Forestry Commission **Proposal for funding Agreement Number CFS 18-2011-15**

FORESTRY COMMISSION
Description of the Research Project or Services

1.	**Research Purchasing Manager (C&FS)**	**Helen Sellars**
	Relevant PAG	**Sustainable forest management**

2.	**Name of FR Programme Manager (PgM) or Project Manager (PM) and staff**	**Ian Willoughby (Programme manager)** **Richard Jinks (Project manager, Seed and Seedling Biology work area)** **Alan Harrison (Project manager, Regeneration Systems work area)** **Katherine Tubby** **Shelagh McCartan** **Matt Parratt** **Tor Stokes**
	Name of Institution/company	**Forest Research**
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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

Regeneration and sustainable silviculture

4. Abstract of proposed research (*Summary to be used on website/FRCC etc***) (200 words)**

Successful regeneration is fundamental for sustainable woodland management in the UK. Regeneration is therefore an essential prerequisite for a wide range of Forestry Commission policy objectives, and this programme provides a vital source of scientifically backed expertise in this area. New challenges for the practice of regeneration are posed in particular by climate change and the emergence of new pests and diseases, but also by increasing interest in continuous cover forestry; natural regeneration; restoration; woodland expansion; and by changes to policy, legislation and certification.

To reflect these challenges the key objective for this research programme is :-

Adapting forest regeneration to increase resilience to climate change and biotic threats, whilst maintaining productivity.

This objective will be delivered through 3 work areas with their own key aims:-

1. Seed and seedling biology

- *Determining how projected changes in seasonal temperature and rainfall will affect regeneration of key trees species in different parts of Britain.*

2. Integrated forest vegetation management and the sustainable use of pesticides

- *Maintaining the availability of pesticides as strategic tools for dealing with damaging pests, diseases and weeds, given the implementation of new pesticides regulations, the need to reduce pesticide inputs and identify non chemical alternatives, and the evolution of new biosecurity threats that may be exacerbated by climate change.*

3. Regeneration systems

- *Investigating how to adapt future regeneration systems to be more resilient to climate change, whilst maintaining productivity.*

5. Aims and objectives (word limit 500)

5.1 Aim of the research

Successful regeneration is fundamental for sustainable woodland management in the UK. Regeneration is therefore an essential prerequisite for a wide range of Forestry Commission policy objectives, and this programme provides a vital source of scientifically backed expertise in this area. New challenges for the practice of regeneration are posed in particular by climate change and the emergence of new pests and diseases, but also by increasing interest in CCF, natural regeneration, restoration, woodland expansion, changes to policy, legislation and certification.

To reflect these challenges the key objective for this research programme is :-

Adapting forest regeneration to increase resilience to climate change and biotic threats, whilst maintaining productivity.

5.2 Work Areas

The main objective of the research programme will be delivered through 3 work areas, each with its own key aims.

Work area 1. Seed and Seedling Biology

Key research question:- How will projected changes in seasonal temperature and rainfall affect regeneration of key trees species in different parts of Britain?

Regeneration is a multi stage sequence of events that begins with the initiation of flowering and ends with the successful establishment of seedlings. Critical events that often occur on a short timescale have long lasting effects on regeneration and species composition. In the context of projected climate change, most stages are dependent on temperature and water supply. Two key areas for which there is a significant lack of evidence on the likely impacts of climate change are the consequences for

seed dormancy breakage and seedling germination and establishment. This leads on to two further questions:-

> *How will projected climate change affect dormancy breakage in species with shallow and deeply dormant seed?*

Seeds of different trees have different degrees of dormancy, requiring varying lengths of exposure to winter cold, or summer warmth followed by winter cold to break dormancy. We need to understand the consequences of milder winters, for example, on the dormancy breakage of seeds with different pre chill requirements: insufficient chill might lead to incomplete dormancy breakage and failure to regenerate of particular species. This may indicate, for example, where native species will no longer be able to regenerate successfully, and how provenance affects dormancy and germination.

> *How will projected climate change affect successful germination and establishment of different tree species?*

Once dormancy breakage has occurred, the safe period for germination starts in late winter/early spring when soil temperatures have risen above the minimum for germination, and ends when temperatures become too warm in spring or early summer, when seedlings are either killed, or in some species, ungerminated seeds return to dormancy. During this period seeds have to accumulate sufficient heat (degree-days) to complete germination and seedling emergence. Tree seeds need to spend several weeks at temperatures between 5 and 20°C to germinate successfully. Impacts of changes in temperature and drought on these processes need to be assessed: will milder winters bring forward the start of the safe-germination period? Will milder springs shorten the safe-germination window and so increase the likelihood of germination failure? Will germination of some species become restricted to particular habitats or topographies?

These questions will be addressed by focusing on developing models for predicting impacts of climate change on germination. Model parameters will be determined using laboratory investigations carried out under controlled conditions, then tested and validated in different habitats under current climatic conditions, but also on sites which already have elements of the future projected climate.

