Forestry Commission **Proposal for funding Agreement Number CFS 9-2011-15**

FORESTRY COMMISSION
Description of the Research Project or Services

1.	**Research Purchasing Manager (C&FS)**	**Sallie Bailey**
	Relevant PAG	**Biodiversity and Environment**

2.	**Name of FR Programme Manager (PgM) or Project Manager (PM) and staff**	**PGM Duncan Ray (deputy Kevin Watts)** **PM WA1 Phil Handley (dep Duncan Ray)** **PM WA2 Russell Anderson (dep Kevin Watts)** **PM WA3 Darren Moseley (dep Mike Smith)** **PM WA4 Kevin Watts (dep Phil Handley)** **PM WA5 Mike Smith (dep Duncan Ray)** **PM WA6 Darren Moseley (dep Kevin Watts)** **PM WA7 Duncan Ray (dep Phil Handley)**
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	Programme Life (years)	**4 Years**
	Start Date	**1st April 2011**
	Completion Date	**31st March 2015**
	Revision Dates	**31st March 2012/2013/2014**

3. Title of Research Project or Service

Land Use and Ecosystem Services (LUES)

4. Abstract of proposed research (*Summary to be used on website/FRCC etc***)**
I haven't commented on abstract – in due course perhaps

The ecosystem service agenda is fast becoming a central tenet in environmental policy. Chapter 8 of the UK National Ecosystem Assessment (UKNEA), with Forest Research authorship, outlines the many ways in which forests and wooded landscapes provide ecosystem services to society, and this programme will maintain close links to conduct further work on the UKNEA.

This research proposal will develop a greater understanding about how and where ecosystem services are provided, starting by gathering all the information available into one place. The programme is aligned to the aspirations of the Living With Environmental Change (LWEC) resources challenge, focussing on the synergies and trade-offs in ecosystem service provision associated with integrated land-use planning and land-use change. A key focus is the development of critically-assessed spatially-explicit indicators to allow policymakers, forest managers and planners to map and understand the how the placement of woodland patches affects ecosystem service delivery. Some of these indicators already exist, and it is likely others will need to be developed. The programme will help identify where trees and forests provide the

greatest benefit, where synergies and trade-offs exist between different services, and where land use or management change could increase benefit. Different future development scenarios will therefore have different projected impacts on ecosystem services and we will conclude the program by synthesising all the information we have found with a range of future scenarios.

A key role of this program is to coordinate and bring together methods to undertake spatial analytical methods from a wide range of disciplines. Objectives will be achieved through the continued development of a strong and cutting edge spatial analytical team, complemented by close interdisciplinary research collaboration within FR and from other research institutes, many of them international. We aspire to developing appropriate and robust methods for assessing, evaluating and valuing ecosystem services provided by forests and wooded landscapes.

5. Aims and objectives

5.1 Aim of the research

This programme has a land-use focus in researching both the spatial and temporal interplay of patches to better understand and assess the contribution that forests, woodland and trees make in providing ecosystem services. The programme will provide information and knowledge to help guide forest policy and land-use management practise. In particular, there is a need to better understand and make transparent the ecological processes associated with the complexities of patch position, size, habitat management and land-use change, and how changes in these drivers affect ecosystem service delivery through trade-offs and synergies. This work is critical in informing more sustainable land-use planning in wooded and agricultural landscapes to deliver ecosystem benefits with limited resources.

A range of ecosystem services provided by forests and wooded landscapes have been studied across a range of disciplines in Forest Research. Uniquely, the LUES programme introduces the use of spatial frameworks in which to coordinate and integrate knowledge from new, existing and past studies, thus assembling descriptions of published work, and coordinating research into ecosystem services that are provided by forests and woodlands in different landscapes in current and future work.

Rationale

UK forests and wooded landscapes provide a broad suite of ecosystem services that provide recognised and tangible benefits to society (Millenium Ecosystem Assessment - MEA, UK National Ecosystem Assessment - UK NEA, Living with Environmental Change -LWEC). Over the last century, forest and woodland cover in the UK doubled, sometimes at the expense of some of the regulating, cultural and supporting services. There was a concurrent significant loss of biodiversity, especially over the past 50 years; different elements of biodiversity (either specific species or functional groups) underpin many of those ecosystem services (e.g. in the process of soil formation and nutrient cycling).

From the mid 1980s this concern resulted in a broader focus on a suite of ecosystem services provided by forests and wooded landscapes, including biodiversity conservation, recreation and other cultural and regulating services, while still recognising the importance of timber production.

Changes to forest and wooded landscapes, planned (e.g. forest and landscape planning) and unplanned (e.g. climate change, disease), may enhance and provide synergies between ecosystem services, while others may conflict requiring trade-offs. For instance, two distinct woodland patches may provide the same amount of timber and carbon storage, but one targeted in a specific area may also provide additional benefits for biodiversity, flood control or water quality. Similarly, woodland

patches may be affected differently by climate based on site conditions. Integrated action at appropriate scales is now needed to manage and target change effectively.

Key linkages between the LUES programme and other research programmes in Forest Research are shown in Appendix 1. Work in this programme must remain flexible in order to respond to policy changes, country requests to address new questions, and to provide opportunities in responding to external funding.

