SECURING TREE HEALTH IN A CHANGING ENVIRONMENT

NOTE OF RESEARCH WORKSHOP

Friday 6 May 2011 (10:00-17:00)

The Royal Horseguards, 2 Whitehall Court, London SW1A 2EJ

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This summary note includes points noted from the workshop discussions, plenary feedback, flip chart notes and other feedback. It is intended as an informal aide memoire rather than a comprehensive record. It does not attempt to capture the detail of the wide-ranging debate, to reconcile views or to comment on the validity of the comments made by participants.

1. Introduction

The agenda for this meeting is at Annex A with the list of participants at Annex B. Presentations will be available on the LWEC website (www.lwec.org.uk) in due course.

2. Welcome and Aims (Bob Watson)

Professor Watson, Defra's Chief Scientific Adviser, welcomed participants to the meeting and thanked LWEC for hosting the workshop.

Tree health is seen as a priority for Defra and the Secretary of State has requested Defra and the Forestry Commission (with support from Forest Research and Fera) to work together to produce an Action Plan on tree health and plant biosecurity. This Action Plan is comprised of four themes (practical actions, import controls, public engagement and research).

The purpose of this workshop is to build on the outcomes of previous workshop held on 16th February and further explore the evidence needs and opportunities related to tree health. Participation by attendees and the outputs of this workshop were considered to be essential to inform the Action Plan.

3. Drivers (Andrew Watkinson)

Professor Watkinson outlined that the major drivers of the change in risk for tree diseases were socio-economic and climate change. Drawing attention to the Foresight report on Infectious Diseases, he illustrated how the complex range of socio-economic drivers together with climate change both affected disease sources and pathways, but that there was a general lack of understanding of how interaction between the drivers might modify the change in risk. There was also a lack of understanding of how the response options might modify the change in risk as had been calculated in the Foresight report on Future Flooding.

In considering the response options, which may in turn act as drivers, he stressed that greater consideration needs to be given to the life time of management decisions (e.g. spraying, felling new variety, land use change) and also on whether the responses should be incremental or transformative. He argued that much more attention should be probably be given to the latter, given the substantial climate change that is likely to occur by the time trees planted now are felled. The complexity of the socio-economic response was also stressed if it was to be effective, including for example, education, improved monitoring and effective regulation.

Finally, in considering the relative importance of different drivers (e.g. introductions, weather, change in population vector, recombination) for different taxonomic groups causing infectious diseases he pointed out that emerging pathogens may in themselves also become direct drivers of biodiversity loss.

4. Priority Pests and Pathogens (Peter Freer-Smith)

Peter Free-Smith outlined current priority pests and pathogens of concern to tree health, both those already present and those on the horizon (see also the workshop's Background Paper, Annex 1: 'Top 20 Pests and Pathogens'). He highlighted the rise in the number of new pest and disease problems in the last decade or so. He introduced the four generic evidence and innovation areas around which subsequent discussions would take place:

- Pest and disease biology, epidemiology, host interactions and risk
- Detection and identification
- Prevention and control
- Awareness and behaviours

The subsequent discussion raised the following points:

- How would generic areas contribute across a number of pests and pathogens? What generic areas might contribute to different pests and pathogens? How should we balance generic versus pest-specific needs?
- How could research provide practical solutions? Where there any quick-wins or 'low-hanging fruit'?
- How would we resource any research?
- We might need different approaches for tackling rapid emergence and spread of new pests and diseases introduced in the last 10 years? Incremental actions are required, as well as improved interactions between scientists and practitioners.
- Bio-control had been very successful, but these approaches still needed to go through the same approvals processes as chemical pesticides and this was a lengthy and expensive process. Current success was largely due to having biological control agents (BCAs) in place prior to more stringent registration requirements being required.
- Stopping new pests or pathogens from entering the UK is most important since everything thereafter is fire-fighting and adaptation (prevention is better than cure)
- Expectations on what success might look like (e.g. reduced numbers of new, damaging pests and pathogens becoming established) should take into account that there may be a lag in success becoming apparent since new pests and pathogens which may have already been introduced may not become apparent for many years. We have also not been very successful in recent times in keeping new pests and pathogens out and prevention may not be possible.
- Generic work is needed that can be brought to bear on new previously 'unknown' pests and pathogens when they emerge. Several current problems have come from pathogens not previously known to science (e.g. *Phytophthora ramorum* and *P. kernoviae*).
- How have Forestry Commission and Forest Research decided on which pests and pathogens are priorities? Is this based on both the impact/importance of the pests and/or the impact that research could have in providing solutions. Prioritisation was not 'low' and 'high', but 'lower' and 'higher'. It is difficult to compare and prioritise between pests/pathogens that are already here and being damaging, and those that are not yet here.

