Department for Environment, Food and Rural Affairs

Tree Health Management Plan

Research Synopsis

April 2014

Contents

Research Synopsis: Chalara

Key facts on Chalara

- Chalara dieback of ash is a disease caused by the fungus *Chalara fraxinea* [1]. The disease causes loss of leaves, dieback of the crown of the tree, and usually leads to tree death.[2] *(CR High)*
- *Chalara fraxinea* has infected many species of ash, but with differing intensities[3]. *(CR High)*
- Common ash (*Fraxinus excelsior*) is the most severely affected species and is the only native species of ash in the UK. Young trees are particularly vulnerable to *Chalara fraxinea* and succumb to disease rapidly.[4] *(CR High)*
- There is no evidence that *Chalara fraxinea* can spread to tree species other than ash or that it is harmful to the health of people or animals. *(CR High)*
- Infection is via air-borne spores produced from fruit bodies on leaf litter. The fruit bodies occur on infected fallen leaves and shoot material in the growing season after infection; trees are likely to need a high dose of spores to become infected.[5] *(CR High)*
- *Chalara fraxinea* infection starts primarily on leaves and is progressive over time with dieback and stem lesions usually manifesting in the next growing season. Leaf symptoms can be detected within two months of infection (experience from Denmark). *(CR Medium).*
- Natural spread is by wind-blown spores (ascospores) from the fruiting bodies.[6] Spread can also occur via the movement of infected material through trade. *(CR High)*
- The impact of *Chalara fraxinea* infection depends on tree age, provenance or genotype, location, weather and microclimate conditions, and presence of honey fungus (*Armillaria)* or opportunistic secondary pathogens. Trees in forests are likely to be more affected because of the greater prevalence of honey fungus and favourable microclimates for

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[1] Kowalski T (2006). *Chalara fraxinea* sp. nov. associated with dieback of ash (*Fraxinus excelsior*) in Poland. Forest Pathology 36, 264-270.

[2] Kowalski T and Holdenrieder O (2009). Pathogenicity of *Chalara fraxinea*. Forest Pathology 39, 1–7.

[3] Forest Research (2012). *Rapid assessment of the need for a detailed Pest Risk Analysis for Chalara* fraxinea

[4] Kowalski T (2006). *Chalara fraxinea* sp. nov. associated with dieback of ash (*Fraxinus excelsior*) in Poland. Forest Pathology 36, 264-270 Forest Research (2012). Rapid assessment of the need for a detailed Pest Risk Analysis for *Chalara fraxinea*

[5] Timmermann V, Børja I, Hietaka AM, Kirisits T and Solheim H (2011). Ash dieback: pathogen spread and diurnal patterns of ascospore dispersal, with special emphasis on Norway. EPPO Bulletin, 41: 14-20. doi: 10.1111/j.1365-2338.2010.02429.x

[6] (Kowalski T (2006). *Chalara fraxinea* sp. nov. associated with dieback of ash (*Fraxinus excelsior*) in Poland. Forest Pathology 36, 264-270. Kirisits T and Cech TL (2009). Zurücksterben der Esche in Österreich: Ursachen, Verlauf, Auswirkungen und mögliche Forstschutz- und Erhaltungsmaßnahmen. Kowalski T and Holdenrieder O (2008). A new fungal disease of ash in Europe. Schweiz. Z. Forstwes 159, 45–50. Queloz V, Grünig CR, Berndt R, Kowalski T, Sieber TN and Holdenrieder O (2010). Cryptic speciation in *Hymenoscyphus albidus*. Forest Pathology. doi: 10.1111/j.1439-0329.2010.00645.x.