5.2 Work Areas

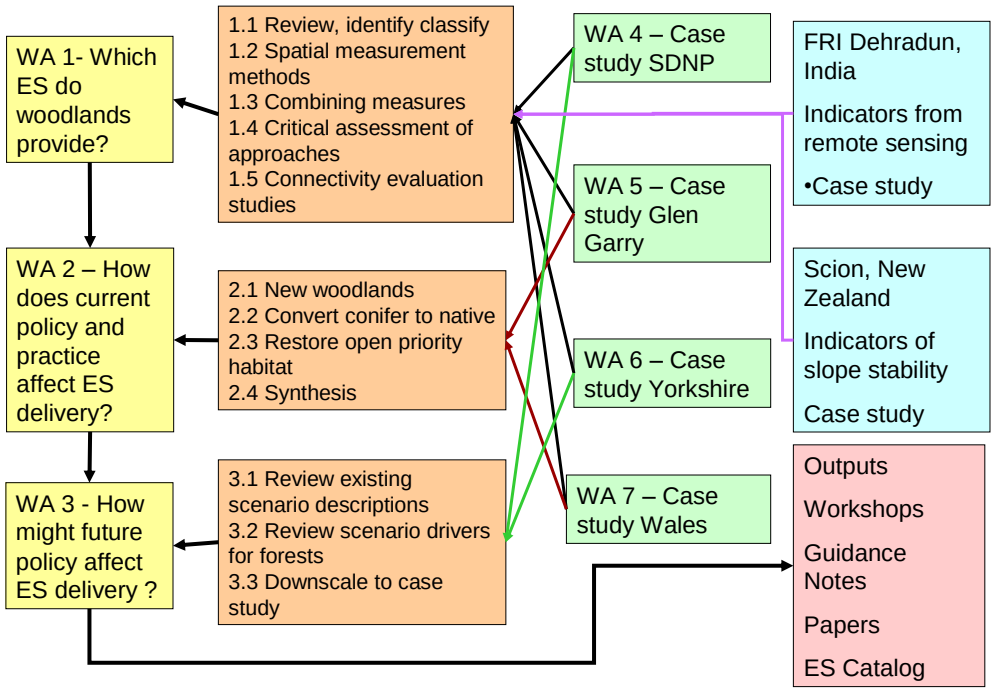
The research programme is strategically targeted around four key research questions which are addressed through three thematic work areas and 4 case study-based work areas:

(i) What are the key ecosystem services provided by forests and wooded landscapes, and how should they be measured? (Work Area 1) Which methods are appropriate, and what are the limitations and benefits of such measures/indicators of ecosystem services for use in different types of landscapes? (Work Area 1)

(ii) How do 'current' changes in UK forests and wooded landscapes affect the flow of ecosystem services (Work Area 2)

(iii) How could 'future' change in UK forests and wooded landscapes affect the flow of ecosystem services? (Work Area 3)

(iv) What can we learn from applying these measures/indicators to different situations and various spatial/temporal scales? (Work Area 4-7)



The schema demonstrates the relationships between the work area research questions and the work packages designed to address those questions. In particular it shows how the programme will use case studies to assess issues and test methods and results. The programme will develop a collaborative approach with international partners, whose area of expertise is shown.

Work Area 1 **Development of methods to spatially map ecosystem services provided by forests and wooded landscapes**

What are the key ecosystem services provided by forests and wooded landscapes and how should they be measured? Which methods are

appropriate, and what are the limitations and benefits of such measures/indicators of ecosystem services for use in different types of landscapes? (research question 1)

In work area 1 there is an expectation to collaborate with international partners. FRI, India and Scion, New Zealand have indicated interest in collaboration to develop the science and the methods to map ecosystem services and use the indicators within spatial assessment tools. A joint scoping study with FRI, India and Scion, New Zealand will assess ES evaluation methods common to forest landscapes in different societies, and influenced by differing socio-economic drivers, and provide a more stringent evaluation of the constraints and benefits of different approaches.

Work package 1.1 <u>Review, identify and classify ecosystem services provided by forests and woodland landscapes</u>

Building on the MEA, UK NEA, and literature, identify and classify key ecosystem services provided by forests and wooded landscapes, including the role of biodiversity in providing a cultural services and underpinning ecosystem services.

- **Output**: A – Develop the specification, design and implement a catalogue for describing ecosystem services provided by forests and wooded landscapes with supporting evidence.
- **Output**: B – Draft a Report on ecosystem services provided by forests and wooded landscapes.
- **Output**: C – Draft a Research Note on the role of those species or functional groups that are characteristic of forests or wooded landscapes in providing or underpinning ecosystem services. This will give policymakers and forest managers evidence to support continuing conservation-based activity.

Work package 1.2 <u>Identify approaches to spatially map/measure ecosystem services</u>

Identify approaches to spatially map/measure ecosystem services identified in WP1.1. In addition to literature, we will utilise considerable data, work and knowledge from FR colleagues, including timber production, carbon storage, hydrology, soils, social benefits, biodiversity indicators (e.g. review of NFI/UKWAS indicators from WP 8.2 and 8.3 functional indicators in species, genes and habitat programme) etc.

- **Output:** A **–** Extend the ecosystem services catalogue (WP 1.1) with approaches to spatially map/measure them along with an assessment of their strengths and weaknesses i.e. scale of analysis, data requirements, uncertainty.

Work package 1.3 <u>Explore opportunities to combine different measures of ecosystem services</u>

In order to optimise synergies and balance trade-offs effectively, various approaches to comparison and aggregation of different ecosystem services will be reviewed including the use of economic valuation methods (linked to economics work within FR), systems to weight services based on stakeholder input (e.g. MCDA), and potential approaches identified in the literature.

