Forestry Commission England

Annex 1

Critical Research Questions for England, Required to deliver the Strategic Research Outcomes of The Science And Innovation Strategy 2015-2020

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1. Background

The requirement for and benefits of government funded forest research are encapsulated in the Science and Innovation Strategy for Forestry in Great Britain 2014 [1]. The strategy, launched by Sir Mark Walport and signed off by country ministers, provides both the rational and framework for the outcomes future research should deliver, as well as how its success will be measured. This document lays out England's most important questions to answer, in order to achieve the desired outcomes of the strategy.

The topics themselves were constructed following a process of extensive stakeholder engagement. The set of base questions was derived from Forestry Commission England's input to the Science and Innovation Strategy [2], a document compiling the outputs of six stakeholder discussion forums on England's top research priorities. These topics have been further challenged and scrutinised both internally and through another round of research focus group events which took place in May 2014, to produce the critical research topics highlighted here. Questions have been further refined and brought into line with government policy at a workshop in May, to ensure they make a significant long-term contribution to government priorities. A final stakeholder workshop took place in July 2014 to further improve the accuracy and reliability of this list.

Each topic has been brought into focus using a select number of research questions. A very brief section has been provided for each question to further elaborate the context, research needs and relevance of each question. This should provide a flexible framework for researchers to work within, delivering clear guidance on what is needed, without overly restricting how that research is undertaken.

The aim of this report is to provide strong evidence of England's priorities when commissioning government funded forest research programmes to cover the period 2015-2020. The intention is that these will effectively deliver the benefits of stimulating economic growth, maximising well-being and protecting our environment – without negatively affecting the ability of future generations to do the same, through evidence based forestry.

[1] FORESTRY COMMISSION (2014). *Science and innovation strategy for forestry in Great Britain.* Forestry Commission, Edinburgh

[2] FORESTRY COMMISSION (2012). *England Input to the Revision of the Science and Innovation Strategy for British Forestry.*

2. Outcomes Focused Research

The new Science and Innovation Strategy sets out the outcomes desired from future research programmes (Figure 1). The questions below are therefore outcomes focused, showing clearly what questions need to be answered in order to deliver the desired outcomes.

The outcome which the research question would most clearly deliver against has been highlighted in that colour.

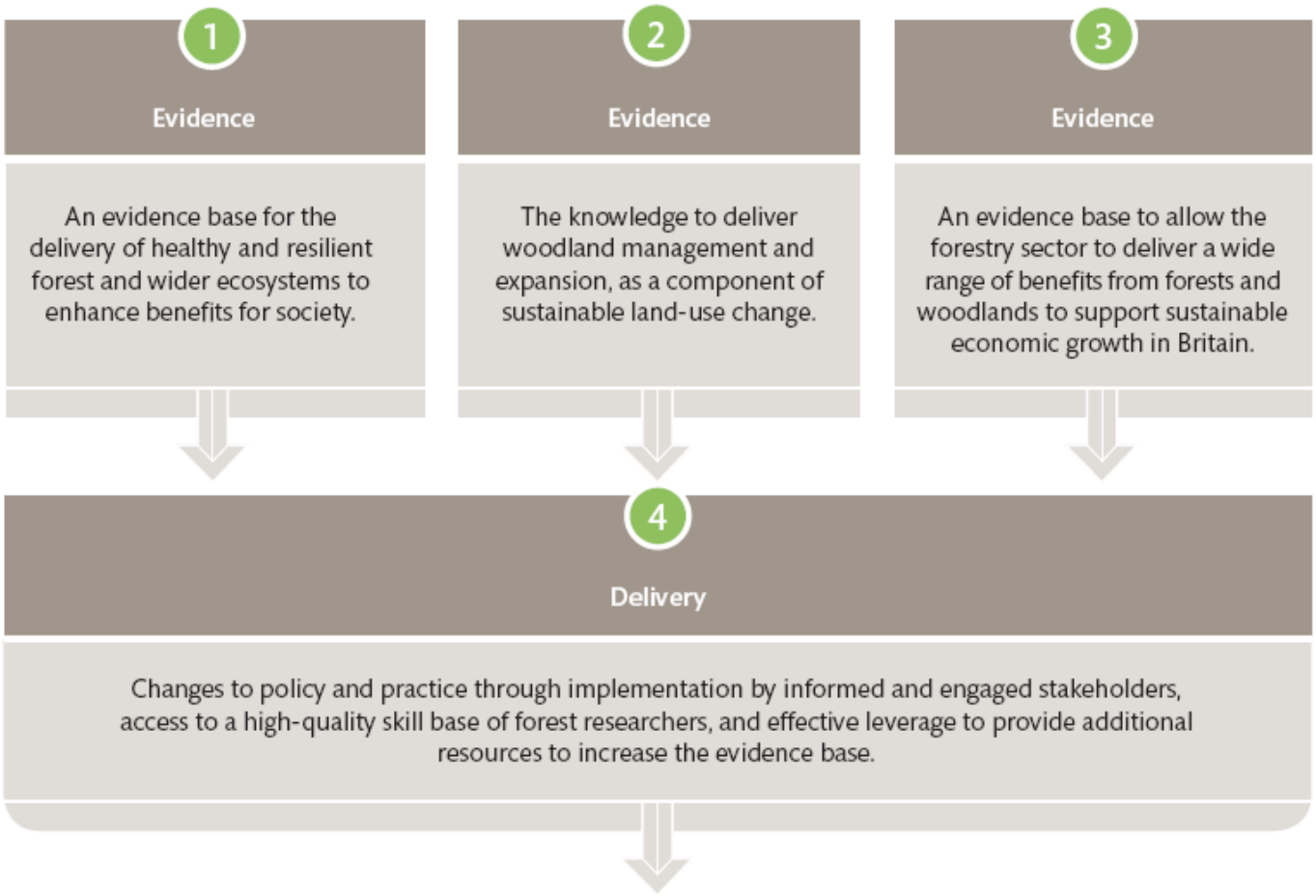
Those which would lead to the outcome of healthy and resilient forests and wider ecosystem benefits for society are in Green.

Those which would lead to the outcome of knowledge to deliver woodland management and expansion, as a component of sustainable land-use change are in Red.

Those which would increase the evidence base to allow the forestry sector to deliver a wide range of benefits from forests and woodlands to support sustainable economic growth in Britain are in Blue

Those which lead to changes in policy and practise through implementation by informed and engaged stakeholders, access to a high-quality skill base of forest researchers, and effective leverage to provide additional resources to increase the evidence base are in Purple

Figure 1: Outcomes targeted by the Science and Innovation Strategy 2015-2020



3. Priority for Government forestry research funding.

Each research question has been given a ranking between 1 and 4 to indicate the level of priority funding it should receive. This was initially done through a voting exercise carried out by Forest Services' National Expertise Team, drawing on experience from a series of research focus groups. This ranking was further scrutinised with stakeholders in July 2014.

