# **Tree Health and Plant Biosecurity Expert Taskforce**

# **Interim Report**

**30 November 2012** 

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# **Chief Scientific Adviser's Foreword**

Tree and plant pests and pathogens<sup>1</sup> can have significant effects upon our environment and the economy. Incursions in the UK, like the recent dieback of ash caused by Chalara, have happened against a wider backdrop of environmental challenges within a continuum of change.

I warmly welcome this interim report of the Tree Health and Plant Biosecurity Expert Taskforce and I personally thank Professor Chris Gilligan, members of the Taskforce and all those involved for the speed with which they applied themselves to the problem. The report is independent of government and is a response to the rapidly increasing threat of tree and plant disease in the UK including a perceived need to quicken the pace of response.

Environmental change is happening faster and with greater frequency, force and impact than in the past. There are two reasons for this. The first is that extreme events are becoming more frequent but the second is that we are failing to build resilience into our social and economic systems. In many areas of environmental change the consequences of building resilience mean taking a long-term view.

Trees are an excellent illustration of the need for a long-term view. It takes 50-100 years for a forest to mature. The aim of building and maintaining woodlands is threatened by the incursion of new pests and pathogens. Building resilience depends upon the multiple actions of many people, and some element of chance, in the intervening period between a delicate sapling being planted and it standing majestically as the parent of future generations of trees. By today's standards involving high-frequency trading or the increasingly rapid turnover of soil nutrients, the rhythms of the forest seem quite out of place. Yet we know that the forests, and the soils they nurture, have to be protected and, if possible, re-built.

The odds against achieving this are stacking up. Some of the values of modern society do not help this process. If we are not very careful, free trade in goods could equate to free trade in pests and pathogens and this could come at a high cost.

The first step forward is to recognise that the challenge of tree health and plant biosecurity exists and requires a shared solution. This interim report takes a mainly near-term view of

<sup>&</sup>lt;sup>1</sup> For the purposes of this interim report, the term 'pests' is used to refer to invertebrates and 'pathogens' is used to refer to microorganisms.

how the UK might wish to respond to the evidential needs for changes in tree health and plant biosecurity. It is the first phase towards the final report to be published in Spring 2013. It adds very practical recommendations to considerable background work under the Government's Foresight Project in Infectious Disease (2006)<sup>2</sup> and the more recent Independent Forestry Panel Report (2012)<sup>3</sup> that presented a vision for a woodland culture for the 21<sup>st</sup> Century.

We need to be realistic about the impact that pests and pathogens are likely to have and about our options for responding to these. Biology has a tendency to come up with unexpected challenges. It may prove to be impossible to prevent some of these pests and pathogens entering the UK and, in these cases, the watchwords will be adaptation and resilience.

There may be a case for reforming some of the systems of governance around plant and tree health, which include the wider EU, to encourage a shift towards greater precaution. Alongside this, there will need for imaginative solutions to managing pests and diseases as they approach our shores. This includes everything from prevention and eradication to slowing them down sufficiently so that we can design resilient woodlands, parklands and gardens using our depth of experience in silviculture and horticulture.

Finally, the problems addressed in this report have most of their solutions embedded fundamentally in the behavioural choices made by people. Their actions in the past have brought certain consequence to bear with respect to tree and plant health. Changing those behaviours is going to be key to success.

Professor Ian L Boyd

Chief Scientific Adviser to Defra

<sup>&</sup>lt;sup>2</sup> www.bis.gov.uk/foresight/our-work/projects/published-projects/infectious-diseases

 $<sup>^{3}\</sup> www.defra.gov.uk/forestrypanel/files/\underline{Independent-Panel-on-Forestry-Final-Report1.pdf}$ 

# **Chairman's Foreword**

Chairing the Tree Health and Plant Biosecurity Taskforce has reinforced my view of the importance of enhancing plant biosecurity to protect the health of our trees. The work of the Taskforce has shown that our trees face significant threats. It has also shown that if we reinvigorate and focus our efforts we can reduce the likelihood of incursion and the impact of pests and pathogens on the nation's trees. The importance of the environmental, economic and social benefits of trees will be appreciated by many. The benefits were emphasised in the UK National Ecosystem Assessment<sup>4</sup> (2011), as well as in the recent report of the Independent Panel on Forestry<sup>5</sup> (2012), which stated: "The incidence of pests and diseases is increasing year-on-year, and as our climate changes this threat will continue to grow". The risks are exacerbated by the movement of plants and plant material associated with the increasing volumes of international trade and travel.

The Independent Panel on Forestry also recommended that: "Government should speed up delivery of the Tree Health and Plant Biosecurity Action Plan<sup>6</sup> by additional investment in research on tree and woodland diseases, resilience and biosecurity controls." This Taskforce was created by the Defra Chief Scientific Adviser to help address that recommendation in the light of the recent discovery of infection of native ash trees by the fungus *Chalara fraxinea*. The Taskforce has undertaken an intensive review of current threats and practices leading to the recommendations in this interim report. The Taskforce has also identified key gaps in our knowledge that need to be filled in order to support the successful implementation of plant biosecurity policy.

The immediate remit for the Taskforce was expressly directed at trees and related woody species. I note that the challenges for plant biosecurity encompass pests and pathogens of other plants including agricultural, horticultural and biomass crops, indigenous vegetation and ornamentals. It will be important to consider how the recommendations in this report can be adapted to support a policy for biosecurity that would include these other host species.

I gratefully acknowledge the hard work, urgency and generosity of time, given by members of the Taskforce in meeting and in producing an interim report in a very short period of time. I am also grateful to Professor Ian Boyd, Chief Scientific Adviser to Defra, for his considerable insight and support and to the government officials who have supported the

<sup>4</sup> http://uknea.unep-wcmc.org/Default.aspx

<sup>&</sup>lt;sup>5</sup> www.defra.gov.uk/forestrypanel/files/Independent-Panel-on-Forestry-Final-Report1.pdf

<sup>6</sup> www.defra.gov.uk/publications/files/pb13657-tree-health-actionplan.pdf

work of the Taskforce. The work of the Taskforce undoubtedly benefited from the valuable insights on current practice from the Officials Advisory Group, with membership drawn from Defra and the Defra Network organisations. I am grateful to the UK Chief Veterinary Officer and his colleagues who provided valuable insight and lessons from experience of preparing for and tackling animal disease outbreaks.

The Taskforce will continue to review and develop the evidence base to support the recommendations in this interim report. Our work will include assessment of the costs, benefits and tractability of the recommendations for practical implementation for publication of the final report in Spring 2013.