- **Output:** A – Three national workshops for countries to discuss ES of wooded landscapes and to review the programme in year 1 and year 4
- **Output:** B - Review of appropriate methods to compare the value of different ecosystem services.

Work package 1.4 <u>Critically assess appropriate approaches of mapping and measuring ecosystem services in combination</u>

	A critical assessment of the suitability, fitness for purpose, and appropriateness in different circumstances of the identified measures (WP1.2) to map ecosystem services and opportunities to combine them (WP 1.3). The assessment will be based on their application to case study landscapes (WP 4-7) and other trial landscapes where existing and suitable data can provide an assessment of the benefits and drawbacks of each method. This will include consultation with FR and FC to ensure their robustness and policy relevance and peer review of selected approaches. • **Output:** A Further extend the ecosystem services catalogue (WP 1.1) including a system for ranking each measure using criteria of the pros/cons (internal deliverable) of different landscape, and climatic situation. • **Output:** B Assessment of approaches to combine different ecosystem service measurements. • **Output:** C Table of 'standard' measures to spatially assess ecosystem services within forest and wooded landscape and methods to combine them. • **Output:** D Journal paper on application of selected measures of ecosystem services in trial landscapes. • **Output** E Organisation of a IUFRO conference on the ES on spruce forests in Autumn 2012
Work package 1.5	<u>Connectivity validation studies</u> Landscape genetic work on wood crickets from the Isle of Wight will be completed and written up by the middle of the second year of the programme. Plans to develop a second landscape genetics case study on wood ants are underway with collaboration from a group at York University. The plan will be completed at the end of the first year of the programme, and the schedule added to this document. • **Output**: A Complete the analysis for, and draft a peer reviewed paper on wood cricket movement on the Isle of Wight • **Output** B Develop a landscape genetics project plan for work on wood ants.
Work Area 2	**Evaluate the impact of land-use choices (woodland creation, woodland conversion, and restoration of open habitats) on the provision and flow of ecosystem services** *How do 'current' changes in UK forests and wooded landscapes affect the flow of ecosystem services? (research question 2)* This work area is intended to support policy development and operational decisions about changing wooded landscapes with information about the impact of such changes on ecosystem services. The work will link with research and outputs from work areas 4-7. WP 2.1 and 2.3 are developments of work formerly funded in the Habitat Management Programme. Work package 2.2 links with a former work package from the Biodiversity Programme. Each Work Package will take a similar structure: 1) Making the case for a particular land use change: direct benefits, policy background (year 2011-2012) 2) Defining the policy, potential and likely change that could occur, identifying key pathways and barriers and mapping opportunities (year 2012-2013) 3) Predicting and/or testing hypotheses about how policy incentives and the

location and operational management of change will affect ecosystem services provided within the area of change and the surrounding landscape (year 2013-2014)

Section C in each case will rely upon WA1 and somewhat on the outcomes of WA 4-7.

WP 2.1 and 2.3 are developments of work formerly funded in the Habitat Management Programme.
WP 2.2 is work formerly defined in the Biodiversity programme
WP 2.4 is a new work package that synthesises the land-use options in a practice Guide (or similar)

Work package 2.1 <u>New woodlands</u>

- **Output:** A – 1000 word report introduction
- **Output:** B – specific output set of maps and data on area (making use of existing land-use data sets and decision frameworks)
- **Output:** C – Paper for peer-reviewed publication on 'Establishing new woodlands that provide appropriate ecosystem service provision at the landscape scale'
- **Output:** D – Survey and report of the ecosystem service provision of new woodlands created under the SFA.

Work package 2.2 <u>Conversion from non-native conifer to native species on previously unwooded land</u>

- **Output:** A – 1000 word report introduction
- **Output:** B – specific output set of maps and data on area (making use of Species, Genes and Habitats Programme WA on Biodiversity)
- **Output:** C – Paper for peer-reviewed publication on questions for restoration practice arising from sections A and B

Work package 2.3 <u>Restoration of open habitats of high biodiversity value on former plantations</u>

(To include outputs already provided for in previous Open Habitats project – completion of practice guide, peatland restoration chapter, and two papers for peer-review)

- **Output:** A – outputs already provided for in previous Open Habitats project – completion of practice guide, peatland restoration chapter, and two papers for peer-review
- **Output:** B – specific output set of maps and data on potential area (making use of existing MCDA framework)
- **Output:** C - outputs already provided for in previous Open Habitats project –two papers for peer-review

Work package 2.4 <u>Summary and Synthesis</u>

Combination of sections A-C from each work package, into an easily-digestible format for country and GB policymakers.

- **Output:** A - Set of recommendations for national and district planners and conservancy woodland officers to use – (e.g. Practice Guide)

Work Area 3 **Evaluate the impact of future scenarios in forests and wooded landscapes and their impact on the provision of ecosystem services**
How could 'future' change in UK forests and wooded landscapes affect the flow of ecosystem services? (research question 3)

Work area 3 will explore and compare the potential impacts of future change in UK forests and wooded landscapes on the provision of ecosystem services through

the use of probabilistic futures. In developing work area 3, there should be a close link with the Department for Business Innovation and Skills Foresight horizon scanning centre (http://www.bis.gov.uk/foresight/our-work/horizon-scanning-centre), to ensure that there is a more thorough peer support for the scenarios selected. The scenarios will represent the evolution of policy and economic framework conditions, social developments, technical innovations and physical environments linked to multifunctional forestry which are applied at a range of spatial and temporal scales.