Rank order:

1. This is essential and urgent research which we would expect to receive high levels of forestry government funding in this set of research programmes. This is research where it is primarily the Forestry Commission's responsibility to fund.

2. This work is essential and should receive at least some Forestry Commission funding during the next research period. Funding for some aspects of the research however, may come from private/partnership sources.

3. While this work is very important, we would not expect it to receive a significant proportion of the government funds available in the next research period. Any major research programme therefore would be predominantly funded by external parties.

4. While this work remains highly valuable, we would not expect that government funding would be made available for these projects, unless doing so would attract significant external funding as a result which would allow other resources to be applied to other higher priority areas.

4. Protect

Protection of our trees, woods and forests, especially our ancient woodland, is our top priority. The ability of science to improve our understanding of resilience is therefore seen as a great opportunity. Resilience here means a forestry sector and woodland resource that keep growing, providing multiple benefits; which are sustainable and affordable; and are well equipped to respond to existing and future threats without requiring more and more intervention by Government, as defined in the Forestry and Woodlands Policy Statement. There is therefore a need to understand and manage the key threats posed to England's woodlands, for example from pests, diseases, livestock grazing and diffuse pollution. The greatest threats to UK woodland have been identified as pests and disease. These effects are potentially exacerbated by climate change, which itself is recognised to be a significant threat to UK woodlands. Pests and disease also present the biggest threat to woodland biodiversity in England. For disease, *Chalara* and acute Oak decline are considered highest in England for woodland biodiversity impact; while for pests, populations of some deer species are currently considered to have the highest adverse effect. High populations of grey squirrels are also a significant threat.

4.1 Evaluating woodland resilience

Evaluating the resilience of new tree species

Critical Research Questions:

- How can the resilience of trees to pest or disease threats be evaluated at a range of scales?

Context: The resilience of tree species against pest and disease threats needs to be thoroughly evaluated to help the sector to make choices about which species are promoted that will increase resilience. The new tree species may not be more resilient than those that are already growing in Great Britain or alternatively could make the situation worse. This problem could extend to all categories of woodland type and owners objectives.

Research needs: What criteria can be used when evaluating resilience (consult Kew and Royal Horticultural Society)? What methodology can be used as a framework for applying the criteria?

What is needed to evaluate the current candidate list against a range of criteria? The FC currently suggests the use of a wider range of tree species[1]. Have we screened these species for susceptibility to current and on the horizon, pests and diseases?

[1] http://www.forestry.gov.uk/fr/INFD-8CVD6H
http://www.forestry.gov.uk/forestry/infd-8mad67

Science and Innovation Strategy (SIS) Outcomes: An evidence base for the delivery of healthy and resilient forest and wider ecosystems to enhance benefits for society. Evaluating approaches to woodland adaptation and increasing resilience, focusing on composition (species, origin, diversity and stability of ecological communities).

Priority for Government forestry funding: 1

- What tree species and silvicultural systems should we be encouraging to produce resilient woodlands and what are their requirements?
- How can breeding and selection for resistance to pests, disease and climate change improve long-term resilience?

Context: The Read Report, the UK Climate Change Risk Assessment and FCE's Adaptation Reporting Power (ARP) report highlighted the risks that climate change and pests and diseases present to the current limited palate of species (native and exotic) available to English forestry and woodland management – including the reliance on monoculture-based management systems. The limited adaptation actions being implemented were outlined in the National Adaptation programme, the Committee on Climate Change's Adaptation su-Committee ASC's 2013 Progress Report and FCE's ARP report, along with the significant barriers to species diversification. For native woodland, the accepted norm has been that local provenance is best because it is adapted to local conditions. This assumption is questionable in the light of climate change projections – but is generally still accepted. Evidence from provenance trials (and production forestry) highlights the improvements in performance that can be achieved through appropriate provenance choice – and the consequences of inappropriate provenance selection. This is included in existing FC guidance that recommends selecting seed origins from up to two degrees south of the planting site – but also provides strong guidance against selecting eastern European seed origins. For a range of reasons, there is reluctance to utilise the available genetic resource, while limited seed availability has resulted in planting stock being inappropriate to UK conditions.

Research needs: Evaluating the alternative silviculture techniques and tree species required to create / develop when restocking woodlands resilient to climate change and future tree pests/diseases. Clear and unequivocal guidance on appropriate 'alternative' species to plant for species diversification, including: site and climatic requirements; susceptibility to pests and diseases; ecological traits; management prescriptions; risk of becoming invasive or harming native biodiversity; timber quality and uses. Guidance should be based on evidence from existing trials and collections, knowledge from elsewhere in the world, anecdotal records in forestry literature and FC records. Limited new trials could be established to test early growth, establishment requirements, pest and disease susceptibility and physiological studies/model parameterisation. Large-scale operational trials, integrated within conventionally managed forests, should be established in preference to small-scale conventional research trials managed to exacting standards. A collation of existing evidence on how appropriate provenance selection can improve performance at a particular site and be used to adapt to particular climates – for both native and exotic species. The evidence should be interpreted into clear and unequivocal guidance on how provenance should be used to extend the range of native and exotic species as climate change progresses. The guidance (and supporting evidence) should be focussed on specific woodland objectives (semi-natural woodland; productive native woodland; productive exotic species) and include guidance on appropriate provenances of commercial conifers (on the

basis of existing trials) where available. The establishment of new research/demonstration plots should be considered.

SIS Outcomes: Evidence to support the delivery of healthy and resilient woodland ecosystems; evidence to support changes to policy and practice. Evaluating approaches to woodland adaptation and increasing resilience, focusing on the composition (species, origin and diversity and stability of ecological communities) and management systems (silviculture and regeneration systems) that effectively address climate change concerns. This theme should include understanding of forestry from regions that currently experience climates similar to those anticipated in England in the future.

Funding sources: This is strategic research to underpin resilient forestry in the UK and, as such, FC should be the principal funder. Co-funding from the processing sector should be sought to support relevant timber properties research, while the nursery sector should be expected to take on germination studies and nursery requirements for 'alternative species, with some co-funding made available by FC.

Evidence to support the use of genetic variability and provenance selection as an adaptation/resilience measure is a strategic priority and should be funded by FC. However, for native woodland, co-funding from conservation agencies and environmental NGOs should be sought to gain 'buy-in' to the approach. For productive forestry, the evidence base would have commercial value and, as such, industry/seed house co-funding should be sought. Research involving genetic manipulation would be attractive to Research Councils.

Priority for Government forestry funding: 1

Acid sensitive catchments

- Do we know enough to prevent further damage and return afforested acid-sensitive catchments to good ecological status without unnecessary impact on the forestry sector?