**Professor Chris Gilligan** 

**Professor of Mathematical Biology** 

Chais Gilligan

**Head of the School of Biological Sciences** 

**University of Cambridge** 

# A. Executive Summary

## **Background**

The UK Government has made a long-term commitment to addressing threats to tree and plant health<sup>7</sup>. In the last few years, several new and/or previously unrecognised plant pests and pathogens have emerged as significant risks. Threats to plant health have increased with globalisation in trade and travel; there has been a marked increase in the volume and diversity of plants and plant products entering the UK. This has led to a build-up in the number of harmful plant pests and pathogens that have become established in the UK, causing a wide range of adverse impacts on biodiversity, human health, timber and crop production and the landscape. Responding to this mounting pressure from pests and pathogens is a challenge facing public and private land owners, farmers, foresters and Government services.

Given this background, Defra's Secretary of State asked the Chief Scientific Adviser to Defra, Professor Ian Boyd, to establish an independent, expert Taskforce to advise on the current threats from pests and pathogens and to make recommendations about how those threats to trees could be addressed. The Taskforce was convened and met for two days in November. This interim report has been prepared rapidly to share the initial recommendations of the Taskforce and to summarise how the recommendations were made and who was convened to make them. The Taskforce will produce a fully referenced final report on its strategic view of the evidence addressing all of its aims in Spring 2013.

### **Key Recommendations**

During the two day meeting, the risks posed by pests and pathogens, the principles to prioritise and address these risks, and emerging knowledge gaps were discussed. The Taskforce will continue to review and develop the evidence base, including assessment of costs, benefits and tractability of implementation, for the final report in Spring 2013.

<sup>&</sup>lt;sup>7</sup> The Taskforce was requested to consider tree health and related biosecurity in the UK. This includes trees in woodlands, forests and in the wider environment, including amenity, fruit and urban trees. Woody shrubs associated with trees and green spaces, are relevant as either a pathway of introduction/spread of serious pest and pathogen threats, or where they act as sources of infection or infestation of trees (LWEC, 2011). Available at Securing Tree Health in a Changing Environment.

The Taskforce unanimously supports the following recommendations.

### **Taskforce Key Recommendations:**

- Develop a prioritised UK Risk Register for tree health and plant biosecurity
- Strengthen biosecurity to reduce risks at the border and within the UK
- Appoint a Chief Plant Health Officer to own the UK Risk Register and provide strategic and tactical leadership for managing those risks
- Review, simplify and strengthen governance and legislation
- Maximise the use of epidemiological intelligence from EU/other regions and work to improve the EU regulations concerned with tree and plant biosecurity
- Develop and implement procedures for preparedness and contingency planning to predict, monitor and control the spread of disease
- Develop a modern, user-friendly, expert system to provide quick and intelligent access to data about tree health and plant biosecurity
- Identify and address key skills shortages

## **Knowledge Gaps**

The Taskforce stuck rigorously to the consideration of knowledge gaps that are likely to have an impact on the ability to implement policy. It assessed gaps in knowledge with particular attention to scientific, technological, logistical, social and political barriers. Defra will be further informed by the cross-departmental Living With Environmental Change

(LWEC) initiative on Tree Health and Plant Biosecurity jointly funded by Defra, the Forestry Commission and the Biotechnology and Biological Sciences Research Council (BBSRC)<sup>8</sup>.

## **Next Steps**

This is an interim report and additional work will be done.

The recommendations are made by the Taskforce that is independent of Government, but the Taskforce benefitted from input from an Officials Advisory Group concerning the underlying evidence base and tractability of the recommendations, as well as the Defra Chief Scientific Adviser. The report has been peer reviewed by independent reviewers (See Annex C for peer reviewers).

Working with a broad range of stakeholders and government officials, the Taskforce will develop this advice further to:

- review the national and international risks and the evidential basis for the effectiveness of response options;
- provide an independent perspective on costs and benefits to inform setting priorities and resource allocation;
- review best international practice in tree health and plant biosecurity management; and
- produce a strategic evidence assessment and make recommendations for next steps including resolving crucial knowledge gaps.

<sup>&</sup>lt;sup>8</sup> www.bbsrc.ac.uk/funding/opportunities/2012/tree-health-and-plant-biosecurity.aspx

# **B.** Background

The UK Government has made a long-term commitment to addressing threats to plant and tree health. This issue has taken on additional urgency as a result of the 2012 discovery of infection of native ash trees by the fungus, *Chalara fraxinea*. The progression of Chalara is an illustration of the vulnerability of plants in the UK to pests and pathogens both from mainland Europe and as a result of importation from other parts of the world. Dutch elm disease arrived in the UK in the late 1960s and resulted in almost complete loss of mature elms from the British countryside. This has been followed by a number of other pests and pathogens that are changing the structure of woodlands, most recently *Phytophthora ramorum*<sup>9</sup>, which are threatening the important environmental, economic and social value of trees.

### Threats to tree health

In the last few years several new or previously unrecognised pests and pathogens have emerged as significant risks. Threats to tree health have increased with globalisation; there has been a marked increase in the volume and diversity of plants and plant products entering the UK. UK trade statistics for live plants, foliage, branches and other parts of plants show a 71% increase since 1999<sup>10</sup>. With this, comes an increased likelihood of plant pests and pathogens being introduced, spreading through gardens, crops and woodlands and potentially causing serious damage to either our native flora or commercial crops. These threats have been highlighted by an increasing number of outbreaks in the UK including, for example, *Phytophthora ramorum* and *Phytophthora kernoviae* affecting trees, heathland plants and heritage gardens; Cameraria moth (*Cameraria ohridella*) and oak processionary moth (*Thaumetopoea processionea*) with an associated threat to human health<sup>11</sup>, and bleeding canker of horse chestnut (*Pseudomonas syringae* pv. *aesculi*)<sup>12</sup>.

As arable crops, and most other commercial crops, are short-lived and harvested regularly, recognition of outbreaks of new pests and diseases and responses to them is often early and rapid, and there is a range of tools available for effective management.