The use of scenario analysis has grown as the role of uncertainty, and the need for trans-disciplinary policy making has become apparent (Wiek et al, 2006; EEA, 2009). The scenario approach is a valuable analytical device for spatial planning (Couclelis, 2005) and the study of integrated analyses for evaluating sustainable development, as a process of steering societal development and enhancing sustainable ecological, economic and socio-cultural outcomes.

Scenario analyses are thus a key decision support aid in decision- and policy-making processes. Interactive media scenarios (e.g. landscape visualization) have proved useful to communicate uncertainties and complexities in coupled human and natural systems (Vervoort et al., 2010). When combined with participatory modelling, scenarios provide a means of access for stakeholder involvement in the input side of the modelling process. This often leads to an improved identification of management intervention to guide sustainable outcomes from complex systems influenced by multiple external influences (Sandker et al, 2010).

This work area may link with parallel work at FRI India and Scion New Zealand, as part of a collaborative research initiative that compares and contrasts between three different societies the iterative process of adjustment to policy implementation, ecosystem service provision, stakeholder assessment leading to policy adjustment.

Work package 3.1 Review of potential scenarios

A review of existing scenarios descriptions and the availability of driving force datasets at the UK and European level to identify appropriate scenarios suited to the ecosystem service case studies.

To facilitate the assessment of ecosystem service provision from forests and wooded landscapes the scenarios will consider the following driving forces affecting multifunctional forestry:

(i) policy and economic framework conditions;
(ii) (ii) population and human settlement trends;
(iii) (iii) technological innovation;
(iv) (iv) the biophysical environment;
(v) (v) social and cultural capital.

- **Output:** B - Interim report on the review of scenarios and driving force datasets
- **Output:** C - Final report
- **Output:** D - Journal paper

Work package 3.2 Review of scenario drivers in forests and wooded landscapes

Review of existing European, UK and country (E,S,W) policy frameworks identifying forest / wooded landscape issues.

A wide range of different policy fields related to forest and land systems will be investigated to capture a variety of alternative perspectives about future 'world' developments.

- **Output:** A - Report on applicability of scenarios within a policy context

Work package 3.3 Scenario customisation

Work package 3.3 will focus on stakeholder consultation for each case study to provide a local context in customising and deriving qualitative scenario narratives.

In each of the case studies in collaborating countries, stakeholder workshops will undertake participatory scenario development to create bottom-up scenarios. Through collaboration with SERG colleagues, the workshops will be organised to address the needs of stakeholders in relation to the design of a geo-database and geo-wiki. The workshops will involve forest owners, land managers and policy-makers to ascertain stakeholder needs for environmental, socio-economic and management scenarios over different temporal scales from the near future to the end of the 21st century (or longer if desired). A set of qualitative narratives will be produced which capture the drivers of change occurring at different spatial and temporal scales, i.e. the planning unit/forest stand, the local landscape, the case study region, as well as referring to national and international levels from work packages 3.1 and 3.2.

- **Output:** A - Report
- **Output:** B - Journal paper describing the development of the methodology, its application through case studies, and differences and similarities between countries.

Work Area 4-7 overview

Case study evaluation of spatial arrangement of patches on delivering ecosystem services within different forest and wooded landscapes

What can we learn from applying these measures/indicators to different situations and various spatial/temporal scales? (question 4)

In work areas 4-7 four 'initial' case studies (open for negotiation and change) are briefly described in which different spatial scales, and different management objectives will be used to evaluate the spatial assessment of ecosystem services and the impact of alternative management options on ecosystem service provision. We plan to gain additional external income and collaboration from partners to undertake these studies.

The case studies are based on: (WA 4) around a 'research forest' in a high-amenity area; (WA 5) an active forest expansion plan; (WA 6) the targeting of woodland for flood alleviation; and (WA 7) national scale portfolio analysis. Other case studies may be added as opportunities arise.

- **Output:** A **-** Short interim reports and a final report on the progress and the interpretation comparisons of ES between case studies.

Work Area 4

Case study 1 - South Downs National Park

The first case study is based around Alice Holt Research Forest within the region of the new South Downs National Park. Potential linkages exist between:

a) the work CEH and FR has published on ES measurement of ECN sites (Alice Holt was included);
b) the work of the Forestry and Carbon Management programme (ManForC) in researching approaches to increase C seq and reduce GHG emissions

at a landscape scale
c) the review of the impacts of SRF and woodfuel management on biodiversity within the landscape of the SDNP
d) Cultural services of forests in the landscape of the South Downs NP
e) Water quantity issues in recharge of the aquifers under land use types
f) An economic appraisal of the ES of the NP

With FR colleagues we will develop a plan and budget for the ES assessment that woodland provides at the landscape scale in the case study. The design of the study will be negotiated with the National Park Authority, and match funding sought to develop the work.

- **Output:** A -Develop a concept note for a collaborative project and seek to lever funding from external sources
- **Output:** B -Develop a work area plan for an integrated and interdisciplinary case study project

Work Area 5 **Case study 2 - Lochaber**

The second case study supports native woodland expansion on the national forest estate in Scotland between Glen Garry and Glen Arkaig through mountainous country. The project has a carbon, soil sustainability, biodiversity, and tree-line woodland theme. The project is a new case study for the GPFLR and will be twinned with a similar forest expansion study in the Uttarakhand, India in the southern Himalaya. We are seeking Defra support to develop the collaborative theme. Work on the ES indicator development will be closely linked to the FRI collaboration described in WA 1.