Chalara spore production and infection. Trees cannot recover from infection, but larger trees can survive infection for a considerable time and some might not die. *(CR Medium)*

- 1058 species have been identified as having all or part of their lifecycle associated with ash woodlands in the UK, for example as a habitat, food source or hunting ground. Of these 45 are only recorded on ash and are considered obligate, a further 62 are highly associated but have also been recorded on other species. *(CR Medium)* [7,8]
- No single tree species will be able to fill the niche provided by ash trees in terms of both its ecosystem characteristics (e.g. nutrient cycling and light penetration properties that influence other ground cover) and biodiversity contribution. The most appropriate strategy for managing the biodiversity impacts of ash dieback will vary from site to site. *(CR Medium)*

Key evidence questions Defra-funded research is seeking to address

The current research programme is made up of a suite of research projects to:

- Identify and exploit resistance (tolerance) for longer-term adaptation and resilience
- Identify potential disease management approaches (including chemical treatments and sources of resistance in ash)
- Improve the understanding of the pathogen (including spread)
- Understand the potential ecological impacts of chalara in woodlands, and how this might help in developing woodland management and monitoring strategies to adapt to the disease

Insights emerging from research[9]

- Epidemiological models have been used to summarise our current understanding of the progression of the Chalara outbreak in GB. As limited information is available on the biology of the disease, spore dispersal and the infection process, model results are subject to uncertainty. Model outputs indicate that the pathogen is likely to continue to spread in GB although there is potential regional variation with areas in the South East,

[7] Mitchell, R.J., Bailey, S., Beaton, J.K., Bellamy, P.E., Brooker, R.W., Broome, A., Chetcuti, J., Eaton, S., Ellis, C.J., Farren, J., Gimona, A., Goldberg, E., Hall, J., Harmer, R., Hester, A.J., Hewison, R.L., Hodgetts, N.G., Hooper, R.J., Howe, L., Iason, G.R., Kerr, G., Littlewood, N.A., Morgan, V., Newey, S., Potts, J.M., Pozsgai, G., Ray, D., Sim, D.A., Stockan, J.A., Taylor, A.F.S. & Woodward, S. 2014. The potential ecological impact of ash dieback in the UK.

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[8] Mitchell, R.J., Broome, A., Harmer, R., Beaton, J.K., Bellamy, P.E., Brooker, R.W., Duncan, R., Ellis, C.J., Hester, A.J., Hodgetts, N.G., Iason, G.R., Littlewood, N.A., Mackinnon, M. Pakeman, R., Pozsgai, G., Ramsey, S., Reich, D., Stockan, J.A., Taylor, A.F.S. and Woodward, S. (2014) Assessing and addressing the impacts of ash dieback on UK woodlands and trees of conservation importance (Phase 2). Natural England Report. Natural England. Peterborough, UK.

[9] Please note this section summaries insights emerging from current projects. These projects are forthcoming and findings have not been peer reviewed. Finding may be subject to change and therefore some caution should be applied when drawing any conclusions from this section.

East and South West most likely to be affected.

- It does not appear that the UK climate will restrict the spread of Chalara. For example, laboratory tests indicate that the pathogen will be suited to the UK climate in terms of temperature (growth is optimal between 15-20ºC) and moisture (e.g. rainfall and humidity). In 2013 spore release was recorded at a number of sites in the expected period between June and September[10].
- The Chalara pathogen has been tested for sensitivity to 17 chemical pesticides. Preliminary results indicate Chalara is sensitive to a number of chemical pesticides under laboratory conditions. Further research will test treatments under field conditions. In addition, further evidence is needed on whether treatments can form part of a practical, cost-effective and sustainable management strategy in some situations (e.g. high-value individual trees).[11]

Evidence gaps that will be addressed by on-going and future research

- Improved understanding of the pathogen's biology is important to improving models of pathogen spread and severity and develop sustainable and practical management strategies.
- Research to produce genetic maps of the pathogen and ash trees is underway. The maps will allow identification and breeding of resistant or tolerant ash trees and, where appropriate, improve detection techniques.[12]
- Ash saplings have been planted in areas with a high risk of infection to identify trees with resistance or tolerance to the disease. Ash seeds have been collected from a number of locations across the UK to be used in future screening and breeding programmes. [13]
- Standardised techniques for producing infection in the laboratory are being developed. This will allow disease development to be assessed under controlled conditions. This will be essential for identifying genetic markers for host resistance for use in breeding programmes. [14]