<sup>9</sup> www.forestry.gov.uk/forestry/infd-6abl5v

<sup>&</sup>lt;sup>10</sup> HM Revenue and Customs data: www.uktradeinfo.com

<sup>&</sup>lt;sup>11</sup> Tiny hairs from the oak processionary moth caterpillar can lead to itching skin lesions, irritated eyes and, less commonly, sore throats and respiratory distress.

www.hpa.org.uk/Topics/ChemicalsAndPoisons/CompendiumOfChemicalHazards/OakProcessionaryMoths/

<sup>12</sup> www.forestry.gov.uk/forestry/infd-6abl5v

However, in the case of long-lived species such as trees, particularly where they are not being actively managed or are a part of semi-natural ecosystems, such as heathland, it can be many years before a small original infection or infestation becomes obvious, by which time effective mitigation action may be far more difficult and expensive. Some native, or well established but previously harmless, introduced pests and pathogens, may become more damaging over longer periods as a result of changes in climate, land use or host distribution, or by evolutionary changes in the pest or pathogen populations.

As a result, there has been a build-up in the number of harmful tree pests and pathogens that have become established in the UK, causing a wide range of potential adverse impacts on biodiversity, human health, timber production and the landscape. Responding to this mounting pressure on our tree populations challenges both public and private land owners and Government services.

### Tree Health and Plant Biosecurity Expert Taskforce

Given this background, Defra's Secretary of State asked the Chief Scientific Adviser to Defra, Professor Ian Boyd, to establish an independent, expert Taskforce to advise on the current threats to trees and woody hosts from pests and pathogens and to make recommendations about how those threats could be addressed.

#### Aims of the Taskforce:

- To review domestic and international risks presented from new and emerging tree and plant<sup>13</sup> pathogens, including using best available evidence, assessment of risk status, and appropriate risk assessment tools
- To provide an independent perspective on costs and benefits to inform setting priorities and resource allocation
- To identify potential barriers to improve tree health and plant biosecurity, and suggest ways of resolving them
- To make use of best international practice in tree health and plant biosecurity management
- To produce a rapid evidence assessment and make recommendations for next steps including identifying crucial knowledge gaps
- To consider whether the current plant health policy and delivery infrastructure and risk mitigation framework needs to be overhauled and make recommendations for change, if required
- To review the current contingency planning and emergency response arrangements and recommend changes, if required.

<sup>&</sup>lt;sup>13</sup> The Taskforce was requested to consider tree health and related biosecurity in Great Britain. This includes trees in woodlands, forests and in the wider environment, including amenity, fruit and urban trees. Woody shrubs associated with trees and green spaces, are relevant as either a pathway of introduction/spread of serious pest and pathogen threats, or where they act as sources of infection or infestation of trees (LWEC, 2011). Available at <u>Securing Tree Health in a Changing Environment</u>.

This interim report has been prepared rapidly to allow timely reporting of the initial recommendations of the Taskforce and identification of knowledge gaps to support evidence-based policy in relation to tree health and plant biosecurity. Each recommendation is prefaced by a brief explanation of why the recommendation is necessary. Each is then followed by a short explanation of what would be required to support the recommendation. The report also summarises how the Taskforce worked and who was convened to support the work of the Taskforce. The source documents for the meeting and this report are cited in Annex C.

The Taskforce will produce a fully referenced final report on its strategic view of the evidence addressing all of its aims in Spring 2013.

# C. The Taskforce's Approach

The Taskforce (see Annex A for Terms of Reference) comprises experts in the fields of plant biology, physiology, epidemiology and ecology, entomology, agricultural and environmental economics, environmental psychology, and risk analysis, and is chaired by Professor Chris Gilligan, Professor of Mathematical Biology and Head of the School of Biological Sciences, University of Cambridge. The Taskforce convened for a two day meeting (13-14<sup>th</sup> November 2012) at Defra's London offices and operated thereafter by email and teleconference.

The two day meeting focused on issues arising in relation to tree health and plant biosecurity and developed practical, evidence based recommendations. A combination of plenary and small group discussions ensured that all members of the Taskforce had a common grounding in the evidence. Views were generated about the risks posed by pests and pathogens and the principles that should be used to prioritise and address these risks. The Taskforce also considered emerging knowledge gaps.

The interim report from these proceedings was externally peer reviewed and the Taskforce unanimously supports the recommendations. The Taskforce focused on trees and woody species, as specified by the terms of reference but noted that the principles addressed in the recommendations would have broader applicability to pest and pathogens of other plant species, as summarised in the Chairman's foreword.

The Chief Scientific Adviser to Defra (CSA), Professor Ian Boyd, attended the two day meeting and was closely engaged with the Taskforce deliberations. In drafting interim recommendations the Taskforce has been informed by the CSA's feedback. The Taskforce was also supported by an Officials Advisory Group (see Annex B for Terms of Reference) which brought tree and plant science experts from Defra and the Defra Network to the Taskforce meeting to:

- raise awareness of current and planned activities on the ground;
- review the feasibility of recommendations from the Taskforce and their relationship to existing activities;
- provide expert advice to the Taskforce where required; and
- develop operational plans to support policy implementation of the Secretary of State's response to the Taskforce final recommendations.

# D. Key Recommendations

# 1. Identifying and Assessing Risk

The Taskforce noted that there are numerous risk assessments about individual pests and pathogens but concluded there should be a single Risk Register. Building on Defra's recent work to develop and implement the Tree Health and Plant Biosecurity Action Plan, a new Risk Register would serve to prioritise risks and formulate a systematic response to them.

#### **RECOMMENDATION 1:**

Develop a prioritised UK Risk Register for tree health and plant biosecurity

Assessment procedures to produce the Risk Register need to incorporate a compilation of evidence of risks with an assessment of the quality of the evidence, and procedures for the inclusion of expert evidence. Horizon scanning, with wider stakeholder involvement, is an essential component of the process. The Risk Register would also need to develop the rationale for prioritisation of responses, incorporating the costs and benefits of different courses of action. It would need to be updated frequently (ie be dynamic) and be used as a learning tool.

The Risk Register should take account of a range of factors, including:

- pathways of infection or introduction (eg commercial import, private import, aerial introductions, soil, timber, seeds, saplings,etc.) as well as pests and pathogens;
- environmental, economic, and social impacts and associated risks/likelihoods;
- current uncertainties, with the capacity for horizon scanning to identify potential future threats; and
- assessment of the tractability of management of pest introduction and spread should also be addressed.

The format of the Risk Register is a matter for further discussion but illustrative components of the Risk Register include:

- assessment of the baseline risk (without mitigation or controls):
  - quantified (as far as possible) likelihood of the incursion, establishment and spread;
  - quantified (as far as possible) impact including economic, social, environmental:
- current controls and mitigation;
- residual risk (after controls and mitigation are implemented):
  - quantified (as far as possible) likelihood of the incursion, establishment and spread;
  - quantified (as far as possible) impact including economic, social, and environmental
- identification of the risk indicators, including pest and pathogen intelligence from the EU and other regions, susceptibility of target hosts, monitoring of trade and aerial movement of the pest and pathogen:
  - establishment of the acceptable level of risk;
  - further action to refine the risk indicators: and
- current assessment and requirements for further information.

