until today. However, the forest law has not been changed for ash dieback. Some forest owners apparently tend to eliminate the problem of ash dieback by "eliminating ash".

In spring 2018, FNR (Agency for Renewable Recourses, commissioned by the Federal Ministry of Food and Agriculture) initiated a coordination group of experts of different disciplines and launched a call for R&D funding in order to foster ash dieback research and management in Germany on a federal level. In this scope, a large joint project is planned, which is divided into the following five aspects:

- Monitoring: implementation of a harmonized monitoring on the federal level
- Tree genetics and breeding: selection and conservation of tolerant trees; resistance mechanisms and influencing factors; development of laboratory methods; breeding
- Phytopathology and forest protection: investigation of the pathogen and its control including associated organisms
- Silviculture: management of ash dieback and assessments of risks and implications
- Transfer of knowledge: provide information to practitioners, policy makers and the general public

Rein Drenkhan and Kalev Adamson (EMU, Estonia)

Fraxinus excelsior covers 0.33% (7630 ha) of the total forested area (2.31 milj ha), but ash volume in the total volume of tree species is around 1% (Raudsaar et al. 2014). The first record of *H. fraxineus* in Estonia dates back to 1997 and the pathogen was documented from herbarium (TAAM) specimen (petioles with ascocarps) (Drenkhan et al. 2016). In spite of that, symptoms based of ash dieback observations on ashes were not detected until 2003 in NW Estonia. The movement of disease was documented NW to SE directional in Estonia. During the surveys of fresh and herbarium specimens of ashes, *H. albidus* was not detected with molecular investigations in Estonia, all found ascocarps were turned to be *H. fraxineus.* In Estonia *Fraxinus excelsior* is damaged on different age classes.

During 6 years (2010-2015) of the research work on the dynamics of pathogen fruiting bodies, the earliest ascocarps of *H. fraxineus* on ash petioles have been found on 5th of June and the latest ones on the 20th of September. Highest number of ascocarps per fallen petiole can be found from the end of July to the end of August, but it depends on weather conditions, temperature and precipitates. In the climate conditions of southern Estonia, the ascocarps of *H. fraxineus* could be found on petioles of European ash during 81 – 85 days per year (Drenkhan et al. 2017a).

In Estonia ash dieback (caused by *H. fraxineus*) was detected on six different ash species: *F. excelsior, F. nigra, F. pennsylvanica, F. americana, F. mandshurica* and *F. sogdiana*. *Fraxinus nigra* trees are most heavily affected with symptoms including wilting of leaves, dieback and necrotic lesions of shoots and twigs, and death of canopy. Similarly, situation is with native *Fraxinus excelsior* (Drenkhan and Hanso 2010; Drenkhan et al. 2017a).

In 2013 and 2015 were assessed ash trees in forest conditions. Three sampling sites were measured on the transect from west coast of Estonia to the eastern border. Worst health of mature European ash was estimated in the westernmost monitoring site, where the percentage of healthy trees was only 11% of the total number of estimated trees (N=118). At central and eastern monitoring site the percentage of mature healthy trees in 2013 and 2015 was similarly and constantly 22%. The higher numbers of healthy naturally regenerated European ash saplings (58%) was registered in the easternmost side of Estonia, compared to the central (40%) and western (44%) monitoring site. Additionally, were analysed health condition of natural regeneration on clear-cuts (N=52, sampling sites) and shelter wood (N=40) sampling sites. The number of diseased saplings was 19% higher in understory sites compared to clear-cut areas, P<0.05 (Drenkhan et al. 2017a).

Another study about retention ash trees on clear-cut areas was carried out. The survival and vitality of European ash retention trees (altogether 577 trees) was monitored on 41 clear-cut areas. Study revealed that crowns of retention ash trees in the pre-cut edges (near fields, roads, forest rides) of clear-cuts were less damaged. Which means that trees growing near to the open edges are already acclimated to better light conditions, their vitality and hence resistance to *H. fraxineus* after clear-cut is apparently higher (Rosendvald et al. 2015). During the same study the infection of *Armillaria* spp. was also documented by molecular methods of randomly chosen wood samples of 102 trees. 28 trees out of 102 were infected by *Armillaria* spp. Although, it could be assumed that trees with more damaged crowns are more likely sensitive to *Armillaria* infection, in this study, the damage of crowns seemed not to be related to damage of roots (Rosenvald et al. 2015). The ashes near open areas (including roads, forest rides and ditches) and with long crowns (which indicates the light acclimation) seems to be potentially more resistant (Rosenvald et al. 2015). Although in the nature the genetically resistant ash trees are quite rare, ca 5% from all ashes (Rosenvald et al. 2015)