Develop a fully costed work plan for a 2 year native woodland expansion ES assessment project of alternate expansion scenarios in terms of resilience to climate change between Glen Garry and Glen Arkaig. The work will provide collaborative linkage with forest scientists studying ES delivery of forest landscape restoration in India as part of twinned GPFLR studies.
Potential linkages with other work in FR include:

a) Carbon sequestration in native woodlands of Scotland MAN4C
b) Biodiversity assessments of wooded and open ground habitats of the mosaic
c) Economic appraisal of the added value benefits of managed native woodland habitat in remote rural communities - also links to GPFLR
d) Water quantity (stream flow and fish stock) and water quality studies (nitrogen deposition)

- **Output:** A -Develop a concept note for a collaborative project and seek to lever funding from external sources
- **Output:** B -Develop a work area plan for an integrated and interdisciplinary case study project

Work Area 6 **Case study 3 - Yorkshire and Humber**

Case study 3 will link synergistic opportunities and trade-offs of regulating service roles of woodland in promoting landscape connectivity for woodland species with the flood protection role of woodland through the targeting of new flood plain woods in Yorkshire. The work will demonstrate synergy with provisioning services (e.g. woodfuel production) and cultural services (e.g. habitat provision of threatened and rare species conservation)

Potential linkages of the Yorkshire Forward funding:

a) studies of flood alleviation in Yorkshire – Don, Wharfe, Ouse etc.
b) examine the ES synergy of targeted woodland expansion, providing regional scale benefits in lowland England
c) economic appraisal of woodland expansion
d) water quality – diffuse pollution from urban and industrial land
e) link to a BESS bid with Nottingham, CEH Lancaster and other (e.g. Leeds, Bradford, Sheffield, York or Hull Universities)

- **Output:** A -Develop a concept note for a collaborative project and seek to lever funding from external sources
- **Output:** B -Develop a work area plan for an integrated and interdisciplinary case study project

Work Area 7 **Case study 4 - Wales**

This fourth study will develop plans and execute a national scale ES assessment for the Welsh Government Woodland Estate (WGWE). In particular:

1) estimate the proportion and position of ES delivered by WGWE – (this builds on the work of the portfolio analysis which described the benefits of the publicly owned woodlands to the people of Wales);
2) define how the estate delivers outcomes for Woodlands for Wales – (need to define the ecosystem benefits and develop useful stakeholder agreed measures of delivery);
3) provide an auditable system – with clear and transparent information – (need to apply the measures in a logical, consistent, repeatable and transparent framework);
4) ensure that the work developed is consistent with Natural Environment Framework (NEF) and describe how the approaches can be mapped.

Agree the approach, design and plan for an assessment of ES across the WGWE with FCW and FR colleagues, including an economic evaluation plan. The plan will build upon work area 1, discussion and agreement of ideas with regional requirements of Forest Districts (with SERG colleagues), and the discussion and agreement of final proposals with FCW policy team.

Potential linkages with other programmes include:

f) SERG – community benefits of woodlands
g) Cultural services of woodlands – rare species, historic environment
h) Regulating services – water, soil
i) Economic value of service provision
j) Portfolio examination to better target and expand service provision of woodland

- **Output:** A -Develop a concept note for a collaborative project and seek to lever funding from external sources
- **Output:** B -Develop a work area plan for an integrated and interdisciplinary case study project

* Add new work areas and packages as required

6. Please indicate which of the FC's 6 Climate change priority actions this work fits into

Protect what we already have	☒	Reduce deforestation	☐
Restore the world's forest cover	☐	Use wood for energy	☒
Replace other materials with wood	☐	Plan to adapt to our changing climate	☒

7. Comment on how this research will address Country Strategy needs/targets (175 words)

The Woodlands for Wales Action Plan asserts that the well managed woodlands "can make a significant contribution to delivering …. social, economic and environmental benefits by providing a wide range of goods and services for everyone's benefit". The work of this program is about quantifying how woodlands and forests do this, providing tools to understand the spatial significance of woodland ES delivery, and eventually to show how better targeted woodland management systems and woodland expansion can be delivered in an integrated planning framework tool to improve ES at a local, regional and national scale.
The Scottish Forestry Strategy Implementation Plan 2011-2014 shows indicators of progress in delivering the benefits of sustainable forest management. ES assessment tools and methods developed in Work Area 1 and demonstrated in Wales in Work Area 7 will demonstrate where to target action to stimulate synergy in SFM delivery and reduce the trade-offs between services delivered by woodlands in the landscape.
There is a mandate from Forestry Commission England through the Climate Change Programme to demonstrate how to maximise carbon sequestration and reduce GHG emissions on the publicly owned forest estate. The methods and tools identified in Work Area 7 for an FC Welsh Assembly Woodland analysis and developed further in a South Downs National Park analysis (Work Area 4) will pilot this FR interdisciplinary work as a key ES spatial analytical problem. The work will support the Natural Environment White Paper (CM8082) in demonstrating the economic arguments for safeguarding the natural environment by stimulating joined-up plans and actions in land-use planning – for example, to reduce fragmentation while expanding woodland for C-seq., flood control, green space.

8. Identify and comment on any associated business risk of undertaking/not undertaking the research and how that will be managed

ES thinking has entered the political agenda through the publication of the UK National Ecosystem Assessment. Defra and other agencies anticipate that an integrated ecosystem approach to assessment and analysis of the goods and services that support society should be approached in ecosystems at a landscape scale. This is clearly a more holistic way of thinking – evaluating the synergy achieved, or the trade-offs to reach a compromise, in land-use change or management in a particular place in the landscape.