The most important risks should also be transferred to the Defra Risk Register and, if appropriate, to the National Risk Assessment. How risks are added to, and removed from, the Risk Register should be considered. The Risk Register should be a public document and consideration should be given to how the risks are communicated effectively to multiple stakeholders and the public.

# 2. National Biosecurity

The Taskforce noted trends in trade and travel towards greater frequency of both the movement of people and goods and greater distance of movement. Together, these lead to a greater risk of introduction of alien pests and pathogens.

The Taskforce reviewed the regulatory framework, natural geographical barriers and the potential for management of introductions of pests and pathogens. It was noted, for example, that a plant (or soil associated with plants) could be imported from a non-EU country into an EU Member State and then moved to the UK and be labelled as originating from intra-EU trade. This would leave the recipient unaware of a potential threat to biosecurity. More generally, in the context of the Single European Market, the UK's biosecurity from non-European threats is completely dependent on the level of biosecurity applied by other EU Member States. The Taskforce saw this as an area for significant improvement because, in effect, this currently means that all pests and pathogens introduced to the EU are eventually likely to be experienced across the whole of the EU (subject to variations in environmental conditions). In addition, the Taskforce felt that businesses that import, or cultivate imported trees and other plants, could take more responsibility to strengthen biosecurity by, for example, assuring the provenance of their supplies including both the plants and, when relevant, the soil associated with those plants.

It was pointed out to the Taskforce by the Officials Advisory Group that some significant progress could be made without legislative changes across the EU. Although additional work would be required to verify that this is possible, tighter controls could probably be achieved through more proactive use of existing mechanisms both by the UK and by other EU Member States, for example, by seeking protected zone status *before* rather than after a pest or pathogen arrives in the UK. The Taskforce noted that the upcoming review of the Plant Health Regime by the EU was timely and was an opportunity to improve the current regime to support better tree and plant biosecurity.

#### **RECOMMENDATION 2:**

Strengthen biosecurity to reduce risks at the border and within the UK

The Taskforce noted that, to be successful, encouraging a culture of biosecurity needs to consider the complexity of human behavioural responses (eg personal, community, and business/organisation). Responses are likely to be affected by interacting factors, including the perceived risk of not taking action and the understanding of the personal, societal and business benefits, in the context of the belief about the action of others. The risks of unexpected, and even perverse, consequences should be considered.

The Taskforce identified three areas in which progress could be made to strengthen national biosecurity to avoid the introduction of new pests and pathogens. These should

be balanced against the benefits of pest and pathogen control and consideration of any unintended consequences:

- Activity in the UK could include:
  - promotion of general awareness of the risks posed by plant pests and pathogens;
  - promotion of greater awareness of, and responsibility for, biosecurity in the commercial movement and importation of plants and plant products amongst key stakeholders, particularly forestry, arboriculture, tree nursery trade, and in private imports by the general public, eg via tourism and mail order;
  - systems of industry-led certification, including original provenance, plant transport trail, monitoring, assurance of trade partners' sources, linked to the regulatory inspection regime;
  - provision and use of rapid diagnostic tests by industry to identify and remove pests and pathogens at the point of entry or within current stock;
  - promotion of the use and value of certified and audited provenance (and other potential product labelling) for pest and pathogen-free plants to encourage a culture of biosecurity; and
  - encouragement of the local production of trees for woodland and amenity planting and the use of natural regeneration, where site conditions allow, and where it is consistent with woodland objectives.
- Intra-EU trade could include:
  - timely notification by all EU Member States to other Member States of occurrences of new pest and pathogen hazards;
  - reviewing the use and effectiveness of plant passports for controlling pest and pathogen spread, including: full chain of custody information (ie place of production as well as origin of seed) and this information reaching the end customers:
  - pest risk analysis at a larger scale (ie across the EU) to match the scale of the problem;
  - timely establishment of protected zones, in the light of epidemiological intelligence, and strengthening the use of protected zone status by shifting the emphasis towards precaution;

- supporting a proposal in the review of the EU plant health regime to extend the internal movement controls (ie "plant passporting") to all plants for planting, subject to the outcome of the review of the effectiveness of such a regime (see above);
- notification across all EU Member States of the import of high-risk plants, defined by the UK Risk Register within any individual EU Member State;
- monitoring of threats including pathways into the UK in order to take rapid protective action if necessary; and
- a more robust approach by the EU to imposing sanctions on those who break the rules, e.g. by hiding infection through the use of fungicides, or exporting plants from areas known to have pests or pathogens present.
- Non-EU trade into the UK (and other EU Member States) could include:
  - prohibition of new trade until an appropriate UK risk assessment has been conducted by the industry/importer;
  - consideration of the use of import levies across a range of plants and wood material to reflect expected damage costs, and to allow cost recovery for mitigation and adaptation strategies;
  - consideration of a quarantine mechanism for imports and exports of plants and wood material, where there is a high risk of pest or pathogen;
  - consideration of mechanisms for reducing the potential for people coming into the UK to carry diseased or pest-infested plant material;
  - review of the potential for treatment to kill pests and pathogens on imported wood products and live plant material; and
  - review of the risks posed by imports of soil associated with plants.

The Taskforce noted that implementation of some of these proposals involves strengthening compliance with existing legislative requirements but others would probably involve the introduction of new legislation and a change in EU legislation. It also noted that original research will be needed to design methods for treating live plant imports when they represent a high risk.

### 3. Chief Plant Health Officer

The Taskforce highlighted the need for an individual to be responsible for identifying key risks and also managing outbreaks. This includes adopting a similar approach to animal health, including a clear strategic approach for prioritisation of resources, making use of the proposed UK Risk Register (see Recommendation 1). The responsibility of the individual should also include development, testing and updating of contingency plans for emergency responses. In the case of animal health control, the Chief Veterinary Officer (CVO) does not have budget responsibility but there is a clear, and well defined, requirement for the CVO to adopt a 'command and control' role in animal-related emergencies. The Taskforce noted the recent establishment of the UK Plant Health Strategy Board, which aims to co-ordinate plant health strategy between responsible official bodies across the UK, including the Devolved Administrations. The Taskforce concluded that the function of the UK Plant Health Strategy Board required further consideration, especially to strengthen and clarify its strategic aims and the relationship with the proposed Chief Plant Health Officer.