- There have been good examples where research has provided practical solutions, e.g. biological control for *Dendroctonus micans*, as well as for indigenous *Heterobasidium.* Equally there have been examples where we have not managed to develop control methods: Dutch elm disease is a good example, resulting in the loss of a tree species from the landscape; Horsechestnuts may be another example, as might Corsican Pine with red band needle blight, and longer-term resilience may need to be considered.
- With new arrivals of pests and pathogens, BCAs can take some time to develop; how long did it take for *D. micans?* Can we learn from other countries and how they manage these pests and pathogens?
- Climate change may not be a highly significant factor: most newly introduced exotic pests and pathogens are primary pests/pathogens which are aggressive when encountering new hosts. Many were lower temperature organisms.
- Modelling needed to take account of wider biological issues, e.g. with Dutch Elm disease, modelling predicted rate of spread but the epidemic would not have taken off without genetic exchange between *Ophiostoma ulmi* and *O. novo-ulmi* that provided resistance in the latter to mycoviruses.

5. Learning from other areas (Martin Ward)

Martin Ward introduced a discussion focusing on what lessons could be learned from others, including:

- The front line (e.g. inspectors): what is stopping them keeping new pests and pathogens out, or managing those that do arrive and cause problems? Generally, Pest Risk Assessments (PRA) have been good at predicting risks and impacts; PRA methodology is fairly robust, as are diagnostic methods. However, the main problems relate to failures to detect problems early and not having control measures available.
- Other countries: there is a good plant health network and scientific collaboration, e.g. facilitated via EPPO (European and Mediterranean Plant Protection Organisation (e.g. diagnostic protocols, horizon scanning, risk assessments, international standards). EUPHRESCO has increased R&D collaboration. There has been lots of bilateral collaboration, e.g. with the US (Californian Oak mortality Task Force, the United States Department of Agriculture, and modelling teams. Research has also been commissioned in other countries, e.g. Fera-funded work on *Epitrix* beetles in Portugal, where the non-native pest species have been introduced and become established.
- Other regimes: e.g. The Foresight project on detection of infectious diseases cut across over animal, plant and human health.
- Invasive species: although these remain outside the Plant Health regime, the responsible European commission Directorates General talk to each other. They draw on Plant Health, but there are opportunities to learn from other areas, e.g. remote sensing.
- Other disciplines: plant health is dominated by biologists with and by biochemists to a lesser degree. We can learn from engineering (e.g. acoustic detection) and other disciplines. Social science might advise how to better engage the public in surveillance. Economists will be important in cost:benefit analyses and impact assessments.

The following points were made in the subsequent discussion:

- Increased trade and rapid transit times make it difficult to manage risks.
- What does the World Trade Organization (WTO) allow in terms or holding material and restricting movement?

- Australia has a more restrictive regime compared to the current open EU regime. It is possible under WTO to not allow new trades until risk is proven to be low.
- The introduction into the UK from continental Europe of *P. lateralis* highlighted a recent breech in biosecurity associated with a lack of regulation, since the pathogen is not EC listed.

6. Table Break Out Discussions (Sessions 1 and 2): Evidence Gaps and Opportunities

(Amendments by participants to the tables provided on the flip charts are shown in blue)

Theme 1 **(Tables 1 and 2 combined): Pest and disease biology, epidemiology, host interactions, modelling, and risk**

What would success look like?