Species to be studied in work area 1 are likely to include, for different aspects of the work, Scots pine, Douglas fir, Sitka spruce, birch, beech, sycamore, field maple, ash cherry, rowan and yew. Provenance variation will also be addressed, as will propagation of species that may become more important in the future due to climate change, such as for example coast redwood, Macedonian pine and Japanese red cedar.

Work area 2. Integrated forest vegetation management and the sustainable use of pesticides

Key research question:- How can we maintain the availability of pesticides as strategic tools for dealing with damaging pests, diseases and weeds, given the implementation of new pesticides regulations, the need to reduce pesticide inputs and identify non chemical alternatives, and the evolution of new biosecurity threats that may be exacerbated by climate change.

Over the next 4 years an entirely new basis for pesticide regulation will be introduced into the UK, and this is likely to have very significant impact on both the range of products approved for forestry use, and the way they can be used. In addition, over the same period, certification requirements regarding pesticides are likely to continue to evolve, new national pest management groups may be put in place to handle national derogations for pesticide use on FSC certified estates, and the outcome of the water framework directive priority hazardous substance review will begin to take effect. This could result in key pesticides for the forest industry such as glyphosate, propyzamide, asulam, warfarin and cypermethrin, and other potential insecticides and fungicides that might be used for dealing with catastrophic pest and disease outbreaks being lost, and methods such as aerial spraying, or

conventional spraying on upland sites near to forest drains may be curtailed or prohibited.

To address this there is a need to engage with those organisations leading on these initiatives, provide specialist advice on likely implications for different policy options to the UK forest industry, carry out research on alternative pesticides, methods and non chemical approaches to address the critical evidence gaps arising from the implementation of these new requirements, and disseminate the results of this research and new legislative / certification requirements in a user friendly and practical way for the forest industry to ensure improved and more sustainable pest, weed and disease control in practice. This dissemination will be achieved through a publication on aerial spraying and a revision of FC Practice Guide 15.

Urea accounts for over 90% of all pesticide usage in the UK, with the only direct alternative being the use of the FC owned biofungicide PG Suspension which is currently restricted to pine. Re registration of the PG Suspension, including a report on opportunities for improving efficacy on spruce, will be completed in 11/12.

Vegetation management to favour the development of trees and other desirable vegetation over less desirable, competitive plants is a vital component of all forms of sustainable woodland management, including clearfell and continuous cover systems, and can make up to 30% or more of the total cost of regeneration. It is clearly key to successfully achieving the objectives of protecting forests, reducing deforestation, restoration of forests, and the management of forests for wood fuel. It is also critical to achieving national targets for woodland expansion. However, climate change is likely to increase the negative impact of weeds, render many existing management methods less effective, and lead to the spread of new alien species which may threaten woodlands. Managers are faced with pressure to adopt non chemical methods of management, but relatively few economically viable approaches exist (direct alternative non-chemical approaches are often 10 – 1000 times more expensive). Changes to pesticide regulations and certification may significantly reduce the range of existing herbicides. The key research issue is therefore how to manage vegetation in an integrated manner to minimise potentially catastrophic losses to young trees from drought and competition, and to maintain long term productivity, resilience and biodiversity, given likely changes in climate, new tree species, new invasive species, pressures to reduce pesticide use and the need to reduce costs?

In addition to work on maintaining pesticide availability, research is therefore required into integrated approaches to vegetation management utilising both alternative chemical and non-chemical methods where appropriate. Priorities will be to identify practical methods of bramble control for continuous cover forestry and natural regeneration systems, to identify non-pesticidal adjuvants to improve the practice of control of *Phytophthora* harbouring rhododendron, to deliver practical guidance on critical periods of weed control to maximise productivity and resilience at minimal cost and with minimal use of herbicides, and to provide evidence on the impact of climate change on the need for and methods available for vegetation management. Work on providing evidence of the long term benefits of early vegetation management for carbon sequestration needs to be completed. Direct seeding may have a role in helping managers achieve higher quality, lower cost, more climate change resilient regeneration of low productivity conifer sites, or PAWS sites, whilst using significantly reduced quantities of herbicides. Existing experiments will be concluded, and a short review produced of lessons learnt to date and practical management implications for the future. Longer term objectives will be to identify more effective chemical or non-chemical control methods for critical evidence gaps, given likely losses in herbicides, for preventing the spread of weeds that are likely to become more problematic or invasive due to climate change, such as bramble, bracken, salal, buddleja, robinina, tree of heaven, and for grasses and injurious weeds such as ragwort and thistles. Future research will need to take account of likely future tree species choice in the countries, including currently minor species that may have a bigger role to play in future in improving resilience of forests to climate change, and continue to take into account the increasing focus on continuous cover forestry and natural regeneration.

Work area 3. Regeneration systems

Key research question:- How can we adapt future regeneration systems to be more resilient to climate change, whilst maintaining productivity?

On many sites patch or larger scale clear felling, rather than continuous cover systems, will continue to be the norm, particularly in less stable, upland areas, or where rapid change of species may be desired, or due to economic factors. In these instances there is a need to consider future silvicultural systems that can achieve sustainable regeneration, resilient to future climate change, whilst maintaining productivity and mitigation potential, at minimal cost. Additional challenges may arise if woodland ownership and management becomes more fragmented with a greater role being taken by the 'Big Society'. A number of approaches will be taken to deliver this key research question.