#### **RECOMMENDATION 3:**

Appoint a Chief Plant Health Officer to own the UK Risk Register and provide strategic and tactical leadership for managing those risks

The Taskforce anticipated that the Chief Plant Health Officer could work in a manner analogous to the CVO although it should be noted that the scales of activity and the potential risks are very different for animal and plant health Responsibility for assessing and managing the risks to tree and plant health ought to be combined within a centralised role on a UK-wide basis. This needs to take into consideration the requirements of the Devolved Administrations. It is likely that the role would encompass responsibilities for management of all plant health, subject to future discussion, and would be most effective if carried out at a UK-wide level.

A Chief Plant Health Officer would have:

<sup>&</sup>lt;sup>14</sup> The host range for plant species, even amongst trees, is much larger than for animals, and the panel of pest and disease risks is very large for trees. Surveillance of animal diseases is also assisted by the reporting potential of the veterinary profession.

- seniority and credibility, and standing in the community, such that he or she would command authority;
- equivalence to the Chief Veterinary Officer; and
- authority to vary the Terms of Reference for the Plant Health Strategy Board and to be the customer for the products of the Board.

The Chief Plant Health Officer could be responsible for:

- updating the UK Risk Register, epidemiological intelligence, surveillance and management protocols, engagement with the media, industry and stakeholders, long-term strategy and horizon scanning and general communication;
- coordination of action across the Devolved Administrations (see Recommendation 4);
- communicating regularly with Ministers, senior officials, stakeholders and the public;
- together with Ministers and senior officials, putting in place mechanisms for timely access to information and data about plant pests and pathogens from EU Member States;
- strengthening border controls as appropriate (see Recommendation 2); and
- contingency plans and emergency response.

The way in which the Chief Plant Health Officer and the UK Plant Health Strategy Board deliver plant biosecurity in partnership with the Devolved Administrations will require further consideration.

### 4. Governance

The Taskforce understood that the Plant Health Act 1967<sup>15</sup> has resulted in responsibilities being split between the Forestry Commission and Defra, who have delegated

<sup>&</sup>lt;sup>15</sup> 1)This Act shall have effect for the control of pests and diseases injurious to agricultural or horticultural crops, or to trees or bushes, and in the following provisions of this Act —

<sup>(</sup>a) references to pests are to be taken as references to insects, bacteria, fungi and other vegetable or animal organisms, viruses and all other agents causative of any transmissible disease of agricultural or horticultural crops or of trees or bushes, and also as including references to pests in any stage of existence;

<sup>(</sup>b) references to a crop are to be taken as including references to trees and bushes.

<sup>(2)</sup> The competent authorities for purposes of this Act shall be—

responsibility for plant health to the Food and Environment Research Agency (Fera). Responsibility for plant health in Scotland lies with the Scottish Government and in Wales the Forestry Commission's functions under the Plant Health Act will transfer to Welsh Ministers. Separate arrangements apply in Northern Ireland. There are currently good working relationships between the different organisations when responding to pest and pathogen incursions. However, the Taskforce was concerned that these depended on the goodwill of the individuals concerned and that the governance arrangements for a joint response to managing pest and pathogen incursions are unclear. In addition to timely production of risk assessments for individual pests and pathogens, there is a need for more coherent governance in order to enable overall prioritisation and responsiveness to risks.

Based on recent experience with the management of tree disease, there are major challenges integrating the management and control responses in the diverse components of the ecosystem affected by disease. These components cover trees in a range of situations including: forests, amenity sites (eg parks and gardens), and orchards, along motorway and rail lines and in trade networks, including nurseries. Management of an invading pest or pathogen currently requires the collection and collation of information from a range of bodies in order to formulate mitigation and control strategies. The task is confounded where the data are owned or only accessible by different organisations. Making governance work more effectively is necessary to eradicate or reduce the spread of the pests or pathogens in future.

The Taskforce also noted that current legal instruments treat forest trees separately from other plant species and there were problems of legal definitions. Since different organisations have responsibility for different parts of the spectrum of tree and plant health and biosecurity and these are treated differently, there is a need to consider whether the current legislation is adequate.

Inconsistent strategies amongst Devolved Administrations could lead to pathogens and pests in one country posing a threat to the tree and plant communities in an adjacent country. Pests and pathogens do not respect political or geographical boundaries so a UK-wide strategy in identifying and managing threats is essential.

<sup>(</sup>a) as regards the protection of forest trees and timber from attack by pests, the Forestry Commissioners ("timber" for this purpose including all forest products); and

<sup>(</sup>b) otherwise, for England and Wales the Minister of Agriculture, Fisheries and Food and for Scotland the Secretary of State.

#### **RECOMMENDATION 4:**

#### Review, simplify and strengthen governance and legislation

The Taskforce concluded that current governance of tree and plant pests and pathogens needed to be strengthened and required:

- challenge to organisational cultures that may act as barriers to developing a strategic approach to contingency planning;
- creation of a coherent strategy for identification of the key threats across the whole
  of the UK and in a manner that can help to lead European policy in this field;
- generation of a common understanding of who is responsible for preparedness and who takes control in emergencies; and
- generation of understanding of how society values trees, what would be expected of authorities in terms of effective management of pests and pathogens, and how people can contribute to the monitoring and control of disease outbreaks.

# 5. International Intelligence

The Taskforce noted the importance of understanding how pests and pathogens could spread rapidly through mainland Europe. They reinforced the importance of sharing data, for example to parameterise epidemiological models, across different EU and EPPO<sup>16</sup> Member States, especially where there are active trading links in live plants with the UK; additionally, post-outbreak analyses of approaches could be shared. This also applies to the potential for the UK to export pests and pathogens. The Taskforce noted that it is almost impossible to know the extent to which current controls have prevented introduction of new pests and pathogens and that only those that do get through are publicised. The Officials Advisory Group reported 1400 interceptions per annum of pests on consignments moving in trade, mostly imported from non-EU countries<sup>17</sup>.

A number of factors have combined and contributed to the spread of plant disease (eg Chalara), and these include:

<sup>&</sup>lt;sup>16</sup> EPPO is the European and Mediterranean Plant Protection Organisation. www.eppo.int/

www.fera.defra.gov.uk/scienceResearch/science/pestDisease/

- continuous natural spread of pests and pathogens by aerial dispersal, movement by trade and by private individuals;
- taxonomic uncertainty regarding the identification of new pests and especially pathogens, which would compromise a formal system of reporting of plant pests and pathogens by EU Member States; and
- the absence of formal EU risk assessments may result in importation of infected trees through free trade rules at the expense of biosecurity.