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[10] TH0119: Mitigation of impacts of on ash dieback in the UK – an investigation of the epidemiology and pathogenicity of Hymenoscyphus pseudoalbidus (anamorph: Chalara fraxinea) and development of methods for detection and containment of disease spread

[11] TH0119: Mitigation of impacts of on ash dieback in the UK – an investigation of the epidemiology and pathogenicity of Hymenoscyphus pseudoalbidus (anamorph: Chalara fraxinea) and development of methods for detection and containment of disease spread

[12] NORNEX: Chalara Resistant Ash Genome Project

[13] Th0133: Screening and breeding of common ash, Fraxinus excelsior, for resistance to Chalara fraxinae (Earth Trust) , TH0132: Rapid screening for Chalara resistance using ash trees currently in commercial nurseries

[14] TH0119: Mitigation of impacts of on ash dieback in the UK – an investigation of the epidemiology and pathogenicity of Hymenoscyphus pseudoalbidus (anamorph: Chalara fraxinea) and development of methods for detection and containment of disease spread

Research Synopsis: *Phytophthora ramorum* and *Phytophthora kernoviae*

Key facts on *Phytophthora ramorum* and *Phytophthora kernoviae*

- *Phytophthora ramorum* and *Phytophthora kernoviae* are non-native fungus-like organisms that cause diseases on a wide range of trees and shrubs in UK woodlands, heathlands and managed gardens. (CR *High)* [15]
- Host tree species include sweet chestnut, beech and oak while shrubs in the wider environment include *Vaccinium* species (e.g. bilberry) and *Rhododendron ponticum*, as well as many ornamental plant genera (e.g. in nurseries, historic gardens). (CR *High)* [16][17][20] *P. ramorum* has a wider host range than *P. kernoviae*[20]. *(*CR *High)*
- *P. ramorum* affected few trees in the UK until 2009, when it was found infecting and killing large numbers of Japanese larch trees in South West England. In 2010 it was found on Japanese larch in Wales, Northern Ireland and the Republic of Ireland, and 2011 in western Scotland. European larch and hybrid larch are also affected. (CR *High)* [18]
- Disease symptoms include leaf necrosis, shoot dieback and bleeding cankers depending on the host species.[19] *P. ramorum* is known to lead to the death of larch trees. (CR *High)*
- The pathogens produce asexual 'spores' in sporangia which are involved in pathogen dispersal. Spores are produced on leaves of susceptible hosts and can be spread from leaf to leaf and plant to plant via rain-splash, wind-driven rain, mist, irrigation or possibly in surface water. Infection occurs through wounds or natural openings. *P. ramorum* also produces chlamydospores which are involved in survival. Long distance spread occurs by movement of infected plant material and associated growing media, in soil carried on vehicles, machinery, footwear or on animals, and potentially through contaminated growing media or mulches. (CR *High)* [15]
- Spread is primarily managed by (i) control of traded plants that can be hosts for either *P. ramorum* or *P. kernoviae* and (ii) surveillance to detect infected plants followed by eradication and/or containment action.

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[15] Van Poucke *et al.* (2012) Discovery of a fourth evolutionary lineage of *Phytophthora ramorum*: EU2. Fungal Biology 116, 1178 – 1191.

[16] Brasier *et al.* (2004) Sudden oak death (*Phytophthora ramorum*) discovered on trees in Europe. Mycological Research 109: 1-7.

[17] EPPO Bulletin (2013) 43 (1) 81-93.

[18] Webber *et al.* (2010) Dieback and mortality of plantation Japanese larch (*Larix kaempferi*) associated with infection by *Phytophthora ramorum*. New Disease Reports 22: 19.

[19] Very well documented in various public documents, especially Pest Risk Analyses and Data Sheets, and the technical review of the Phytophthora Programme.