Context: A new Practice Guide outlines measures to protect acid sensitive catchments from the negative impacts of forestry. Some of the requirements are potentially high cost while evidence of the negative impacts of forestry, particularly in 'at risk' catchments is limited.

Research needs: Research is required to establish the scale, location and intensity of long term monitoring, including in 'analogue and representative catchments' to minimise the burden on the sector while ensuring adequate protection of the freshwater environment.

SIS outcomes: Knowledge to deliver sustainable land-use change, specifically, helping to manage ecosystem services, such as sustainable flood management, and protection of soil and clean water resources. Also, evidence to support the delivery of healthy and resilient woodland ecosystems; an evidence base to allow the sector to deliver a range of benefits to support sustainable economic growth; evidence to support changes to policy and practice.

Funding sources: FC should fund the work to ensure that UKFS is complied with at minimum burden to the sector. Co-funding (including in-kind data provision) from water regulators should be sought as this is an area of shared interest. Co-funding from LWEC might also be appropriate, if the work is part of an integrated monitoring framework.

Priority for Government forestry funding: 2

Pest susceptibility and behaviour

- How are host susceptibility and pest behaviour influenced by changes such as climate change, changing silvicultural practice and changing age structure?
- What interaction is there between the impact of newly established and endemic pests?
- What impact can introduced pests have on native species occupying the same niche?

Context: Woodland that is susceptible to pests is of less value to society i.e. Intervention to control pest outbreaks imposes environmental and socio-economic costs. These may ultimately lead to a reduction in the perceived value of woodlands and thus pose a risk to future investment. Improving woodland resilience should minimise or avoid these costs but the understanding and/or evidence required to properly advise owners and managers is incomplete.

Research needs: Much greater understanding of the biology and ecology of major pests identified on the risk register, both exotic and native, is an essential first step to being able to devise appropriate adaptive strategies and responses.

SIS Outcomes: An evidence base for the delivery of healthy and resilient forest and wider ecosystems to enhance benefits for society. Evaluating approaches to woodland adaptation and increasing resilience, focusing on composition (species, origin, diversity and stability of ecological communities).

Priority for Government forestry funding: 1

4.3 Improving woodland resilience

Management techniques to protect woodland and promote resilience

Critical Research Question:

- What adaptive strategies and management techniques, including silvicultural systems such as coppicing and pollarding, can be developed to reduce the risk and effects of pests and diseases and what are their impacts?
- How can we better instigate behaviour change in owners to enable and encourage a more co-operative approach to the management of forests?
- How can we better build consensus with the public on controversial methods to manage pests and disease such as wildlife management, biological control, lack of intervention and use of pesticides?

Context: The UK Climate Change Risk Assessment (CCRA) and FCE's Adaptation Reporting Power highlight the risks of not adapting forest management to the future effects of climate change. Evidence has been presented outlining how adoption of alternative silvicultural systems can be used as an effective measure to increase resilience. However, there is limited understanding of Continuous Cover Forestry (CCF)/ Alternatives to Clearfell (ACF)/Least Impact Silvicultural Systems (LISS) in mainstream forestry in England and, in particular, of impacts on the economics of forest management. The impacts of adaptive strategies need to be understood by owners so they can approach contingency planning in a risk based manner which is appropriate for their management objectives. Further research is required to better understand public attitude and engagement with pest management. There is therefore a strong call for greater behavioural insight to better understand the most effective ways to engage and support landowners' collaboration to ensure sustainable, well-managed wildlife populations, control of invasive species and encourage natural regeneration. More owners managing their woodlands and greater support from the public provide some of the best opportunities for improving woodland resilience.

Research needs: Comparative evidence on the relative benefits of different alternative silvicultural systems adaptation to threats such as climate change, including decision support systems, economic analysis and practical guidance to support implementation. The establishment of demonstration plots should be considered to effectively communicate best practice. What effective methods can be used to reduce the numbers, halt the spread and reduce the adverse impacts of deer and how can barriers to their uptake be overcome? What are the most effective methods to limit grey squirrel damage? There is a need for more evidence on the effectiveness of utilising predatory species to reduce the impact of pest species, in particular, evidence on the possible use of pine martens against grey squirrels.

SIS Outcomes: Evidence to support the delivery of healthy and resilient woodland ecosystems; evidence to support changes to policy and practice.

Funding sources: This is strategic evidence to support forestry practice, so FC should be the principal funder. However, conservation agencies may have an interest as may Living with Environmental Change (LWEC); co-funding should be considered. Conservation agencies may share an interest in supporting behavioural research for controversial management techniques.

Priority for Government forestry funding: 1

Detecting and responding to outbreaks

Critical Research Questions:

- How can the rapid detection of pests be improved?
- How can we better understand and respond to pest introduction pathways?
- What can we do to achieve a better understanding of how the outputs of modelling can be interpreted to inform pest response strategy?
- How do we improve our ability to respond appropriately to the priorities identified through the risk register and contingency planning processes (to include short-term work to prepare PRAs)?
- How can we improve our use of diagnostic techniques?

Context: The woodlands in Great Britain have proven to be inadequately protected against introduced pests. Adequate intervention measures are essential to treat pest outbreaks and prevent damage to hosts. There can be a number of obstacles to implementation of control measures, such as the financial cost of the measure or public attitude to control. The absence of control options and / or the lack of means to overcome obstacles to their implementation may result in increased socio-economic and environmental costs. These may ultimately lead to a reduction in the perceived or actual value of woodlands and thus pose a risk to future investment and utility. The understanding and/or evidence that is required to recommend effective controls and to overcome obstacles to implementation is incomplete.

Research needs: How can we optimise the effectiveness of existing aerial surveillance for specific circumstances (spatial and temporal considerations)? How can we evaluate the feasibility and cost-effectiveness of alternative methods of surveillance? What are the barriers to implementation of alternative surveillance methods (e.g. social acceptance and cost, regulatory, logistically)? What are the short-term solutions to enable the rapid detection of pests and their outbreak eradication or control? How do we address the risk posed by unrecognised or informal pathways which are not adequately controlled in relation to pest introductions? What role does seed play as a potential pathway for the introduction of tree pests? What use can we make of indirect indicators for early detection, particularly at ports of entry? How can epidemiological modelling be best deployed to predict pest dynamics on arrival? How can climate change modelling be used to predict pest epidemiology under different scenarios? What emerging diagnostic techniques can we adopt for use on existing platforms (e.g. Genie, LFD, and real-time PCR)? How can we remain alert to newly developed diagnostic techniques? How can we improve our understanding of the interpretation of results from diagnosis (what is the epidemiological significance of confirmed infection)?