#### **RECOMMENDATION 5:**

Maximise the use of epidemiological intelligence from EU/other regions and work to improve the EU regulations concerned with tree and plant biosecurity

In the future, intercepting pests and pathogens effectively would require an UK and a broader EU response including:

- better positioning of tree health and plant biosecurity within EU regulations to ensure that threats from pests and pathogens are formally recognised at early stages and are followed by appropriate responses;
- improving the communication of high level information about the spread of introduced pests and pathogens into and within the EU; and
- accessing better data about trade imports into the EU, intra-EU movements, and the provenance of imports and plant materials traded within the EU.

### 6. Preventing and preparing for outbreaks

The Taskforce noted the remarkable efforts that had been made to deal with the infection of UK ash trees by Chalara in 2012, and considered with the benefit of hindsight what further resources would have helped with the response. Developing preparedness requires adequate maps and related resources for identifying where key susceptible host species are located. Work by the National Biodiversity Network, for example, is already collating data in an easily accessible form. Data about host distribution in natural and managed environments, importers and nurseries and the distribution of tree and plant hosts requires

consolidation, quality-assurance, and coordination. There is also a need to determine gaps in data when this relates to identified threats.

Improvements in data should focus on tree and plant distribution on non-public land, in the urban environment, and along motorways and trunk roads to bring it up to the same level as for public land. Information about trade networks is important for identifying the potential likely occurrence of a problem, for efficient deployment of inspectors for detecting and controlling outbreaks, and for understanding vulnerability to inadvertent spread of introduced pests and pathogens.

It was clear to the Taskforce that there was a much greater sophistication in the preparedness for emerging livestock disease compared with plant disease. The larger diversity of pests and pathogens, and pathways for their introduction, in the plant sector presents a bigger challenge than for animal disease. The procedures for animal disease outbreak control include clear protocols for engagement with stakeholders, the deployment of resources, command and control, access to models, sampling and reporting protocols, and communication with the media.

#### **RECOMMENDATION 6:**

Develop and implement procedures for preparedness and contingency planning to predict, monitor and control the spread of disease

The Taskforce considered that part of national preparedness for novel pathogens and pests should be to provide assurance that there is the capacity to model the epidemics. This would provide policy makers rapidly with information and advice. This capacity should enable an efficient response both to known threats on the Risk Register as well as newly emerged pests and pathogens about which little is known. It would promote both the early detection of incursions and increase responsiveness, thereby reducing the overall cost of pathogen and pest management. Measures should include:

### **Detection and diagnosis:**

 forward planning for the detection of pests and pathogens and diagnosis of diseases; strategies for known threats should be drawn up in advance and gaps in knowledge (eg taxonomy) and resources (eg rapid molecular diagnostic tests) should be identified and commissioning research to address them considered; and • draft generic plans for novel types of threats (eg insect pests, *Phytophthora* fungi etc.) should be prepared.

### Statistical epidemiology:

- assurance of statistical epidemiological capacity for different types of threat to enable cost-effective monitoring and surveillance of the spread of pathogens and pests; and
- estimation of key parameters describing disease aetiology and transmission that will be required to build epidemiological models to study spread and control.

#### Trade and human behaviour:

- planning to incorporate human activity into novel threat response, for example human-mediated spread of disease, and the response of different actors (forestry industry, nursery trade, retailers, the public etc.) to different types of interventions; and
- protocols to trace forward and trace back the sequence of past or potential infections through trade networks.

### Pest and pathogen modelling:

- capacity to model the spread of different diseases and other threats to determine their rate of spread, the effectiveness of different control measures, and to identify key epidemiological parameters and hence prioritise research needs;
- for known threats specific models should be developed in advance while generic models should be available as the basis for studying novel threats;
- models should be open to examination and testing by the research community and be transparent to all stakeholders; and
- models should ideally combine ecological/epidemiological and economic and social drivers and responses.

### Contingency planning:

 designed to anticipate incursions and define the roles of those organisations responsible for the response, including communication with stakeholders; and  agreed with stakeholders ahead of incursions and shared amongst other EU Member States.

### 7. Co-ordination of information and communication

While there are multiple sources of information about pests and pathogens, including risks, methods of control and management, the Taskforce identified a need to introduce new methods for the collation of information. It saw that at present much of the information base consists of accumulated reports and stand-alone databases. There is an opportunity using modern information and the science of informatics to develop a structured approach to the knowledge base which will allow the efficient interrogation of databases, the "semantic web" and related tools. Such a resource would enable information to be accessed and summarised more efficiently, whether it is required for high-level policy or for detailed studies of particular threats. Implementation of such a system will be linked to the implementation of Recommendation 1.

#### **RECOMMENDATION 7:**

Develop a modern, user-friendly, expert system to provide quick and intelligent access to data about tree health and plant biosecurity

Robust approaches to biosecurity increasingly rely upon genomic, taxonomic, ecological, epidemiological, social and economic analyses as well as the integration of information from disparate sources. Not only should the requirements be catered for using up-to-date tools for interrogation and analysis but the gathering of data needs intelligent design. In particular, there is a need to consider:

- learning from elsewhere (eg animal health tools and international practice) to develop expert systems for rapid and efficient interrogation of information related to risk registers, epidemiological preparedness and contingency plans for pest and pathogen threats, including changes in strain prevalence within species;
- updating of pest and pathogen intelligence and mitigation responses with crosslinkage to effectiveness of mitigation measures for generic pest reduction;
- developing cost-effective surveillance and response strategies;
- employing citizen science as an additional method of surveillance with allowance for uncertainty in reporting accuracy; and

 promoting effective general communication about tree and plant pests and pathogens.

## 8. Building Capability

The Taskforce highlighted the fact that there has been an erosion of skills and capabilities, in the UK and internationally, to deal with tree and plant disease at different scales, as well as some of the underpinning natural and social science essential to inform and implement policy. Some issues can be addressed with the existing skills base but others require a more long-term strategic review involving the Research Councils, Higher Education Institutes as well as government.

# RECOMMENDATION 8: Identify and address key skills shortages

Skills are needed to perform a number of key tasks, especially:

- research capability to understand the basic biology, taxonomy, genetics and genomics
  of organisms, considered to present a high risk to plant health, and their hosts;
- development of new control measures, landscape ecology and social and economic analysis of disease risk at the regional and landscape scales;
- skills so that the inspectorate has the capacity identify and mitigate plant health risks;
- informatics to manage data and knowledge;
- epidemiological and multi-criteria risk analysis to assess risks on multiple time and space scales, wider environmental influences and concurrent pest and pathogen interactions. All of these should be with integrated socio-economic and ecological analysis of disease impacts and response strategies; and
- training and leadership within the wider stakeholder community.