Key evidence questions Defra-funded research is seeking to address

- A 5-year Phytophthora Research Programme from 2009 to 2013 has enhanced knowledge and understanding of *P. ramorum* and *P. kernoviae* alongside a wider programme of disease management and stakeholder and public engagement work (including understanding behaviour change).
- All the research broadly supports disease management, especially by improving:
    - epidemiological and biological understanding (including host range and susceptibility, growth, infection, sporulation, survival and spread) and associated impacts of the pathogens and of management actions
    - monitoring, surveillance and detection methods
    - disease management tools, methods and approaches
- A key evidence question is whether *P. ramorum* and *P. kernoviae* need to be managed differently, and whether different environments need different approaches.

Insights emerging from Defra-funded research[20]

- Models using data from epidemiological research have been applied to host maps to inform our current understanding of the progression of the *P. ramorum* outbreak in GB and likely impact of management options. Model outputs indicate that the spread of *P. ramorum* will continue, although there is likely to be regional variation due to location of current outbreaks, climatic suitability and host presence, type and density.
- *P. ramorum* is more serious than *P. kernoviae* due to its wider host range, the scale of impacts on tree species (mainly larch), its greater persistence and wider potential distribution.
- Current differences in the biology, rate of spread and range of host plants susceptible to *P. ramorum* and *P. kernoviae,* suggest that the pathogens should be managed differently.
- Host species differ in their potential to support pathogen sporulation and hence drive disease spread and this may influence priorities for management action.
- It will continue to be important to keep out new lineages of *P. ramorum*, but it may to be difficult to differentially manage those already arrived in the UK.
- The best times and approaches for surveillance and management action can vary with pathogen, host, environment, site and region.[21]
- Through research, best management practices have been developed for controlling both pathogens, including cultural, physical and chemical methods depending on environment and substrate.[22]

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[20] Please note this section summaries insights emerging from current projects. These projects are forthcoming and findings have not been peer reviewed. Finding may be subject to change and therefore some caution should be applied when drawing any conclusions from this section.

[21] Project reports from PH0601, PH0602 and PH0603 – forthcoming Defra publications

- Heritage garden stakeholders have been helped to manage impacts of *P. ramorum* and *P. kernoviae* through techniques to clone/regenerate valuable plants at risk.[23]

Evidence gaps that will be considered for future research

- The current programme is near completion with the future programme at a planning stage.
- Future disease management by government and stakeholders will need to consider and be informed by the costs and benefits of different management approaches.
- Wider lessons and more generic and strategic research needs (highlighted by *P. ramorum* and *P. kernoviae*) will also be considered, e.g. in terms of preparing for and managing risks from future Phytophthora species.

[22] Final project report for PH0604 - forthcoming Defra publications

[23] Final project report for PH0606 – forthcoming Defra publications

Research Synopsis: Oak Processionary Moth

Key facts on Oak Processionary Moth

- The Oak Processionary Moth (*Thaumetopoea processionea*) is a significant defoliator of oak in Europe. The caterpillars feed on the foliage of many species of oaks, including English, Sessile and Turkey oaks (*Quercus robur, Q.petraea* and *Q.cerris*).[24] Hornbeam, hazel, beech, sweet chestnut and birch are also reported to be attacked, although mainly when growing next to severely defoliated oaks. (*CR Medium)*
- OPM poses a risk to human health. The older caterpillars are covered in irritating hairs that contain a toxin; contact with these hairs, or their inhalation, can result in skin irritation and allergic reactions in people and animals.[25] These problems are potentially significant because OPM is often most abundant on urban trees, along forest edges and in amenity woodlands. (*CR High)*
- OPM caterpillars can threaten the health of oak trees because they feed on the leaves. Large populations can strip whole oak trees bare of leaves, leaving them vulnerable to attack by other pests and diseases, and less able to withstand adverse environmental factors such as drought or flood.[26] (*CR Medium)*
- OPM is a native species of parts of central and southern Europe, where it is widely distributed, but its range has been expanding northwards. It is now firmly established in northern France, Germany, Belgium and the Netherlands, and has been reported in southern Sweden.[27] (*CR High)*
- There are UK outbreaks of OPM moth in London (in West and South-West London from 2006, and the Bromley/Croydon area of South London) and the Pangbourne area of Berkshire. (*CR High)*
- Outbreaks are currently managed by (i) surveillance in affected and at-risk areas to detect signs of eggs, caterpillars, nests and (by pheromone trapping of) adult male moths; (ii) treatment of affected trees through controlled use of approved insecticides or nest removal.