- Preventing the arrival of new pests and pathogens
- Research enabling more enhanced and targeted phytosanitary entry controls
- Capability to respond in time
- More responsive and timely research – contingency plans
- Better-informed and effective control methods and management actions for new or established pests and pathogens
- Predict cost effectiveness of control/management e.g. avoiding ineffective/wasteful control
- Practical application of research, strongly linked to practitioners
- Uptake of control/management measures by woodland/tree managers
- Wider commitment to building plant resilience against current and future pests/pathogens
- Strategic decisions on planting
- Clarity on all costs/benefits, including non-market benefits
- Ability to determine impacts such that effective decisions on action can be taken

Research and evidence gaps (plenary feedback and additional table notes): Short term priorities

1 General biology:

1.1 A priority is new pests and pathogens that we know least about – understanding, what to 'look for', prioritised data needs (based on retrospective analysis)

1.2 Open, shared scientific exchanges that enable us to learn from the past (as well as escaping from the past). Appraisals of the research response to past invasions might also identify whether the research response was appropriate. How much emphasis should be put on host range testing; how reliable is this; can we develop better approaches to host testing?

1.3 Need to adapt classical pathology approaches and acquire data that informs: transmission rates; dispersal kernels (relating probability of spread with distance); infectious periods (how long does an infected/infested host remain infectious, e.g. is it killed or does it recover); and cryptic infectious periods (how long is the host infectious before symptoms are expressed).

1.4 Need to analyse evolutionary changes associated with introduced pests/pathogens (mutations, adaptations, hybridisation with other species): how do introduced pests/pathogens spread in new environments, free from natural enemies; how do such pests/pathogens evolve as spread occurs; can natural enemies be identified in their

habitats of origin; can genomic analysis of introduced pests/pathogens and their hosts provide benefits?

2 Learning from the past:
- 2.1 Incremental improvements – sharing of research and quick feedback
- 2.2 Longitudinal studies – impact. We should also maintain surveillance of invasions past the time official control is ended in order to better understand invasion processes, spread and resilience of native tree populations.
- 2.3 Spatial and species differences, genetic variation scale, lessons from ecology
- 2.4 Forest design to build in resilience.

3 Hosts, host testing and vegetation mapping:
- 3.1 Research should be incremental, feeding interim results quickly into risk management approaches.
- 3.2 Exposing key UK tree species to situations around the world to identify future pest and pathogen threats.
- 3.3 Genetic variation and resistance mechanisms could help with resilience; need to add pests and pathogens to other factors when considering resilience.
- 3.4 Research to improve understanding of the extent and spatial structure of genetic diversity in host tree populations, specifically for variation in susceptibility, resistance and resilience to pests and diseases. This could include controlled experiments (progeny trials) to establish heritability of pest /disease response traits for improved understanding of the evolutionary responses of tree populations to selection pressures imposed by pests and diseases. Approaches should take advantage of emerging genomic resources for tree species and of current state of the art in plant community genomics.
- 3.5 A national tree database could be considered that brought together Forestry Commission and BSBI data on species distributions, as well as county wildlife trust maps (that are often higher resolution than that provided by the National Biodiversity Network) and the very detailed tree distribution data from city councils.
- 3.6 A distinction should be made between data for strategic mapping (e.g. for national PRAs) and for emergency response (requiring higher resolution and more current data).
- 3.7 Need to consider wider microbial interactions in addition to host-pathogen or host-pest interactions (also urban and environmental trees as well as planted forestry).
- 3.8 Need ready access to host distribution and vegetation data/maps that are kept updated.
- 3.9 How can missing vegetation date be dealt with when trying to predict spread and the effectiveness of control options?
- 3.10 Greater understanding of variations in host response mechanisms.

4 Modelling:
- 4.1 Improve input data sources and parameter estimation: Can spatial and temporal signatures be extracted from incidence maps showing the spread of pests or pathogens, e.g. through optimised data collection? Can parameters be estimated using statistical methods applied to incomplete data or biased data
- 4.2 Trade pathway information
- 4.3 Convert presence/absence (of hosts) to density assessment at appropriate resolution
- 4.4 Evaluation of existing models and where these have helped.
- 4.5 Improved approaches for model communication to decision makers
- 4.6 Data collection: how best to optimise data collection from surveys and experiments to produce better spatio-temporal maps that can predict spread and impact; how best to produce data that informs transmission rates, incubation and infectious periods.

4.7 Sampling strategies: different sampling strategies are required depending on whether presence/absence is being determined, or the actual amount (density) of a pest/pathogen; mapping requires inclusion of 'negative' sample points as well as the 'positives'

4.8 Model innovations: adapt generic models for different host-pest/pathogen systems; evaluate against specific exemplars; determine and communicate uncertainty; provide models to stakeholders in formats that they can test 'what-if' scenarios; identify uncertainty in models to better inform estimation of risk.