# E. Knowledge Gaps

Knowledge gaps are likely to have impact on the ability to implement policy in the short and long term. Some of these have emerged in the preceding recommendations. The Taskforce, with input from the Officials Advisory Group, explored knowledge gaps against a set of evidence categories as in the table below. Attention was also given to scientific, technological, logistical, social and political barriers that might affect implementation of policy and that might be overcome by research.

The principal knowledge gaps and potential areas for improvements, along with short explanations, are summarised in the table below. These will be developed further in the final report. It is anticipated that these knowledge gaps will feed into the current call for the cross-departmental research initiative on Tree Health and Plant Biosecurity, jointly funded by Defra, the Forestry Commission and the Biotechnology and Biological Sciences Research Council (BBSRC)<sup>18</sup>, and supported by the Living with Environmental Change (LWEC) initiative.

<sup>18</sup> www.bbsrc.ac.uk/funding/opportunities/2012/tree-health-and-plant-biosecurity.aspx

Category	Examples of knowledge gaps
Epidemiology <sup>19</sup>	Shortage of data on host distributions: essential to collate and make data available
	<ul> <li>Generic modelling and parameter estimation frameworks: promoting transparency in model assumptions and flexibility in adapting for new pests and pathogens including 'unknown' but related genera and species</li> </ul>
	<ul> <li>Knowledge of transmission and dispersion patterns to inform estimates of spread and effectiveness of landscape-scale control strategies</li> </ul>
	Economic and social costs of disease
Surveying and Surveillance	Methods for sensitive and rapid detection at ports of entry
	Improve the sensitivity and effectiveness of remote sensing
	<ul> <li>Intelligent survey informed by modelling, including risk-based sampling</li> </ul>
	<ul> <li>Sensible sampling: reporting of negative results; taking account of temporal and spatial nature of pest and pathogens for optimal sampling</li> </ul>
	Behaviours and compliance of stakeholders in relation to controls
	Citizen science: quality assurance / development of systems to handle large volumes of uncertain data
Detection	Diagnostic tools, genomics; portable equipment for improved detection
	Improved taxonomy including within-species variation
	Sentinel plants to identify unknown risks
	<ul> <li>Understand costs versus benefits of detection in the context of significant uncertainty</li> </ul>

 $<sup>^{19}</sup>$  Epidemiology is taken here to include the introduction, establishment, spread, and control of pathogens and the impacts of disease.

Mitigation and adaptation strategies	Quarantine and cross-border activities
	<ul> <li>Role of chemical control in managing pest and pathogen incursions</li> </ul>
	<ul> <li>Breeding methods (including developing pest and disease- resistant host cultivars): understanding of native and non- native trees in ecosystem services and the role of forest diversification</li> </ul>
	<ul> <li>Cultural control: matching the scale of control with the inherent temporal and spatial scales of an epidemic</li> </ul>
	<ul> <li>Biological control (has proved effective in controlling selected tree pest and pathogens)</li> </ul>
	<ul> <li>Impact on disease spread (linked to epidemiology) and policy measures, and related benefits and costs of mitigation and adaptation</li> </ul>
	<ul> <li>An understanding of resilience at the tree and stand level and of the influence of silvicultural systems on resilience and epidemiology</li> </ul>
	<ul> <li>The effects of management and forest operations on the establishment and spread of pests and pathogens</li> </ul>
	<ul> <li>Assessment of capacity of mitigation procedures to remove multiple pests in a 'manage once, remove many' process</li> </ul>
Trade patterns	<ul> <li>Effects of changing patterns of trade and travel on risk of pest and pathogen introductions</li> </ul>
	<ul> <li>Trade patterns (volume and pattern) including traceability and private importers</li> </ul>
	<ul> <li>Industry imports and costs of import control (eg to forestry sector, to households)</li> </ul>
Environmental change	Predict effects of environment change on susceptibility of trees and risks of known pest and pathogen threats

# F. Next Steps

This is an interim report from this Taskforce and additional work needs to be undertaken. The report was compiled in less than three weeks, so current recommendations are necessarily lacking some of the details but peer reviewers agreed with the central conclusions. In addition, while the Taskforce takes responsibility for the recommendations, the Taskforce benefitted from input from the Officials Advisory Group in assessing the tractability of the recommendations.

Some of the reviewers also identified ways in which recommendations may be expanded and strengthened, and the Taskforce is ready to build on those suggestions. Working with a broad range of stakeholders and government officials, the Taskforce will develop this advice further to:

- review the national and international risks and the evidential basis for the effectiveness of response options;
- provide an independent perspective on costs and benefits to inform setting priorities and resource allocation;
- review best international practice in tree health and plant biosecurity management; and
- produce a strategic evidence assessment and make recommendations for next steps including resolving crucial knowledge gaps.

# Annex A – Taskforce Terms of Reference

# TREE HEALTH AND PLANT BIOSECURITY EXPERT TASKFORCE

### **Terms of Reference**

### **Summary**

Professor Ian Boyd, Defra's Chief Scientific Adviser (CSA), has convened a Tree Health and Plant Biosecurity<sup>20</sup> Expert Taskforce to support Defra's response to tree and plant disease outbreaks. The Taskforce will draw on and review evidence to provide recommendations to identify risks to the UK from tree pests and disease and on the steps necessary to prepare for and deal with outbreaks.

The Taskforce will provide independent expertise on tree and plant health and will support Defra's CSA in ensuring the Secretary of State for Defra has access to the most up-to-date and robust evidence to inform decisions on dealing with tree and plant disease outbreaks. The Taskforce will work towards a new UK Tree and Plant Health Strategy and will complement work already underway as part of the Tree Health and Plant Biosecurity Action Plan.

#### Aims of the Taskforce:

- To review domestic and international risks presented from new and emerging tree and plant pathogens, including using best available evidence, assessment of risk status, and appropriate risk assessment tools
- To provide an independent perspective on costs and benefits to inform setting priorities and resource allocation

<sup>&</sup>lt;sup>20</sup>The Taskforce will focus on tree health and related biosecurity in Great Britain. This includes trees in woodlands, forests and in the wider environment, including amenity, fruit and urban trees. Woody shrubs associated with trees and green spaces, are relevant as either a pathway of introduction/ spread of serious pest and pathogen threats, or where they act as sources of infection or infestation of trees (LWEC, 2011). Available at Securing Tree Health in a Changing Environment).