Many funding agencies ask for research programmes that try to understand the processes by which ecosystem services are delivered. NERC in particular, is keen to fund research proposals that help develop an understanding of the relationship between biodiversity and ecosystem services, and this subject is of particular interest in the delivery of ecosystem services from different woodland types. Forest Research has a broad disciplinary base of scientists who can fulfil many areas of work on woodland and open land ecosystem services. To ensure FR is able to attract future funding from Defra and NERC and other sources it would be prudent to begin to develop more interdisciplinary ecosystem service research. This is particularly critical following Forest Research's key involvement in the drafting of the woodland chapter of the UK National

Ecosystem Assessment report.

9. Research impact (economic, social, or biodiversity)

Who will benefit from this research? FC country policy and practice, Devolved administration land-use policy groups, Defra, DfID, FR through international and national collaboration
How will they benefit from this research? Understanding of ES thinking with forests and woodlands in a landscape, Understanding of synergy and trade-off negotiation and agreement in a policy and planning context. FE estate management will benefit from a better understanding of the ES delivery achieved (portfolio analysis through MCDA).
What will be done to ensure that they have the opportunity to benefit from this research? Ultimate development of a framework spatial platform to show ES synergy and trade-off issues to stakeholders. Improved stakeholder understanding of forests and woodlands in the landscape. Stakeholder workshops and conferences in the 4th year of the work.
Potential for innovation and new markets? Mainly through improved research and development collaboration to improve opportunities for external funding.

10. Communication Strategy

Publications: Open habitats Practice Guide , Research Note on 1) species colonisation in woodland expansion, 2) ES benefits of converting secondary plantation forests Woodland Management for Fuel and Biodiversity Practice Guide
Reports: Several interim and Final reports
Seminars/conferences: 3 stakeholder workshop events – 1 each country by 4th year
Decision support systems:
Website: Yes
Peer review papers: Case study papers x4, Uncertainty paper, Restoration of peatlands paper, Woodland biodiversity supporting ES, 1-2 international author papers on ES indicator approaches for forests and wooded landscapes

11. Under government survey control procedures, Ministerial approval must be sought before statistical surveys of businesses or local authorities can proceed. Please indicate any intention to carry out a survey.

Yes ☐ No ☒ • If yes please give brief details

12. Details of support agreed *or to be sought* from funding bodies for project (*including in-kind support)*

13. Resources (times and fees) requested from the Forestry Commission

14. Milestones (M) and deliverables (D) and associated costs to Forestry Commission

Work Area number	M D	Output	2011/12				2012/13				2013/14				2014/15				Output	Total Cost
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Unique Identifier	
1.1 A	M	Framework plan for reviewing and cataloguing ES				X													Plan	
1.1 B	M	RN ES provided by forests and wooded landscapes							X										Report	
1.1 C	M	RN on the role of species and functional groups of woodlands												X					RN	
1.2 A	M	Extension of catalogue plan and spec to record ES, Indicators, and methods							X										Plan	
1.3 A	M	National Country Workshop ES of forests					X							X			X		workshop	
1.4 A	M	Population of catalog – attributes of methods and ranking etc									X								Report	
1.4 B	M	ES approaches assessment													X				Report	
1.4 C	M	Table of standards for spatial assessment															X		Report	
1.4 D	D	Journal paper on spatial ES assessment approaches														X			Manuscript	
1.4 D	D	IUFRO conference on ES of spruce forests							X										Conference in	

																			Edinburgh	
1.5 A	D	Journal paper final draft – Isle of Wight wood crickets								X									Paper	
1.5 B	D	Landscape genetics project proposal on wood ant movement and dispersal				X													PhD study	
2.1 A	M	New native woodlands summary report -100 words					X												Report	
2.1 B	M	Maps land-cover data and decision frameworks				X													Data and maps	
2.1 C	M	Establishing New woodlands manuscript for peer review			X				X										Conspectus	
2.1 D	M	SFA paper on ES provision								X									Draft	
2.2 A	M	Conversion for biodiversity – summary report 100 words					X												Report	
2.2 B	M	Maps land-cover data and decision frameworks							X										Maps and data	
2.2 C	M	Peer reviewed paper on conversion practise										X							Report	
2.3 A	D	Practice Guide a, Peatland restoration Chapter b,				X		X											Reports	
2.3 B	M	Maps land-cover data and decision frameworks								X									Data and maps	
2.3 C	M	2 papers for peer review c+d							X			X							papers	
2.4 A	D	Practice Guide on land-use choices for UK forests															X		Report	
3.1 A	M	Interim report scenarios and driving force datasets			X														Interim report	
3.1 B	D	Final report															X		Final report	
3.1 C	D	Journal paper																X	Journal	

																		paper	
3.2 A	D	Report on applicability of scenarios in a policy context															a	Scenarios report	
3.3 A	D	Report on scenario customisation/downscaling methods											X						
3.3 B	D	Journal paper – methodology and applicability													X				Journal paper	
4 A	M	Plan and budget for SDNP case study				X													Agreed plan	
4 B	M	Work schedule																	Plan	
5 A	M	Glen Garry Plan				X													Agreed plan	
5 B	M	Work schedule																	Plan	
6 A	M	Yorkshire plan			X														Agreed plan	
6 B	M	Work schedule																	Plan	
7 A	M	Wales AW plan					X												Agree plan	
7 B	M	Work schedule																	Plan	
4-7 A	D	Interim and final reports on case studies							X				X				X		Reports	
All Work Areas	D	Provide a report on advisory work to CFS				X				X				X				X		

Signed…….Research Provider/HOD
Date…….