4.9 Tractability: it is important to be realistic about what experimentation can realistically achieve, e.g. can spore dispersal distances be determined. What can be done practically in the time and resource available and how useful is it?

5 Environment:

5.1 Climate maps; stress factors.

5.2 Are species planted in the right place (stress affecting pathogenicity)?

5.3 We are mainly looking at invasives: therefore we need to find and examine their natural environments and look at what their hosts and wider ecology there.

6 Socio-economic impacts:

6.1 Better evaluations of ecosystem services and their values

6.2 Evaluate cost effectiveness of intervention strategies

6.3 Improved appropriation of non-market values

6.4 How do we determine impacts from new pests/pathogens if eradication action removes infected/infested trees?

Evidence need/opportunity ***Pest and disease biology, epidemiology, host interactions, modelling, and risk (flip chart)***	**Immediate/ short term priority? – number of dots**	**Medium/ Long term priority?**
Research on organism biology, including pest/pathogen, tree and soil interactions to improve understanding of disease aetiology and epidemiology, and inform risk analysis. This includes provision of data for use in modelling. **Land management**	**10**	
Host-pathogen interactions, especially those that may inform management strategies or breeding programmes	**3**	
More host testing – to assess impact on unknown hosts	**2**	
Further evaluation and development of generic model frameworks for practical application.	**4**	
Development, testing and application of methods for assessing socio-economic and environmental impacts in a manner that supports more rapid decision making.	**7**	
Impact of climate change	**3**	
Assessment of risks from species hybrids		
Genetic variation of trees: Research to improve understanding of the extent and spatial structure of genetic diversity in host tree populations, specifically for variation in susceptibility, resistance and resilience to pests and diseases. This could include controlled experiments (progeny trials) to establish heritability of pest /disease response traits for improved understanding of the evolutionary responses of tree populations to selection pressures imposed by pests and diseases. Approaches should take advantage of emerging genomic resources for tree species and of current state of the art in plant community genomics.	**1**	
Combining pathway (including evolution) and epidemiology *		
Host distribution (vegetation maps); variation in response		

mechanisms		
Parameter estimation **Invasiveness verses natural environments**		
Tractability (in scale with priority)		

Theme 2 **(Table 3): Detection and identification of pests and diseases**

What would success look like?

- Healthy trees and forests
- Informed and engaged stakeholders (biosecurity culture)
- Informed and engaged public
- Earlier detection (of known and unknowns) in trade and in the environment
- Technology transferred to trading partners, contributing to increased 'prevention'
- Reduced rate of entry and establishment of new pests and pathogens
- Better tools to detect pests and pathogens
- Better understanding of the impact (on outcomes) of detection tools
- Effective surveillance to detect 'change' from baseline, especially detecting new 'unknowns'.

Research and evidence needs (plenary feedback):

- Early detection is a priority since there is a clear link between early detection and success of control: we are generally good at identifying pests and pathogens (but still need some taxonomic underpinning and skills) but don't have tools for: where to look; how to look; dealing with latency issues; addressing detection and identification of 'unknown' pests and pathogens. In-field detection tools can help target and prioritise sampling.
- Pests and pathogens don't stay the same and they can develop, change and evolve; we need to monitor this and develop tools to do so.
- Can we use sentinel species in and around forests?
- Learning lessons is important, as well as horizon scanning (longer term) e.g. for changing legislation. What is working and what is not.
- The highest medium-term priority could be increased stakeholder engagement as 'eyes and ears' and increasing stakeholder/public understanding of what 'unhealthy' looks like (recognition).
- New technology could be brought to bear and many are close to application: metagenomics (especially for 'unknowns' and 'syndromes'); base-lining what a healthy tree/woodland looks like; other 'omics' approaches (e.g. looking for stress markers, for both abiotic and biotic stresses); optical remote sensing (multispectral imaging) and sniffer technologies; thermal detection of insects; acoustic detection (e.g. longhorn beetles).
- Understanding the trade landscape: what trade is moving and where.
- Generic models are useful but need pest specific information and baseline data. Statistical design can help in determining how to deploy detection methods and how much resource to put into surveillance etc.
- Need to consider the whole supply and production chain including in the country of origin (critical control points; chain analysis) in order to reduce risks of introduction. This is important since it is not possible inspect all imports 100% effectively at the point of entry.