SIS Outcomes: Answers to these questions will help to deliver against outcome 1, an evidence base for the delivery of healthy and resilient forest and wider ecosystems to enhance benefits for

society. Specifically the section on understanding the impact of invasive pest species at the ecosystem level and finding technically and financially effective ways of anticipating new threats, rapid detection and identification, monitoring and improving response strategies, modelling, biosecurity controls and practical measures for addressing them.

Priority for Government forestry funding: 1

Indicators for effective biosecurity

Critical Research Question:

- What appropriate success criteria and indicators might be used to select biosecurity response options and to monitor their effectiveness and how would these be chosen, used and evaluated?

Context: There is no accepted method to evaluate the impact of biosecurity measures. We don't have the means to determine whether we are getting the best value from the resources deployed. Without a comparable baseline it is not possible to say whether the measures that we are putting in place make any difference on outcomes. A particular issue is that success will result in absence of a problem, yet significant resource may be required to maintain that state.

Research needs: What can we learn from the way that other countries have evaluated the impact of biosecurity measures? What is the most appropriate methodology to use for option evaluation? What are the critical success criteria (indicators) for different evaluation scenarios (i.e. policy option responses)? How can biosecurity indicators be applied to evaluate probability x impact? What means have been most effective at delivering best practice in the different sectors?

SIS Outcomes: Outcome 1 through understanding the impact of invasive pest species at the ecosystem level and finding technically and financially effective ways of anticipating new threats, rapid detection and identification, monitoring and improving response strategies (by development of an agreed methodological framework[1] for determining the 'best' policy option response to a potential threat (pre-border/border) or actual threat (inland)).

Priority for Government forestry funding: 1

[1] See: Baker, Simon. (2006) "The eradication of coypus (Myocastor coypus) from Britain: the elements required for a successful campaign." *Assessment and Control of Biological Invasion Risks. Shoukadoh Book Sellers, Kyoto, Japan and IUCN, Gland, Switzerland*: 142-147.

4.4 Utilising social science effectively

Behavioural insight and public engagement

Critical research questions:

- How can the effectiveness of citizen science projects be evaluated and improved?
- What are the most effective methods to inform, enable, engage and deliver useful results from the public on issues such as biosecurity, increasing woodland resilience and climate change (for example through citizen science programmes, community ownership and management)?

Context: Government cannot win the fight against pests and diseases by itself. Industry, landowners, civil society organisations and the wider public all have a role to play to deal with these immediate threats and make our woods more resilient in the long term. Citizen science is increasingly being utilised as a method of monitoring and reporting on the detection of emerging and existing pests and disease and for population and distribution data for biodiversity. We are uncertain whether we are making the most of and getting best value out of citizen science projects, and ensuring those involved are benefitting so that we build knowledge and expertise, in the wider sector, so and we need the means to evaluate this. Very few citizen science projects are designed with the necessary metrics embedded to evaluate benefits to all those involved. Although citizen science is relatively new there have been a number of tree-related projects which could be evaluated to determine whether the effectiveness of achieving the broad range of objectives under consideration.

Research needs: How do you evaluate citizen science projects? What makes a good citizen science project? How can the information obtained be used effectively (to include the processes of data interpretation and processing)? How cost effective is it against other methods of surveillance? How do we ensure we transfer knowledge and build skills and capacity in the wider sector? How can we increase the value from these types of projects?

SIS Outcomes: Outcome 4: Changes to policy and practice (i.e. improved efficiency and effectiveness) through implementation by informed and engaged stakeholders, access to a high quality skill base of forest researchers, and effective leverage to provide additional resources to increase the evidence base

Funding Sources: The Woodland Trust have expressed an interest in further supporting research projects which would answer these questions.

Priority for Government forestry funding: **2**

Knowledge transfer and raising capacity

Critical research questions

- What are the barriers to behaviour change which will ensure that the results of the research are adopted and become part of mainstream activity?
- How effective is traditional knowledge transfer and is moving away from this approach towards "knowledge exchange" and "knowledge Integration" achievable and effective?

Context: Many pieces of research do not consider how best to disseminate the findings or exact a change in behaviour, until during or after the research has been commissioned, or even completed. In order to ensure that the results are generated in way that is meaningful and useful to the recipients for whom it's intended, resulting in a potential change of behaviour then consideration must be given to the most effective means of dissemination.

Research needs: What behaviour change is required from the commissioned research? What is the most effective means of evoking this change? How will we evaluate whether the change has occurred? Will the change be sustained or temporary?

SIS Outcomes: How research is communicated. Public participation in scientific research is an important new area for the strategy.

Priority for Government forestry funding: 1

5. Improve

Science plays a vital role in informing our management decisions to increase the value of trees, forests and woodlands to society and the environment. Developing ways of realising more of our woodlands' value through the many social and environmental benefits of woodlands and utilising new market opportunities to realise these is recognised as a key growth area and opportunity for Forestry. Investing in our valuable Woodland assets in ways that contribute to economic growth and realise benefits for people and nature is something which we want to see much more in future. In an era of reducing public funds, we need to be able to evolve and develop innovative ways of attracting and funnelling these investments to achieve the benefits we want. This will involve emerging concepts such as payments for ecosystem services and natural capital, but also investing in people so as to retain a skilled cadre of empowered forestry experts within the sector.

5.1 Understanding and realising the value and benefits of ecosystem services

Critical Research Questions:

- How can the value of woodlands and their associated services be captured and articulated so interactions between services (such as biodiversity, sustainable management, tourism, landscape, heritage and access) are maximised? Furthermore how can these benefits be achieved at both landscape and local level?
- What payment methods for ecosystem services are most likely to result in beneficial impacts in the real-world (such as increased woodland creation and sustainable management) and how do we identify the provider of the money/service?
- How can assessment and valuation tools such as iTree be adapted to UK conditions and developed to value benefits over time in a manner that allows users to easily undertake valuation exercises at a range of geographic scales?
- How can the particular challenges facing the urban forest (e.g. ensuring species chosen are resilient to climate change, spread of pest and diseases, and impact of liability concerns) be better understood to ensure the full benefits, of the urban forest are realised?
- How can the longer term impacts of social interventions within woodlands and forests be evaluated* at both individual and community level?