- To identify potential barriers to improve tree health and plant biosecurity, and suggest ways of resolving them
- To make use of best international practice in tree health and plant biosecurity management
- To produce a rapid evidence assessment and make recommendations for next steps including identifying crucial knowledge gaps
- To consider whether the current plant health policy and delivery infrastructure and risk mitigation framework needs to be overhauled and make recommendations for change, if required
- To review the current contingency planning and emergency response arrangements and recommend changes, if required

#### **Governance:**

The Taskforce is chaired by Professor Chris Gilligan and will report to Professor Ian Boyd, Defra's Chief Scientific Adviser who will in turn make recommendations to Defra's Secretary of State. It is acknowledged that Taskforce members may have links to other groups working on behalf of Defra or may be in receipt of Defra funding. Any potential conflicts of interest will be recorded. The Taskforce will be supported by a public sector Officials Advisory Group, and external peer reviewers.

The outputs of the Taskforce are expected to be:

- (i) An interim report including evidence-based recommendations (by end November 2012)
- (ii) Final report on the Taskforce's strategic view of the evidence (Spring 2013)

### **Taskforce Members**

#### Professor Christopher Gilligan (Chair):

Professor of Mathematical Biology, University of Cambridge.

#### **Professor Robert Fraser:**

Professor of Agricultural Economics, University of Kent.

### **Professor Charles Godfray**:

Hope Professor of Zoology (Entomology), University of Oxford.

#### **Professor Nicholas Hanley:**

Professor of Environmental Economics, University of Stirling.

#### **Professor Simon Leather:**

Professor of Entomology, Harper Adams University College.

#### **Professor Thomas Meagher:**

Professor of Plant Biology, University of St Andrews.

#### **Professor Judith Petts:**

Professor of Environmental Risk Management, University of Southampton.

#### **Professor Nicholas Pidgeon:**

Professor of Environmental Psychology, Cardiff University.

#### **Dr Jens-Georg Unger:**

Head of the Institute for National and International Plant Health in Germany.

#### **Dr Stephen Woodward:**

Reader at the School of Biological Sciences, University of Aberdeen.

**Observer:** Professor Michael Jeger, Imperial College London

# Annex B – Officials Advisory Group Terms of Reference

# TREE HEALTH AND PLANT BIOSECURITY OFFICIALS ADVISORY GROUP (OAG)

### **Terms of Reference**

### **Summary**

Professor Ian Boyd, Defra's Chief Scientific Adviser (CSA), has convened a Tree Health and Plant Biosecurity<sup>21</sup> Expert Taskforce to support Defra's response to tree and plant disease outbreaks. The Taskforce will draw on and review evidence to provide recommendations to identify risks to the UK from tree pests and disease and on the steps necessary to prepare for and deal with outbreaks.

An Officials Advisory Group (OAG) comprising experts from Defra and the Defra Network will support the Taskforce. The OAG will help to ensure complementary actions to work already underway for the Tree Health and Plant Biosecurity Action Plan.

#### Aims of the OAG:

- To raise awareness to the Taskforce of planned and current activities on the ground
- To provide expert advice to the Taskforce where required
- To review recommendations from the Taskforce to consider their feasibility and how they complement existing activities
- To develop operational plans to support policy implementation of the Secretary of State's response to the Taskforce recommendations

The Taskforce will focus on tree health and related biosecurity in Great Britain. This includes trees in woodlands, forests and in the wider environment, including amenity, fruit and urban trees. Woody shrubs associated with trees and green spaces, are relevant as either a pathway of introduction/ spread of serious pest and pathogen threats, or where they act as sources of infection or infestation of trees (LWEC, 2011). Available at <a href="Securing Tree Health in a Changing Environment">Securing Tree Health in a Changing Environment</a>.

#### **Governance:**

The OAG provides an advisory role to the expert Taskforce and as such will not make an independent report or meet separately. The Taskforce will draw on the OAG advice to revise recommendations and in their work moving forwards.

### Officials Advisory Group members

Joan Webber Forest Research

Tony Kirkham RBG Kew

Nigel Gibbens Defra

Martin Ward Food and Environment Research Agency

Roger Coppock Forestry Commission

Ian Mitchell Defra

Peter Freer-Smith Forest Research

Hugh Clayden Forestry Commission - Scotland

Hugh Evans Forestry Commission - Wales

David Slawson Food and Environment Research Agency

# **Annex C – Peer Reviewers**

We gratefully acknowledge the contributions of five peer reviewers who provided constructive critique and insightful comments. These comments were considered in drafting this interim report and will also inform the next phase of the Taskforce work.

Peer reviewers were:

Professor Ian Bateman: University of East Anglia

Professor John Lucas: Rothamsted Research

Professor John Mumford: Imperial College London

Dr Clive Potter: Imperial College London

Professor Michael Shaw: The University of Reading

## **Annex D – Source Documents**

The Taskforce and the Officials Advisory Group were informed by the following sources prior to their first meeting and during the compilation of this interim report.

The Forestry Commission information relating to distribution, biology and management strategies. <a href="https://www.forestry.gov.uk/forestry/infd-6abl5v">www.forestry.gov.uk/forestry/infd-6abl5v</a>.

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www.defra.gov.uk/forestrypanel/files/Independent-Panel-on-Forestry-Final-Report1.pdf

LWEC. 2011. Securing Tree Health in a Changing Environment.

Tree Health and Plant Biosecurity Initiative. 2012. <a href="https://www.bbsrc.ac.uk/funding/opportunities/2012/tree-health-and-plant-biosecurity.aspx">www.bbsrc.ac.uk/funding/opportunities/2012/tree-health-and-plant-biosecurity.aspx</a>

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Plant Health Act 1967. www.legislation.gov.uk/ukpga/1967/8

Interception and Outbreak Charts

www.fera.defra.gov.uk/plants/plantHealth/pestsDiseases/interceptionCharts.cfm

Chalara Key Scientific Facts 2012. <a href="https://www.forestry.gov.uk/forestry/INFD-8ZSS7U">www.forestry.gov.uk/forestry/INFD-8ZSS7U</a>

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www.defra.gov.uk/publications/files/pb13657-tree-health-actionplan.pdf

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www.fera.defra.gov.uk/plants/plantHealth/pestsDiseases/documents/chalaraFraxinea.pdf

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