Evidence need/opportunity ***Detection and identification of pests and diseases (flip chart)***	**Immediate/ short term priority?**	**Medium/ Long term priority?**
Developing and deploying statistical and modelling tools and SOPs (for decision making and implementation) to inform surveillance planning	**H**	
Development and use of in-field tools which best ensure early detection of pests (including unknowns)	**H**	
Routine surveys to audit nurseries to look for **any** new and evolving pathogens, particularly those that pose the most risk in this environment such as phytophthoras, not just surveys for organisms on quarantine lists	**H**	
Development of new technologies for gathering, managing, analysing and using data in support of surveillance and monitoring activities	**H**	
Analyses and lessons-learned reviews from past or current campaigns and Biosecurity failures in the UK, Europe or more widely, with respect to early detection and surveillance and monitoring	**M**	**H**
Improved understanding of public/stakeholder awareness of non-native pest issues and strategies for engaging them more in the detection and reporting of incursions or outbreaks **(include horizon scanning)**	**Very H** Q:What does healthy look like?	
Improved networks for environmental surveillance and surveys (improved training in symptom recognition), possibly through citizen science approach.		
Taxonomic research to better underpin diagnostic methods, pest risk analysis and legislation.	**L**	**M**
Modern metagenomic approaches such as Next Generation Sequencing (NGS) could be a powerful tool for rapidly identifying both **known** and **unknown** causal agents from samples **and microbial populations**	**H**	
Recognising 'healthy' in the context of 'declines'		**H/M**
Understanding Trade landscape	**H**	

Theme 3 **(Table 4): Prevention and Control (including novel solutions)**

What would success look like?

- Number of invasives over time would decrease through resolution of organisational issues and potentially research (though accepting that invasives often don't become apparent until several years/decades after initial introduction, so a lag should be accounted for when measuring success in this way).
- Rapid evidence-based implementation of eradication, containment and control actions against those pests and pathogens that do enter , leading to healthy trees
- IPM (integrated pest management) for established problems.

To achieve 'rapid evidence-based reactions', resources need to be deployed early. The evidence required to inform this would be PRAs (Pest Risk Analyses) for known threats. The nature of the

response is dependent on the degree to which the threat is understood, its impact and if it is endemic/exotic.

Research needs and gaps (plenary feedback):

In addition, or supplementing, those in the tale below:

- Learning from past successes and failures: depends on what questions are being asked and we need to tailor lessons flexibly to new challenges; information may be fragmented, but could be drawn together and made available to those working on the ground.
- Models and Decision Support Schemes (DSS): PRA methodology might need refining; need more generic approaches when information is not available on a new pest or pathogen; have more contingency planning.
- Novel control: tailor this by taking out generic control since each pest has its own requirements. Better implementation of what we know. In the longer term, we need more novel approaches.
- Difficult to prioritise between areas especially since these are at generic levels. Need to use a matrix approach which is more pest specific.
- Matrix Table identifying priorities (voted by ●) and quick wins (Q):

	Pests/Pathogens which are **Coming**	Pests/Pathogens which are **here**	Pests/Pathogens which are **established**	?
Lessons	●	● Q	Q	
Models	●	●●		
Novel control		●●		
Novel disinfestation	Q	Q		
IPM - current	●	●●●●	●●	
Resilience	●●●	●	●●	●
Target samples	Q	Q		
PRA	Q ●			
Outbreak Monitoring	●	●●●		
Watch	●			

Evidence need/opportunity ***Prevention and Control (including novel solutions) (flip chart)***	**Immediate/ short term effect**	**Medium/ Long term effect**
Analysis and lessons learnt from past biosecurity failures and successes, e.g. with respect to intervention strategies (eradication and containment actions)	√	
Models and decision-support systems that inform policy decisions on action against outbreaks of invasive non-native pests and pathogens of trees		√
Development of novel ~~and/or generic control~~ and management methods, e.g. novel biosecurity and disinfection/disinfestation approaches for imported propagating material	√	√
Application of existing methods		
Evaluate the efficacy of treatments and controls in order to inform future management strategies	√	
Behavioural change, e.g. determining best approaches to increase stakeholder responsibility and cooperation, including best	√	

management practices etc		
Approaches for future proofing against future threats (potentially including: working with trading partners; plant breeding; planting strategies). Strategic research into how to increase resilience of trees to pest and pathogens and climate change through the identification of resistance/recovery genes to enhance plant selection and/or breeding programmes		√
Surveys of areas **in the UK** that may harbour high risk pathogens **because of local factors**		
PRA* (underpins/ links with 3, 4, 5, 8, 10 and 11)		
Rapid reaction research **Science input to monitoring/outbreak management (links to 1)**	√	
IS (Information system?) outbreak studies specific		