Signed…….C&FS Advisor
Date…….

Proposal Approved CFS Date 31st August 2011

15. Agreed Changes

Description of change:
Signed……..Research Provider Date…… Signed……..C&FS Date……
Signed……..Research Provider Date…… Signed……..C&FS Date……
Signed……..Research Provider Date…… Signed……..C&FS Date……

16. Detailed communications plan:
Year 1
Year 2
Year 3
Year 4

ANNEX A

FR CFS proposals	Lead	Aim	Link to ecosystem services	Link to landscape spatial issues
Advice & scientific support for tree health				(c) i. use of **landscape ecological** and other techniques to **model pathways and possible geographic spread** of specified pests and pathogens; (c) iii. science to increase understanding of the effects of climate change on existing pests and pathogens...**increased use of modelling**; (c) iv. determination of likely **optimal pre-emptive control and management strategies** to mitigate the risks e.g. implications for **forest expansion, species choice, mixtures, forest design** etc.
Alternative management approaches	Gary Kerr	How can we adapt forests to increase resilience to climate change and biotic threats, whilst maintaining productivity?	How can we adapt forests to increase resilience to climate change and biotic threats, whilst **maintaining productivity**?	1. Vertical and **spatial structure of forests** - understanding how to manipulate forests to diversify vertical structure, **spatial arrangement** and species composition to increase resilience to climate change and biotic threats.
Bioenergy development programme	Ian Tubby		How can **woodfuel** volume be evaluated, harvested, processed and delivered to market **sustainably and**	How can woodfuel volume be **evaluated**, harvested, processed and delivered to market sustainably and profitably in a range of woodland types?

			profitably in a range of woodland types?	
Forest climate change adaptation strategies	Bruce Nicoll	To provide research, evidence and tools to assist forest planners, managers, and owners in adapting forests and woodlands to the changing climate.	11. Links with Ecosystem Services Programme – final proposal by June 2011.	Developing tools for risk assessment and management that use climate change scenarios to inform adaptation decisions and **focus action** where it is most needed; Multidisciplinary collaboration to provide results, information and guidance at **forest stand to landscape and regional scales**.
Economic research	Gregory Valatin	Realising the Economic Value of Ecosystem Services of Woodlands	a. Payments for **ecosystem services**: How to design mechanisms to ensure that the public values of woodlands are taken into account in decision-making; b. Valuation: How to **value ecosystem services** and account for **synergies and trade-offs** in provision.	1 (d) What evidence is there that grants are the best way to drive **woodland creation and management** (e.g. in addressing climate change agendas)? 2 (a) How could **decision support tools** be developed further to **assess where planting woodlands provide best "value for money"**? 2 (d) How should the impacts of different risks be taken into account in valuing ecosystem services and in **comparing different woodland creation and management options**?
Ecosystem services	Duncan Ray			

Habitat management	Ralph Harmer	understand how practical management can influence habitat and community development	29. Quantify data on stand dynamics and succession that can be fed into **landscape ecology** group modelling efforts; 33. Community development in **newly planted and restored woodlands** in relation to priority and other woodland species, and development of indicators to monitor success; 39. Comparison of the **effects of different methods of vegetation management** on the development of habitats and plant and animal communities especially in relation to ancient / semi-natural woodland and other sensitive sites.	
Intergrated forest monitoring	Andy Moffat		Research Forests - facilitate the **evaluation of forest ecosystem status** in the context of management and environmental influences and help **identify changes and trends** in indicators of sustainable forest management	
Long term experiments				
Managing forest carbon and GHG balances	James Morison		1) Delivering a strong scientific evidence base integrating information about **C** and other **GHG** balances for forests and the wider forestry sector to guide policy and practice; 2) Providing estimates of **C** stocks and **GHG** fluxes in trees and soils, and those caused by forestry operations; 4) Develop analyses of the benefits, costs and relative cost- **effectiveness of different forestry management options** for GHG balances; 2. Updated national forest soil **C stock estimates** using new Woodland Area	1. How will the C stocks and GHG fluxes change with **future changes in forest areas**, forest types and climatic conditions? 4. What are the appropriate **methods for assessing woodland C stocks at different scales**? 6. What are the benefits, costs and relative cost- effectiveness of different forestry management options for GHG balances?

			Map	9. Which **tools** can be provided for robust stand and **landscape-scale estimates and optimisation** of forest GHG balances ?
Operational efficiency woodland operations				
Protecting soil & water resources	Tom Nisbet	evaluate the impact of forests and woodlands on soil and water resources to support the development and implementation of sustainable forest management.	Evaluate the impact of forests and woodlands on **soil and water** resources to support the development and implementation of sustainable forest management; 3. Is energy forestry, including short rotation forestry and the harvesting of forestry residues compatible with sustaining soil and water resources? Which locations and soil types are most sensitive and what are the impacts on **soil carbon stocks**, **site fertility**, **soil biodiversity**, **water quality** and **water yield**? 5. To what degree can forestry reduce **flood risk** and how can this be modified by forest design and management practice? 8. How much riparian woodland would be required at a catchment scale to **mitigate the increasing risk of thermal stress** to fish due to climate change? How should this woodland be best designed and managed to protect sensitive populations?	Measuring the impact of forests, woodlands and management practices on soil and water resources by conducting **multi-scale** (spatial and temporal) studies; Developing **mapping and modelling tools** to promote integrated catchment management by **guiding woodland creation** to the most effective locations for maximising soil and water services while minimising risks and disbenefits; 3. Is energy forestry, including short rotation forestry and the harvesting of forestry residues compatible with sustaining soil and water resources? Which **locations and soil types are most sensitive** and what are the impacts on soil carbon stocks, site fertility, soil biodiversity, water quality and water yield? 5. What are the **best locations and soils for woodland**