*includes economic analysis and valuation

Context: The Sustainable management of our forests and woodlands means that we must better understand the value of cultural, regulating and supporting ecosystem services (including aspects such as heritage, landscape, health and well-being) and their associated evaluation. Valuing and understanding these interactions, with other forms of ecosystems services is essential to ensuring that the benefits are realised, understood and valued both intrinsically and economically. Better evaluation of cultural and shared services is required to provide a cost/value/tangible expression of the wide range of services that sustainable forest management provides, as well as understanding the interactions and constraints that they may place on other ecosystems services. Tools such as iTree remain relatively untested in the UK but have the potential to provide a financial valuation of an urban forest, helping policy and decision makers apportion resources accordingly. The urban forest (this includes woodlands in and around urban areas, individual street and garden trees) is where the majority of the population have their interaction with woodland and trees and so also plays an important contribution to building a woodland culture

Research needs: There is a need to understand not only the goods and services provided by a range of woodlands, but also to know how these compare with other land uses. What value can be given to the intrinsic benefits of providing trees in an urban setting (shade, heat island effect, particulate absorption)? How do we give a financial cost to the environmental health benefits of trees close to people? Can we give a financial figure to the contribution that trees make to people's health and well-being through their presence and as a venue for physical activity? How we do balance the various ecosystem services to ensure sustainable forest management? What is the contribution of economic forestry to generating wider ecosystem services? What are the most effective mechanisms/instruments for delivering payments for ecosystem services and what are the principal sources of funding – both public and private.

SIS Outcomes: Outcome 4: Changes to policy and practice (i.e. improved efficiency and effectiveness) through implementation by informed and engaged stakeholders, access to a high quality skill base of forest researchers, and effective leverage to provide additional resources to increase the evidence base.

Priority for Government forestry funding: 2

Understanding the value of undisturbed forestry soils, in particular those located on Ancient Woodland Sites and soil management for carbon, biodiversity and water.

Critical Research Questions:

- What are the relationships between undisturbed forest soils and above-ground biodiversity value?
- What are the sensitivities of undisturbed forest soils to the impacts of climate change and how can the impacts best be mitigated?

Context: Comparatively little is known about forest soil biodiversity and its importance in delivering ecosystem services. There are many symbiotic relationships in nature, particularly between fungi and higher plants. Understanding these relationships better will help us to make better decisions about woodland management to benefit biodiversity, how to help woodlands adapt to threats and how to best conserve their features of interest.

SIS outcomes: These research question help address outcome 1: Delivery of a healthy and resilient forest, specifically, identifying new options for forest management to address the threats posed by climate, pest and disease, and supporting delivery of healthy multipurpose and resilient forests, which deliver the widest range of benefits. The specific research areas addressed are better understanding of the basket of ecosystem services when evaluating the benefits of woodland to society and by evaluating approaches to woodland adaptation and increasing resilience and improving woodland biodiversity by reducing adverse impacts.

Funding sources: The Woodland Trust are setting up long term site monitoring locations which include monitoring impact of site management on soils. They have expressed a particular interest in working with Forest Research on developing opportunities for collaborative working to answer these questions.

Priority for Government forestry funding: 3

5.2 Attracting investment

- How can forestry be incorporated into domestic and international carbon markets and agreements?

Context: Forestry is currently excluded from EU climate change agreements limiting policy support and access to funding. The inability of UK-based woodland carbon projects to generate international carbon offsets has limited access to funding and led to the development of the Woodland Carbon Code (WCC). Although the WCC is presented as an early and functional approach to 'payment for ecosystems services', take-up has been relatively limited and carbon prices are low and insufficient to fund woodland creation in the absence of grant aid.

Research needs: A robust greenhouse gas inventory for the forestry sector is required to support international climate change negotiations and ensure that the optimum outcome is achieved for UK forestry. The same robust approach to monitoring, measurement and forecasting is also required to support the ongoing development and take-up of the Woodland Carbon Code and the embedding of forestry as a climate change mitigation measure in domestic ecosystem markets and policy development. Accumulated research knowledge on carbon modelling, greenhouse gas inventories and carbon economics is required to provide forestry input at the research-policy interface and ensure an optimum outcome for English/UK forestry.

SIS Outcomes: An evidence base to allow the sector to deliver a range of benefits to support sustainable economic growth; the knowledge to deliver sustainable land-use change; evidence to support changes to policy and practice.

Funding sources: As the Government Department responsible for forestry and having access to critical data through administrative records and the National Forest Inventory, FC should lead (and fund) forestry models that are required as input to the development of the greenhouse gas inventory, supporting strategic (domestic and international) policy development and facilitating English forestry's access to ecosystem markets. Co-funding should be sought from DECC for greenhouse gas inventory work and from the sector for research to support the Woodland Carbon Code and to promote the low-carbon credentials and accounting of harvested wood products.

Priority for Government forestry funding: 2

Critical Research Question:

- Through collaboration with the Biomass Energy Centre or any successor body, how can the knowledge supply chain promoting the use of timber for bioenergy be further improved and thus how can greater uptake/implementation of this knowledge be encouraged and monitored?

Demand for woodfuel is increasing. If UK based production is to keep up with supply and forest managers are to benefit economically from this market, more work is required to:

1) Ensure woodland owners, fuel suppliers and boiler owners understand the principles of sustainable forest management as described in the UKFS and meet DECC bioenergy sustainability criteria.
2) Highlight the economic and environmental benefit of bringing woodlands into management to supply woodfuel
3) Ensure successful woodfuel supply business models are identified and repeated at multiple locations around the country.
4) Maintain an independent source of expert advice on the production and use of woodfuel that can be used by woodland owners, end users and policy makers in FC and other parts of Government.

- What is the potential for growth in the number of direct and downstream jobs in the forestry workforce represented by increased area of woodland in management in a range of locations and silvicultural systems/management scenarios?

Context – It is increasingly important to be able to demonstrate the potential for economic growth, particularly jobs, from forestry, especially through undermanaged woodland being returned to management. Work to leverage investment into forestry from e.g. LEPs depends on evidence of good return on investment of jobs and GVA growth.

Research needs – To ensure that adequate provision is planned for in future forestry learning and development, there is a need to understand the potential for increased workforce opportunities through greater levels of woodland in management (e.g. how many hectares of woodland in management represent 1FTE?). Without a suitably skilled workforce of adequate size, operating within a strategic framework of professional expertise, aspirations for woodland into management are likely to be unmet.

SIS Outcomes - An evidence base to allow the forestry sector to deliver a wide range of benefits from forests and woodlands to support sustainable economic growth in Britain.

Funding sources – FC should be a funder of this work to enable the case for investment across the sector. Government departments, i.e. Defra and BIS will need to endorse any findings to give the figures credibility and ensure that any economic analysis is consistent with HMT's 'Green Book'.

Priority for Government forestry funding: 3

5.3 Tree and Timber properties

Achieving a better understanding of financial and yield appraisals of future forest growth rates particularly in relation to climate change.

Critical Research Question:

- How do management interventions affect future growth and yields in light of projected climate change?

Context: The current threats of pests/diseases and climate change coupled to environmental concerns mean that different approaches to forest management are required. Current yield models do not adequately cover the range of forestry systems that will need to be deployed to meet aspirations for increased resilience. This evidence is urgently needed to inform practical guidance. The same evidence is required to inform the Woodland Carbon Code, Greenhouse Gas Inventory projections and national Production Forecasts.