Theme 4 **(Table 5). Awareness and behaviours (understanding and influencing behaviours)**

What would success look like?

- Informed and engaged stakeholders (including owners with a biosecurity culture)

Research needs and gaps (Plenary feedback):

- Initial broad stakeholder analysis and mapping – who are the stakeholders and what makes them tick and what affects their behaviour.
- Role for valuation studies in understanding the suite of values that trees bring to us and inform decision making and understanding of impacts; draw on existing studies.
- Governance: tree-health-focused analysis comparing our governance system with other countries; review the role use of regulation, economic instruments and incentives.
- Behavioural change: draw on other sectors' experience and bring this to tree health.
- Understanding the industry (timber, nurseries etc): understanding the industry structure and risk pathways for pests and pathogens.
- Public understanding: possibly consider as part of stakeholder analysis; how does the public understand tree health problems; what are the barriers to understanding.
- Assessing scope for the use of citizen science: although there was some scepticism, we could better utilise this and explore if we are missing a trick here. Identify how citizen scientists handle and identify data. Data from the public is very valuable (e.g. horse chestnut leaf miner) allowing science; it can be used in some cases but not all. How do we define citizens: could be 'the public' (e.g. for urban trees); could be specific woodland managers (for forests and woodlands). Look at Natural History Museum project in relation to methodology.
- Risk: we have a lot of evidence already and ways of communicating risk; apply this to tree health.
- Landscape governance (including nursery schemes): Can exist schemes be used for trees (e.g. monitoring of woodland assurance scheme).
- Who owns woodlands: this is not known very well; need large-scale land ownership survey.

- Valuation: how do you appropriate values to a private landowners; consider 'appropriation values; stakeholders would be more engaged if there was a way to 'appropriate' value.
- The biggest gap is in applied social science and economic analysis. What motivates key actors? Generic issues relating to behaviours.
- Learn and apply what known elsewhere, e.g. from Behaviours Centres.

Evidence need/opportunity ***Awareness and behaviours (understanding and influencing behaviours) (flip chart)***	**Immediate/ short term priority?**	**Medium/ Long term priority?**
Understanding public awareness and determining best approaches for increasing it		
Understanding and influencing public and stakeholder motivations and behaviours For example, how can we incentivise nurserymen/landowners/merchants to take biosecurity more seriously and to look for and report pest problems? How could we influence plant sourcing/buying behaviours (both in the industry and for the public)? Research into the role of economic instruments		
Stakeholder engagement: developing new approaches and adopting best practice, including learning from other areas (public health; animal health) and other countries		
Introduction of certification schemes into nurseries **(not only nurseries)**		
Stakeholder analysis and mapping	**Yes**	
Extend and better utilise valuation systems		**M**
Governance analysis (comparative analysis; role of regulation; use of economic instruments)	**Yes**	
Learn and apply behavioural change knowledge	**Short and Medium**	
Understand industry structure and risk pathways (prior to box above on 'introduction of certification schemes')		**M**
Assessment of broad public understanding of plant/tree health issues	**Yes**	
Assessing scope for increased citizen science	**Yes**	
Application of risk knowledge / evidence to tree health		
How can established landscape-scale governance structures promote tree health science, e.g. understanding the role of certification schemes		
Large-scale land-ownership survey		
Educating the next generation is important		

Note: Generally, immediate research needs are under researched

7. Discussion Session 3: Implementation

Table Group 1:

- Three key areas: mapping host distribution; bringing together existing databases in a coordinated way in order to identify priority gaps; respond to unknowns by engaging more people and by understanding their motivations and providing incentives for their participation.

- Contingency funds for rapid responses to emergencies.
- Motivations: nurseries may have many of the 'unknowns', we need their cooperation and reporting of new things; how do we incentivise such cooperation.