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[24] H. Stigterll, W.H.,J.M. Geraedts & H.C.P. Spijkers (1997) *Thaumetopoea processionea* in the netherlands: present status and management perspectives (lepidoptera: notodontidae). *Proceedings of the Section Experimental and Applied Entomology of the Netherlands Entomological Society,* **8**, 3-16

[25] Lamy, M., Novak, F. (1986) The oak processionary caterpillar (*Thaumetopoea processionea* L.) an urticating caterpillar related to the pine processionary caterpillar (*Thaumetopoea pityocampa* Schiff.) (Lepidoptera, Thaumetopoeidae), *Experientia* **43**, 456-458.

[26] Thomas,F.M., Blank,R. & Hartmann,G. (2002) Abiotic and biotic factors and their interactions as causes of oak decline in Central Europe. *Forest Pathology*, **32,** 277-307.

[27] 5 Groenen, F., Meurisse, N. (2012) Historical distribution of the oak processionary moth Thaumetopoea processionea in Europe suggests recolonization instead of expansion. *Agricultural and Forest Entomology*, **14**, 147-155.

Key evidence questions Defra-funded research is seeking to address

- Defra and Forestry Commission are funding research on OPM to improve its management, e.g. by developing better methods for monitoring and detection, developing effective and deployable management approaches and gaining a better understanding of the pest.
- Research is underway to trial novel techniques, including spectral imaging, to detect eggs, larval activity and feeding damage. Research is also improving the attractiveness of pheromone lures that are used in monitoring traps and phenology modelling to inform when control measures should be applied.
- Research and monitoring is taking place to determine the most effective spray-application approaches for control OPM, whilst minimising biodiversity impact, including phenology modelling to inform spray timing and research informing longer-term, sustainable, integrated and cost effective pest management.

Insights emerging from research[28]

- One approved biopesticide and two approved chemical treatments have been tested in field trials at outbreak sites against OPM, applied with both high and low volume application methods. Results have yet to show a statistically significant positive effect, but nest numbers have been low in both the treated trees and untreated control trees.
- Bioassays of novel treatments have highlighted the potential of entomopathogenic nematodes and fungi for use in future control strategies.

Evidence gaps that will be considered for future research

- Further development and validation of detection methods
- Determining the most cost-beneficial interventions.
- Further development and testing of sustainable, longer-term, cost-effective, environmentally-friendly and integrated management approaches.
- How lessons from OPM can be applied to future pest introductions, especially in the context of the complex governance and management problems that occur in urban environments.

[28] Please note this section summaries insights emerging from current research projects. These projects (TH0101, TH0102, TH0103, TH0109) are forthcoming and findings have not been peer reviewed. Finding may be subject to change and therefore some caution should be applied when drawing any conclusions from this section. Findings will also emerge from the current FC-led OPM pilot control programme.

Use of Confidence Ratings

Data in this paper has been sourced from different organisations / publications. In order to help the reader understand the data presented a confidence rating has been applied where appropriate. Confidence ratings have only been applied to completed projects.

1. CR High: Based on significant evidence (e.g. recent survey, statistically sound using up to date methods, HMRC data, current industry practices; published in peer reviewed papers; recent qualitative research (interviews, focus groups etc) with sound methodology that includes results from a number of studies in different locations with different types of people that report similar findings).

2. CR Medium: Based on incomplete or dated evidence (e.g. an estimate based on old survey data, trade association estimates, a survey result which may not be entirely representative of the whole; qualitative research from one or two case studies; published in only one or two peer reviewed papers; published in grey literature).

3. CR Low: Based on speculative or incomplete evidence (e.g. rough estimate from a single expert, or industry body lacking supporting analysis, or early result based on fast developing situation on ground, not published in peer reviewed papers, qualitative research that involves a single case or does not provide details of the sample studied or method used.

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