Research needs: Improved yield models for mixed species/mixed age stands, young stands and stands beyond current definitions of commercial maturity; economic analyses based on these new yield models should follow. There is also a requirement for more evidence of current 'minor' species.

SIS Outcomes: Delivery of a healthy and resilient forest, specifically by maintaining or improving woodland biodiversity, halting species declines; creating knowledge to deliver woodland expansion as a component of sustainable land use change; an evidence base to allow the forestry sector to deliver a wide range of benefits from forests and woodlands to support sustainable economic growth in Britain.

Priority for Government forestry funding: 2

Addressing and identifying current/future market requirements and price trends.

Critical Research Questions:

- How do the properties of UK timber currently reaching market compare to the properties needed for modern timber products and timber use?
- What species and silvicultural systems will provide fibre with the properties needed to meet future market demands (for example timber properties for joinery, construction and biochemical purposes)? Collaborative work with timber engineers, architects and retailers may be needed in the future.

Context: Apart from woodfuel, there is significant market failure in the hardwood sector. The first step towards addressing this is to establish what hardwood products the construction sector and other end users need. These requirements can then be matched to the characteristics of individual species and processing techniques. Economic analysis is required to ensure any promising products are priced attractively in the market place whilst still covering costs of production.

Research needs: Improve sector knowledge of a) the physical and chemical properties of timber in the current growing stock b) what the market requires from British timber. There is a requirement for a horizon scanning element to this research to investigate what the silvicultural system and timber properties are needed for.

SIS Outcomes: Delivery of healthy, productive forests that improve the economic contribution forestry makes to the economy. Reversal of current market failure in the hardwood sector.

Priority for Government forestry funding: 3

Trialling alternative silvicultural practices and species to optimise timber growth but retain desired timber properties.

Critical Research Questions:

- What is the effect of continuous cover forestry and other establishment and management systems on timber quality?
- What silvicultural systems best reflect the various needs of hardwood timber markets (such as construction, joinery and biomass)?

Context: Silvicultural systems and species in use today may not meet the needs of future markets. This work (ideally carried out alongside themes 1 and 2 above) would address this and also improve our understanding of how management regimes affect timber properties.

Research needs: Develop an evidence base which will help ensure that silvicultural practices used in the short term provide marketable timber in the longer term.

SIS Outcomes: Delivery of healthy, productive forests that improve the economic contribution forestry makes to the economy. Reversal of current market failure in the hardwood sector.

Priority for Government forestry funding: 3

Improving existing knowledge of timber properties and developing modern technologies and simple methodologies useful for the sector.

Critical Research Questions:

- What cost effective, certified, stress grading equipment and simple methodologies could be developed for use by smaller wood processing businesses, in particular those using hardwood species?

- What are the timber properties of UK grown hardwoods (durability, strength, stiffness, kWh per m^3 etc.) in relation to a variety of woodland types and silvicultural regimes especially small diameter material, diseased timber and unmanaged woodland?

Context: Most of the 45% of unmanaged woodland in England is mixed broadleaf. Forestry Commission statistics show that deliveries of hardwood to sawmill remains in decline. If government aspirations for increased levels of woodland management are to be met, markets for hardwood products need to be found or created. Being able to accurately and cost effectively characterise the properties of timber from such woodlands and convey these to processors and end users could help develop new markets.

Research needs: A lack of management and possibly increasing presence of pest and disease in English woodlands has resulted in many woods becoming overstocked with smaller diameter, possibly diseased, timber. Characterising the properties of this resource could help develop new markets and products and lead to more woodlands becoming productively managed.

SIS Outcomes: Theme 4 is most likely to have an immediate, positive impact on policy objectives. It should be pursued as a joint priority with Theme 1.

Theme 1 seeks to improve our understanding of the existing timber resource, especially the proportion of the resource present in unmanaged woodlands. Theme 2 aims to quantify current and future market requirements. Theme 3 aims to close any gap between the properties of timber available to market and the properties required by timber processing businesses and consumers. Theme 1 underpins this proposed research programme and as a result is current priority.

Priority for Government forestry funding: 4

5.4 Improving Biodiversity

Maintaining and improving biodiversity in English woodlands and halting decline of priority species

Critical Research Questions:

- How do practical measures & management interventions affect priority species in light of projected climate change?

Context: Maintaining and improving biodiversity in English woodlands and halting decline where applicable (for example through implementing management methods to benefit woodland species) is a commitment made by government to halt biodiversity decline, for example through Biodiversity 2020. Ancient woodland plays a particularly important role in achieving this goal.
While there are signs of improvement for some groups, such as the woodland birds index in recent years, woodland specialist species and some generalist species associated with woodland continue to decline in population. Why some groups should do so well while others do not, is not well understood. It is therefore important to understand how we can benefit or inadvertently harm species groups through the management choices we make for woodland as well as the impacts of additional woodland in the landscape.

Research needs: The role of woodfuel and restoring plantations on ancient woodland sites are areas where more evidence is particularly needed.

SIS outcomes –The research question helps address outcome 1: Delivery of a healthy and resilient forest, specifically by maintaining or improving woodland biodiversity, halting species declines.

Funding sources: Partnership with Natural England in particular, but also LWEC and conservation agencies should be sought.

Priority for Government forestry funding: 2

5.5 Investing in people

Better understanding the demographics of the forestry workforce to predict future requirements.

Critical Research Question:

- What is the current and projected size, nature and distribution of the forestry workforce, in particular the workforce age profile and skill level/training need?

Context - Anecdotal evidence suggests that the workforce is ageing, and workers are not being replaced as they retire, or are retiring and taking irreplaceable skills with them. We need to understand this better in order to know where our most effective interventions might be and at which stage of the recruitment and learning process.

Research needs – Since the Sector Skills Council for the land based sector, Lantra, lost core funding to undertake Labour Market Intelligence (LMI) work, there has been no provision of national LMI. Furthermore, the blurring of the lines and the data between forestry and arboriculture make accurate profiling very difficult. If the workforce is indeed in decline, we need to be able to plan ways to reverse the decline and ensure that forestry's ability to contribute to economic growth is not threatened by a lack of skilled, motivated workers, and to do this we need up to date accurate data on the workforce now and into the future. This work is required to sit alongside the NFI data to ensure that the projections for harvesting potential are matched by an understanding of the workforce, actual and potential, who will carry out the work.

SIS Outcomes - An evidence base to allow the forestry sector to deliver a wide range of benefits from forests and woodlands to support sustainable economic growth in Britain.

Funding sources – FC should be the funder of this work to underpin the enabling of economic growth from forestry, to complement the enabling work made possible by the NFI.