Table Group 2:

- Governance and management of new pests and pathogens: there is a lack of cohesion in existing arrangements; responsibilities are split between different agencies and different funders; there is also a split between regulation and science; a '*new pests and pathogens forum'* may be an idea to bring together scientists, policy makers, stakeholders and funders to address medium-term responses and longer-term R&D requirements (sub groups on individual pests and pathogens could be envisaged). This forum could be used at an early stage when there are new emergencies/introductions.
- Modelling: there is scope for a modelling toolbox, i.e. providing existing models in a format that can be assessed for their application for new pests and pathogens. How can we communicate modelling to wider stakeholders so that they can test their utility, e.g. using models to test hypotheses (two way process between modellers and stakeholders); models are often not trusted because they are only as good as their assumptions; how can we make models understandable and usable by end-users; how can we compare risks from different pests and pathogens and different control strategies.

Table Group 3:

Potential funding sources could be explored, including:
- Earth observation: approach UK Space Agency to explore (as a case study) how this could be used for tree health and for tree location (tree species mapping).
- Molecular diagnostics: this is driven by companies developing the equipment; work with Technology Strategy Board (TSB) and companies with respect to a technological push on tree pests and diseases.
- Build on the current public resonance related to trees and forests: is there any interest from the National Lottery or the Welcome Trust with respect to tree health and the benefits from trees.
- It would be good to see something done jointly via LWEC, especially, more generic issues of diagnostics and translational science, with Defra and FC and Research Councils.
- Europe: COST Actions and ERA-Nets.

Table Group 4:

Table 4 used a matrix to first identify areas for quick wins (specific questions), then voted on priority areas for research:
- Quick wins: lessons from the past (paper exercise); small projects looking at novel disinfestations/disinfection methods (e.g. keeping chain saws clean); replacements for old methods (methyl bromide).
- Target samples: use existing knowledge relating to where new pests and pathogens are most likely to arrive.
- PRAs needed for non-native pests and pathogens that are on our door step, as well as contingency plans.

Longer-term:

- There was good support for a better understanding of IPM for pests and pathogens that we already have; scope to put together management techniques, including alternative species.
- For pests and pathogens on the horizon and likely to arrive: the main defence is resilience (species diversity genetic diversity; having unstressed trees); how can you make a resilient system economically.
- From Oak Processionary Moth (OPM) experience: need to make decisions quickly with little information; may need to assess controls in a single season. Need to divert resources to practical applied work and learn from other countries (what do they use for control).
- Need to ensure that practical control trials are reported and captured in the literature; there is a journal for this, so make sure these studies and results aren't lost.

Table Group 5:

- We have a coherent research agenda but not a funding mechanism.
- Something like a RELU tree health initiative was desirable (inter- or multi-disciplinary; problem-focussed; merging effort of university and applied researchers; with good stakeholder engagement). However, Research Councils have already made funding allocations and have planned programmes; they may be impervious to political pressures. Therefore, a RELU-type approach may not feasible; if so, the following alternatives could be possibilities:
- The European Union's 8th Framework Programme (FP8) may be an opportunity (from 2013) and we need to influence this agenda.
- ESRC (strategy areas around 'influencing behaviours' and 'risk' themes; and existing centres) may provide some opportunities.
- It may be possible to pump-prime partnerships via government agencies by way of some initial small steps, e.g. co-funding of fellowships to get some of these activities going.
- Partnership funding involving some of the following: Defra, Forestry Commission, Scottish Government, ESRC and NERC.

8. Concluding Remarks (Bob Watson):

Bob Watson thanked everyone for their contributions and gave particular thanks to Alan Inman and others for preparing the background paper. He summarised the outcomes of the day saying that there was no major disagreement from the workshop participants with the background paper and that there was general agreement about the value and importance of many evidence needs and opportunities, including: adopting a multidisciplinary approach (including social science and economics), Modelling, Governance, funding (in terms of partnership working and potential to redirect funds from lower priority areas)

Bob said that benefits would be realised from improved prevention/exclusion, better and earlier detection and surveillance, enhanced action/control and better approaches for living with new pests and pathogens. He also emphasised that it is essential to link R&D to management in the field and what does success looks like. Further work is now required to identify the highest priorities to inform the Tree health and plant biosecurity Action Plan.