Two experimental stands of *Fraxinus* spp. were planted in Järvselja (SW Estonia) in spring of 2017. Both experimental areas are ca 1 ha, totally 2 ha. More than 4000 seedlings have been germinated from collected seeds, while 50% of the seeds were originated from visually diseased mother trees and 50% visually healthy looking mother ashes. Seed were collected from 5 provenances across Estonia. Additionally, were used seed of *F. pennsylvanica, F. chinenses, F. mandshurica* and some of seeds originated from Russian Far East, where *H. fraxineus* is thought to be native. This experiment is good base for future research and international cooperation.

At the moment, there is no single solution to ash dieback disease. However, some tools can help to mitigate the development of the disease, and improve conditions for ash trees to exist in the future. We point out four of them:

1) Genetic resistance. The apparently most perspective solution against ash dieback seems to be introducing genetically resistant trees. Although in the nature the genetically resistant ash trees are quite rare (ca 5% from all ashes); those trees can be a source for the creation of new resistant generations for the future. Hence, in case of clear-cutting, visually healthy ash trees must be retained as retention trees (Rosenvald et al. 2015).

2) Enhancing resistance of ash trees through the harvest. Less competition and favourable conditions (enough light, nutrients and water) enhances the vitality of ash trees. Favourable growth conditions enhance the survival potential of genetically resistant ash trees but also trees with medium resistance to ash dieback (the resistance to *H. fraxineus* is not absolute). Ash retention trees near open areas (including roads, forest rides and ditches), but also the trees having long crowns (which indicates the light acclimation) are potentially more resistant. Visually healthy trees should be retained by selection cutting and thinning practice, but the effectiveness of this action for promoting the long-term vitality of trees needs more studies (Bakys et al. 2013, Rosenvald et al. 2015).

3) Specific plant protection methods. One, although still theoretical perspective is the biological control of *H. fraxineus* by the use of mycoviruses (Schoebel et al. 2014) or other microorganisms. From chemical treatments, the use of urea prevents apothecium formation on collapsed ash leaf petioles, and thus prevents the spread of the pathogen (Hauptmann 2015). The use of fungicides (Dal Maso et al. 2014) and heat treating of ash seedlings (Hauptman et al. 2013) slows down the development of *H. fraxineus*, although it is not applicable in practical large-scale forest management in Estonia.

4) Import *Fraxinus* spp. seedlings. Inspection of imported ash seedlings to avoid the introduction of new pathogen lineages and subsequent formation of genetically new virulent strains of *H. fraxineus*.

Daiva Burokienė (NRC, Lithuania)

The total forest land area is 33.5 % in Lithuania (by the data of Lithuanian Statistical Yearbook of Forestry, 2017). Common ash (*Fraxinus excelsior*) is the only naturally growing ash species in our country.

Ash dieback was first observed in 1995–1996 in Lithuania. Currently, a large part of the native distribution area of *F. excelsior* is affected by this potentially lethal disease. Over 20 years this disease affected forest stands, seed plantations, clonal archives, profeny trials, forest nurseries. Thus, it is considered that the ash dieback is in its chronic phase. Since mid 90s the forest stand of *F. excelsior* decreased from 2.7 % [in 1995–1996] to 0.9 % in 2017. Howerver, the remaining ash trees are dying out every year – approx. 9 % [in permanent forest monitoring plots].

The current research projects in Lithuania. Lithuanian researchers are working on research projects related to ash dieback and tree breeding [in areas of forestry and phytopathology]:

- self-regeneration of ash trees following sanitary clear fellings in dieback-affected ash stands;
- disease resistant ash planting stocks;
- research on genetic variation of trees (population, progeny, clonal trials) and their response and plasticity under climatic change and other environmental stressors;
- studies on communities of fungi in declining ash trees;
- studies into genetic diversity, population structure, virulence of the causal disease and biological control of this pathogen;

In practice, there were no effective control measures have been offered till our days. General forestry recommendations for management (Lithuanian Rules on Forest Fellings, 2015) are to perform sanitary clear-fellings if stocking level gets lower than 40 % [after felling dead and severely damaged trees]. And re-establishment of ash is not recommended due to a high risk of infections of this fungal pathogen.

Priorities for future needs:

- critically important – forest monitoring and proper stand management strategies should be estimated;
- studies on forest regeneration potential;
- breeding/genetic diversity of resistant ash trees and genetic markers for resistance against causal agent of ash dieback.