Priority for Government forestry funding 2

Assisting the development of a skilled forestry work force by promoting and increasing the number of forestry qualification opportunities.

Critical Research Question:

- Can increasing the number of integrated forestry qualifications, before and at degree level and within a strategic professional framework, best assist the development of a skilled forestry workforce and if so, how would this be achieved?

Context - Answering this question would require understanding of how best qualifications can be aligned to help professionalise the workforce, providing clear and adequate progression and leading to recognised professional status. A more professional and business-savvy workforce would be better able to harness the potential for growth represented by forestry, e.g. by innovation, better business planning or embracing e-business practices.

Research needs – The vast majority of forestry businesses are micro-enterprises and the sector is disadvantaged against others where larger, more structured and hierarchical businesses are better able to ingrain professional practice. We need to understand how existing educational and professional qualifications and can be dovetailed to provide effective learning opportunities at all levels of the workforce, and how the workforce can be best enabled to access the opportunities available.

SIS Outcomes - An evidence base to allow the forestry sector to deliver a wide range of benefits from forests and woodlands to support sustainable economic growth in Britain.

Funding sources – While FC should part fund this work it will be in the interests of other professional bodies in the sector, e.g. RFS and ICF, to contribute.

Theme 1 is a higher priority than Theme 2 – there is a need to understand the workforce profile in order to understand the interventions needed to raise skills levels to meet future forestry aspirations.

Priority for Government forestry funding: 3

6. Expand

Government's Forestry and Woodlands Policy Statement recognises the ecosystem services that woodland provides and sets an aspiration to increase woodland cover to 12% by 2060 – equivalent to an average planting rate of 5,000 ha per year. Increased woodland cover will deliver increased environmental, social and economic benefits in most, but not all landscapes. While all new woodland will contribute to meeting the UK's challenging climate change targets, there is a recognition that most can be gained from more trees and woodlands in and around our towns and cities and where they will safeguard clean water, help manage flood risk or improve biodiversity. The Policy Statement highlights the challenging nature of the aspiration, the need for it to be attractive to landowners to plant woodland and that 'the shared objective' of increased woodland cover will only be achieved if private funding of woodland creation increases in line with Government's expectations.

6.1 Where should new woodland be located?

Developing an interactive valuation, location, feasibility and design model for woodland creation to be deployed across policy makers, landowners and investors.

- What is the optimum location to plant new woodlands?

Context: There has been a recent move to account for ecosystem services when land use change is considered, particularly in the context of targeting grant aid. Comparative values for different ecosystem services have, to date, prevented the approach from being mainstreamed into land-use planning. An interactive woodland creation decision support tool would help quantify the costs and benefits of woodland creation at a range of spatial scales. These estimates would better inform decision-makers (policy makers, landowners, and woodland advisers) on cost and benefit variation when different land parcels are considered for woodland creation. The need to prioritise research which identifies those opportunities for woodland creation which provide the greatest value for society, but where it is also achievable and affordable to create is also an important element in delivering this research.

Research needs: A cross-cutting model that can account for and value the full range of ecosystem services that woodland provides, including (but not restricted to) water quality, flood alleviation, soil protection, provision of habitat, recreation, air quality and public health). The modelling system should incorporate other models/DSSs including Ecological Site Classification (ESC) and the Woodland Carbon Code (WCC) as well as outputs from other models such as BEETLE (Biological and Environmental Evaluation Tools for Landscape Ecology). Decision making over priorities for open habitat restoration should also be supported. The ability to identify where maximum benefits coincide with maximum willingness to create woodland would be invaluable. There is therefore a corresponding element of social research which should also include recommendations for how the outputs of the model should be translated into terms that

landowners, investors and the public understand and are motivated by. The fundamental principle should remain the right tree, in the right place for the right reasons.

SIS Outcomes: Knowledge to deliver sustainable land-use change; specifically developing multi-disciplinary tools to help managers identify and evaluate those new woodland sites that may offer the best potential to deliver the most ecologically efficient basket of ecosystem services. An evidence base to allow the sector to deliver a range of benefits to support sustainable economic growth; evidence to support changes to policy and practice.

Funding sources: This research would be of interest to a range of land uses and benefit from being developed through a collaborative approach. Co-funding from other Government Departments, LWEC and Conservation Agencies should be considered. The Defra funded WrEN project is addressing aspects of biodiversity regarding woodland creation, investigating species population differences in different types of woodland created over the last 100 years, and attempting to understand the benefits or otherwise of the landscape context / networks of other woodland. It should result in advice about where to put woodlands to benefit species. This project is focussed on the National Forest Area, so upland habitats and species are still to be addressed

Priority for Government forestry funding: 2

Landscape scale approach

- What is the role of landscape scale (i.e. more widely focussed than individual sites) adaptation in forestry? What evidence is there that landscape-scale approaches to climate change adaptation are effective?

Context: Evidence is needed to identify whether working at landscape scale, through joining up woodlands, increasing the size of individual woodlands and creating wooded landscapes more permeable to the movement of woodland species are sufficient for adapting to the future climate and the impacts on species. Landscape-scale approaches to climate change adaptation through the development of woodland habitat networks are a focus for adaptation in the biodiversity sector. However, evidence of the effectiveness of such approaches are limited. Furthermore, there are increasing concerns that landscape approaches could represent maladaptation in some circumstances, where the movement of invasive species or pests/diseases is promoted.

Research Needs: Clear evidence of how the development of habitat networks has a positive outcome on priority woodland species. The research should also provide guidance on where the development of woodland habitat networks represents a risk to biodiversity and biosecurity.

SIS Outcomes: Evidence to support the delivery of healthy and resilient woodland ecosystems; knowledge to deliver sustainable land-use change; an evidence base to allow the sector to deliver a range of benefits to support sustainable economic growth; evidence to support changes to policy and practice.

Funding sources: Co-Funding should be sought from Defra (biodiversity policy) and Natural England as this is an area of shared interest. The Woodland Trust have expressed an interest in supporting this research, particularly on evidence of contemporary gene flow through different landscapes.

Priority for Government forestry funding: **2**

6.2 Value of new woodland

Quantifying and valuing the benefits of woodland creation and management on ecosystem services and comparing different woodland types with different types of existing land use.

Critical Research Questions:

- What are the benefits of different types of woodland creation and management for a range of ecosystem services, particularly water quality/availability, flood risk ecosystem service objectives and public health benefits?

Context: Fundamental research on the benefits woodlands and woodland creation provides, in accessible language, is needed to inform discussions with policy makers, stakeholders and landowners. Key areas where greater understanding could lead to woodland creation are through water and public health benefits. Meeting Water Framework Directive objectives has been identified by Ministers as a key outcome from the next Rural Development Programme, while land management measures to help alleviate flooding have also been brought into focus following the widespread flooding during the winter of 2012/13 and 2013-14. Woodlands have an important role to play in both aspects of water management. A comprehensive evidence report (Woodland for Water) was published in 2011, while opportunity mapping for both addressing agricultural diffuse water pollution and flooding has recently been completed.