ANNEX A

SECURING TREE HEALTH IN A CHANGING ENVIRONMENT

Research Workshop Agenda

OBJECTIVE - *To identify and prioritise evidence and innovation gaps (specific and generic, immediate and long-term) to secure tree health in a changing environment*

Timing	Session	Lead
09:30	(Registration and tea/coffee)	
	CHAIR – Andrew Watkinson	
10:00	Welcome and aims for the day	Bob Watson
10:05	Issues and drivers of change in risk	Andrew Watkinson
10:20	Drivers of change a changing environment	Bob Watson
10:30	Priority pests and diseases 10:30 Overview presentation 10:40 Discussion	Peter Freer-Smith
10:55	Learning from other areas 10:55 Overview presentation 11:05 Discussion	Martin Ward
11:20	**Table breakout discussion (i)** Evidence/research gaps and opportunities for managing risks and impacts from current and future tree pests and diseases. Four themes: T1) Pest and disease biology, epidemiology, host interactions, modelling and risk T2) Detection and identification of pests and diseases T3) Prevention and control (including novel solutions) T4) Awareness and behaviours	Miles Parker
12:30	Lunch	
13:10	Plenary feedback from tables on session **(i)**, and discussion	Miles Parker
14:10	**Table breakout discussion (ii)** Evidence gaps and opportunities (continued): Tables discuss a different theme	
15:00	Tea/coffee including opportunity to annotate table outputs	
15:30	**Table breakout discussion (iii)** Evidence gaps and opportunities – linking across themes and implementation options	
16:10	Plenary feedback from tables on sessions **(ii) (iii)** and discussion	Peter Freer-Smith
16:45	Concluding remarks	Bob Watson
17:00	Close	

ANNEX B

SECURING TREE HEALTH IN A CHANGING ENVIRONMENT

RESEARCH WORKSHOP: LIST OF PARTICIPANTS

Name	Organisation	Table no. (discussion group)
Baker, Richard	Food and Environment Research Agency (Fera)	1
Bosch, Frank van den	Rothamsted Research	2
Bray, Jo	Defra	1
Brasier, Clive	Forest Research	2
Brown, Anna	Forest Research	2
Cavers, Steve	Centre for Ecology and Hydrology	1
Cooke, David	James Hutton Institute	3
Coppock, Roger	Forestry Commission	4
Costigan, Peter	Defra	3
Dandy, Norman	Forest Research	5
Denman, Sandra	Forest Research	3
Freer Smith, Peter	Forestry Commission and Forest Research	4
Gilligan, Chris	University of Cambridge	2
Grant, Murray	University of Exeter	2
Green, Sarah	Forest Research	3
Harding, Debbie	BBSRC	1
Harper, Wilma	Forestry Commission	3
Harris, Brian	BBSRC	2
Jackson, John	Royal Forestry Society	1
Jeger, Michael	Imperial College, London	1
Kirkham, Tony	Royal Botanic Gardens, Kew	4
Leather, Simon	Imperial College, London	4
Meagher, Tom	University of St Andrews	2
Meddins, Nia	Welsh Assembly Government	3
Mumford, Rick	Fera	3
Northing, Phil	Fera	4
Parker, Miles	Defra	2
Petter, Francoise	EPPO	3
Pocock, Michael	University of Bristol	1
Popple, Sue	Defra	1
Potter, Clive	Imperial College, London	5
Quine, Chris	Forest Research	5
Richards, Geraint	Duchy of Cornwall	4
Rothnie, Bruce	Forestry Commission, England	1
Shaw, Michael	University of Reading	4
Siasou, Eleni	University of Aberdeen	2
Siddons, Richard	Forestry Commission, Wales	2

Slawson, David	Fera	5
Straw, Nigel	Forest Research	4
Turner, Judith	Fera	2
Ward, Martin	Fera	4
Ward, Meredith	Defra	5
Watkinson, Andrew	Living With Environmental Change (LWEC)	5
Watson, Bob	Defra	1
Webber, Joan	Forest Research	1
Wilding, John	Clinton Devon Estates	5
Xu, Xiangming	East Malling Research	4
Organising team		
Barkham, Mary	Living With Environmental Change (LWEC)	-
Bejta, Justine	Defra	-
Inman, Alan	Defra/Fera	-