Jon Stokes (Tree Council, United Kingdom)

Ash Dieback is the most significant tree disease to affect the UK since Dutch Elm Disease. It has the potential to destroy over 2 billion ash trees[8] (from 1.6 billon saplings and seedlings to over 150 million mature trees).

Ash Dieback will lead to significant changes to the British landscape, tree populations, changes to biodiversity, landscape character and potentially increase effects such as flooding.

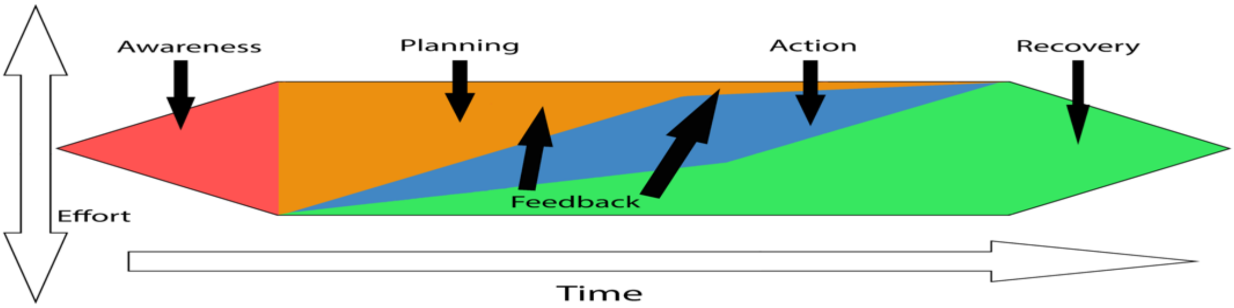
Across the UK the national cost of removing trees with Ash Dieback is difficult to calculate but the health and safety implications of affected roadside trees will require significant investment – for example, Kent County Council (KCC) have estimated the cost of managing the decline of ash on Kent's roads could eventually total as much as £400 million.

Dealing with the scale of health and safety risks caused by Ash Dieback alone will mean that it will not be 'business as usual' for any organisation managing ash trees.

Tree failures could translate into an increase in the number of people harmed by trees and a potential increase in property claims. Organisations, particularly Local Authorities, will need to review and, where necessary, make changes to tree safety management regimes and practices as well as dealing with all the other issues that Ash Dieback could bring.

In the UK, work undertaken in 2014 by The Tree Council as part of the Future Proofing Plant Health Programme, identified that '*Local Action Plans should be developed and implemented by agencies dealing with Ash Dieback*'. This recommendation was based upon discussions with Local Authorities who felt unprepared for the impacts of Ash Dieback. It is also based on research by FERA on the management of Dutch Elm disease, which caused the loss of 30 million trees.

[8] See page 13 http://sciencesearch.defra.gov.uk/Document.aspx?Document=13337_ChalarainNonWoodlandSituationFinal.pdf



Since 2014 The Tree Council and Fera have identified the four key parts of response to a potential or current tree pest /disease. It is based upon the widely used protocols of Emergency Planners and was the basis of the Kent response to Ash Dieback.Figure 2: Phases of Local Authority management of a tree pest/disease

The elements in this model are:

- Raising awareness of Ash Dieback and the issues it may cause - Awareness/Anticipation: Learning about Ash Dieback and realising that work needs to be undertaken to understand and deal with the problem;
- Preparing the Ash Dieback Plan - Planning/Assessment: Preparing and developing a plan to help moderate or manage the problems caused by the Ash Dieback;
- Action/Response to Ash Dieback: Undertaking actions (e.g. felling trees) to remedy the problems faced because of Ash Dieback;
- Adaptation and Recovery from Ash Dieback: Landscape restoration in the wake of Ash Dieback, an essential element of any emergency process;

Using these 4 elements, a Toolkit has been developed that will allow local authorities and other organisations to plan for the impacts of Ash Dieback and develop an Ash Dieback Action Plan (ADAP). The Ash Dieback Toolkit aims to:

- provide information to improve understanding of the implications of Ash Dieback;
- provide a local/regional framework for preparing an ADAP;
- work at the county level (but be adaptable to any scale);
- focus around the ‘tactical’ issues that an organisation may face but incorporates the need to deal with the ‘strategic’ impact of tree pest and disease on the wider treescape;

Currently the UK’s understanding of the best approaches for dealing with Ash Dieback is still in its infancy. As a consequence, the Toolkit will be updated and expanded over time. In parallel, work is underway to explore whether elements of the processes for dealing with Ash Dieback are transferable to other pests and diseases, with the aim of providing a single system for local authorities and other agencies to deal with any pest or disease.