Research needs: Much of the evidence presented in the Woodlands for Water report is either from abroad or theoretical and there is an urgent need to provide hard evidence from UK studies of the benefits of woodland creation (and management) in water management. Evaluating historic water flow or quality data following land use change provides one approach, while new catchment level studies, relevant to lowland England in particular, would also be desirable. Recent opportunity mapping has identified where woodland can help meet water management objectives – the next phase for this work should be to integrate with other policy objectives through development of a landscape-scale ecosystem service decision support tool (see 3.7.3).

SIS outcomes: The knowledge to deliver woodland management and expansion, as a component of sustainable land-use change. Specifically, helping to manage ecosystem services, such as sustainable flood management, and protection of soil and clean water resources.

Funding sources: As this is a shared agenda, co-funding should be sought for new catchment scale initiatives, either from Defra or EA, in line with their newly published 'Working With Natural Processes Research Framework'. FC should continue to fund evaluation of existing data-sets and their interpretation for policy development.

Priority for Government forestry funding: 2

Maximising the potential role of forestry in climate change mitigation, including through improving measurement and management of forestry carbon and greenhouse gas balances.

Critical Research Questions:

- How can forestry's role in climate change mitigation be optimised?

Context: Forestry policies and practices, both domestic and international promote woodland creation, deforestation, bringing woodlands into management and adopting low intervention management or non-intervention as climate change mitigation measures. In particular, there are current controversies over the use of wood as a bio-energy feedstock, the place of forests on organic soils and the type of woodland that should be planted to meet climate change objectives. This research cannot be done in isolation, as the interaction of forests and woodlands with other land uses for the management of soil, water, local climatic conditions and energy production will be required to illustrate (and therefore communicate) the role of trees in an integrated landscape.

Research needs: Clear evidence, decision support tools and underpinning communications are needed to support policy development and forestry practice in the following areas: greenhouse gas balance of forestry operations over varying timeframes, focussing on different approaches to forest management; the greenhouse gas balance of harvested wood products (including woodfuel) compared to alternative materials; the carbon benefits, over varying timeframes, of creating different types of woodland in different locations, on different soils and adopting different approaches to forest management; improved greenhouse gas modelling of specific issues including early stage growth and soil carbon exchange; if and in which circumstances woodland removal from peat soils will deliver net greenhouse gas savings; direct comparisons of the greenhouse gas balance of forestry systems with other (agriculture, wind farms, solar parks) land uses. The role of urban trees in mitigating the urban heat island effect and by extension energy usage in buildings could also be explored.

SIS Outcomes: The knowledge to deliver sustainable land-use change; an evidence base to allow the sector to deliver a range of benefits to support sustainable economic growth; evidence to support changes to policy and practice.

Funding sources: FC should be the lead funding body for modelling woodland and forestry greenhouse gas balance. However, co-funding should be sought for comparative studies with other sectors (renewable energy: DECC, Research Councils and the energy sector; harvested wood products (wood processing and construction) and where other sectors have an interest (peatland management: NGOs and conservation Agencies; land use strategy: LWEC, Research Councils).

Priority for Government forestry funding: 2

6.3 Increasing the rate of woodland expansion and woodland management

Identifying methods to successfully increase England's woodland cover and the percentage of woodlands under recognised management plans (i.e. consistent with the UK Forestry Standard).

Critical Research Questions:

- How can changes in landowner behaviour be enabled to encourage woodland creation and sustainable management?
- What is the applicability of international woodland investment/delivery models to advise and promote woodland creation and management in England?
- How have historic and existing grant/incentive systems, in this and other countries, affected woodland creation and management and what lessons can be learned to improve the situation in Britain.

Context: The rates for woodland expansion and woodland being brought into management have shown improvement in recent years according to existing statistics. However, both are still below desired levels. Substantial government investment has occurred in the past and the long term future of it continuing is uncertain. Improving value for money and finding alternative methods of generating results are considered particularly relevant in the current political climate.

Research needs: Incentive models for how grant funding generates woodland creation and management and how current grant schemes could provide greater value for money are an area of interest. A retrospective analysis of previous grant schemes, such as EWGS, and their effectiveness and value for money for desired outcomes may provide valuable lessons when designing future incentive schemes. Looking to other countries for methods of promoting sustainable woodland creation and management, such as the American inheritance tax system, is also an area of interest. Furthermore, how can the value of woodland management and creation be communicated to landowners in ways which encourage them to create and manage woodland? Increased knowledge on the role of market pull for woodland products and models to support the supply chain.

SIS Outcomes: This would lead to the outcome of knowledge to deliver woodland management and expansion, as a component of sustainable land-use change and changes in policy and practise.

Priority for Government forestry funding: 1

7. Cross-Cutting

Integrating Social Research

We need to better integrate the social dimension into wider research questions across many areas, some are more obvious than others. Most research will have some form of human interaction and it is important that this is considered and built into the research questions from the outset. This may for example include how the outputs from the research might be used to invoke a behaviour change or seek to influence the way in which decisions are made (i.e. Outcome 4).

Priority for Government forestry funding: **1**

Developing and maintaining capacity in measuring the current woodland resource and projecting how it will change in the future.

- The development (or at least maintenance) of the series of permanent sample plots managed by Forest Research was highlighted as an irreplaceable data resource that could be called upon by the Sustainable Forest Management; Monitoring and Biosecurity and Forests and Climate Change research programmes, amongst others.
- What is the size and condition of the English woodland resource and how will it change in response to different management decisions, climate change and natural disturbance events?

Context: The National Forest Inventory collects a wealth of data that has been used to report statistics on woodland area, composition, biomass and carbon stocks, standing volume and timber availability. The data and associated modelling systems are critical for the preparation of Production Forecasts and the forestry sector greenhouse gas inventory. The work of the National Forest Inventory team is dependent on supporting research.

Research Needs: The maintenance of a network of sample plots, including changes to its composition to reflect changing management practices and species choice, growth and yield modelling particularly of mixed age and mixed species stands, the maintenance and development of underpinning modelling systems and support for field assessments, including the introduction of new technology.

SIS Outcomes: An evidence base to allow the sector to deliver a range of benefits to support sustainable economic growth; evidence to support changes to policy and practice.

Funding sources: The ability to report on and project changes to the Woodland resource is a central responsibility of FC as the Government's forestry Department. Core funding to support

the NFI and associated modelling systems should therefore be provided by FC. Where the forestry (including processing) sector has specific demands from the NFI or growth and yield modelling, it should be expected to contribute funding.

Priority for Government forestry funding: **1**