				creation for flood alleviation? 6. Is **targeted woodland creation** an effective measure for **reducing diffuse pollution** within agricultural and urban areas? What are the **best locations** and woodland design for **pollutant retention** and how is this affected by management practice?
Regeneration & sustainable silviculture	Ian Willoughby	Adapting forest regeneration to increase resilience to climate change and biotic threats, whilst maintaining productivity.		
Remote sensing applications programme	Helen McKay	(a) identification of Interpreted Forest Types (IFTs); (b) monitoring of changes; (c) estimation of stand parameters.		
Societal benefits of trees, woods and forests research programme	Anna Lawrence	a) develop a critical and greater understanding of the relationships between trees, woods and forests (TWF), and society - including individuals, groups, organisations and institutions; b) provide the evidence base to develop, modify, evaluate and replicate policy, programmes and	b) provide the evidence base to develop, modify, **evaluate** and replicate policy, programmes and projects within this area, in order to improve delivery of sustainable forest management and **ecosystem services** (ES); e) What behaviour change and/or education initiatives might increase social action around conserving and enhancing **ES**? 2. How can we identity and value the social and cultural **ES** associated with	For social and cultural **ES** linked with TWF to be properly articulated and given appropriate value they need to be attached not only to particular **landscape/woodland units** but also to the communities and stakeholders with an interest in them.

		projects within this area, in order to improve delivery of sustainable forest management and ecosystem services (ES).	TWF and their impact on human well-being and what are the implications for SFM policy and practice? a) How does change in, and new models of, **land/woodland ownership** affect planning/pursuit of **ES** provision? b) How can landscape partnerships contribute to an **ES** approach?	
Species & gene conservation	Joan Cottrell		Species - from a focus on single species conservation to a more holistic approach which concentrates on the maintenance of healthy ecosystems. **Healthy ecosystems deliver ecosystem services (ES)??**; By maintaining or enhancing wild species diversity, ecosystems provide both Provisioning and Cultural ES; a. Can the efficacy of **woodland ecosystems** in providing for priority woodland species be **enhanced through active management of habitat structures /features**? If so, what is the best method to monitor the delivery of this service? Outputs from this research would **support targeting of incentives**; b. Is there a lack of understanding of the **functional processes** involved in priority species survival which acts as a barrier to **effective land use planning and sustainable forest management and ultimate delivery of ESs**? d. What is the role of priority species in **provision of cultural ecosystem services** (e.g. as assessed as socially	Genetics - inform models for predicting likely adaptability of woodlands to climate change and will allow the **efficiency of woodland habitat networks** to be tested; In the interaction between natural selection, drift and gene flow that produces such patterns, **landscape complexity** plays a significant role in determining the **scale** at which adaptive divergence occurs. The whole concept of woodland habitat networks is based on the assumption that habitat corridors maintain genetic connectivity for all woodland species. Molecular markers, which can provide **measures of population differentiation and gene flow**, are being applied to test this assumption in two woodland specialist species. This work is ongoing and demands **collaboration between molecular geneticists,**

			valued and meaningful) and in **functional processes** in the ecosystem (e.g. as in keystone s	**landscape ecologists and statisticians**.
Tree breeding				
Urban trees & greenspace in a changing climate	Tony Hutchings	to investigate critical interactions between trees and the built environment with a view to informing urban policy, planning and practice for improving quality of life and climate change adaptation via urban tree green infrastructure.	(3) Quantification of the **functions which urban trees perform**? • Heat Amelioration • SUDs/Water Infiltration • Carbon Storage • Air Quality • Shading • Noise (4) What **services** do such functions perform? • Flood Prevention • Human Health • Environmental Quality • Ecological function • Economic prosperity • Property Values • Aesthetic value • Social – *Greenspace User Behaviour, Governance, Attitudes, Perception, Value*; (ii) collaborative work with FR and external economists for **valuation of specific services;** 4. Produce a guideline on data needs for a **standardised inventory system/framework** for managing urban GI and **quantifying ecosystem services** under a changing climate, enabling managers to prioritise the information they collect to **deliver targeted outputs**.	How should **tree planting and wider GI be planned to maximise benefits** to counter climate change whilst **maintaining or increasing other benefits**?

Vertebrates programme	Brenda Mayle	To provide increased understanding, knowledge and tools to support large herbivore management to reduce their negative impacts and provide positive impacts.	1. How do **impacts by native and introduced species** (plants and vertebrates) benefit or limit woodland habitat structures, features and associated Priority Species or groups, and the ability of Woodland ecosystems to provide **ecosystem services**. 2. Can we use vertebrate management to manipulate habitats for **ecosystem service** benefits?	How can land managers manage deer, and their impacts, at a **landscape** scale? • Use the results of this analysis, and other information, to develop **landscape-scale models of deer** density, distribution and impacts to allow more effective collaborative deer management. Grey squirrel - Improve **landscape scale risk assessment** methods to more **effectively target** limited resources for control