Investigations are required into how to establish more minor or novel species that may increasingly be favoured in an attempt to adapt future woodland to climate change. Both establishment and nursery practices may require adaptation if novel species are to be grown successfully on a larger scale outside specialist arboreta. A review of existing knowledge will be undertaken, and guidance placed on the species specific web pages developed as part of the species programme. As part of this process, liaison will take place with the countries over likely future species priorities. Any critical evidence gaps requiring future research will be identified.

On conifer sites intended for restoration to broadleaved species, or sites targeted for high quality broadleaves (e.g. resilient, actively managed, economically viable, producing high value timber and delivering multiple objectives), where natural regeneration is poor or restricted to low value species such as birch, low density early enrichment planting using high-value timber species, or using future species or provenances from more southerly origins to increase resilience to future climate change, warrants further study. The practicality of such an approach, including gap size, orientation, and the duration of maintenance required will be investigated.

The increasing amount of forest land now under wind turbines presents the challenge of growing an economic crop within fixed height constraints. A review will investigate options for adapting species choice and silvicultural management on such sites. Depending on objectives this might include for example the aim of maximising productivity or biodiversity, or minimising long term site management costs.

Both planting stock and regeneration practices might need to be adapted in future in response to climate change. Investigations will commence into the potential for manipulating and conditioning planting stock so that it leaves the nursery in the best possible physical and physiological condition to meet the challenges of climate change on regeneration sites, in particular spring drought and late frosts.

Links with other research programmes

Regular liaison with colleagues across a range other research programmes will take place to ensure complementary working and avoid overlap. This is covered under the programme development output in each work area, and this output also covers external networking and income generation activities.

Work on predicting the impacts of climate change on specific regeneration processes, and practical methods of adapting regeneration practices to cope with climate change, will support the modelling and landscape approaches of the Alternative Management Approaches programme, and the Forest Climate Change Adaption Strategies programme. Development of strategies for adapting forest management to maximise mitigation potential will take place in conjunction with the Alternative Management Approaches programme and Forest Climate Change Adaptation Strategies programme in particular, through working up a potential bid for EU FP7 funding. Further linkage with the

Alternative Management Approaches programme will take place in producing guidance on vegetation management in continuous cover forestry systems.

Work on establishment techniques for future species will support the species identification work within the Tree Breeding, Conifer, Broadleaf and Emerging Species programme.

Work on maintaining pesticides as strategic tools for the GB forest industry provide important support for the work of the Advice and Scientific Support for Tree Health programme. A £250K externally funded Defra project on improved methods for eliminating sporulating hosts of Phytophthora and dealing with residues also involves joint working in particular with the Advice and Scientific support for Tree Health and Operational Efficiency in a Sustainable Forest Industry Wood Chain programmes.

Summary of work areas and work packages:-

Work Area 1	**Seed and seedling biology** (Richard Jinks, Shelagh McCartan, Matt Parratt) **Key outcome:-** *Determining how projected changes in seasonal temperature and rainfall will affect regeneration of key trees species in different parts of Britain.*
Work package 1.1	Seed and seedling biology research
Work package 1.2	Seed and seedling biology knowledge exchange
Work Area 2	**Integrated forest vegetation management and the sustainable use of pesticides** (Ian Willoughby, Tor Stokes, Kath Tubby, various TSU colleagues) **Key outcome:-** *Maintaining the availability of pesticides as strategic tools for dealing with damaging pests, diseases and weeds, given the implementation of new pesticides regulations, the need to reduce pesticide inputs and identify non chemical alternatives, and the evolution of new biosecurity threats that may be exacerbated by climate change.*
Work package 2.1	Integrated forest vegetation management and the sustainable use of pesticides research
Work package 2.2	Integrated forest vegetation management and the sustainable use of pesticides knowledge exchange
Work Area 3	**Regeneration systems** (Alan Harrison, Colin McEvoy, various TSU colleagues) **Key outcome:-** *Providing evidence on how to adapt future regeneration systems to be more resilient to climate change, whilst maintaining productivity.*
Work package 3.1	Regeneration systems research
Work package 3.2	Regeneration systems knowledge exchange

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)

Successful regeneration is fundamental for sustainable woodland management in the UK, and research backed evidence in this area is an essential underpinning requirement for a very wide range of Forestry Commission policy objectives.

UK and European policies
Climate change
Appropriate and effective regeneration practices will clearly be key in the future to successfully achieving the core objectives of Forestry Commission Policy on Forests and Climate Change, namely protecting forests, restoration of forests and the management of forests for wood fuel. Managers will need expert support and additional evidence to help them adapt future regeneration practices to help ensure forests are more resilient to a changing climate.

UKWAS and the UK Forestry Standard
The FC estate is certified using the UK Woodland Assurance Standard, and Country strategies aim to encourage the private sector to adopt the practices outlined in the UK Forest Standard. The Regeneration and Sustainable Silviculture programme underpins the expertise required to deliver sustainable management and the protection of the resource against biotic threats as outlined in the UK Forest Standard and UKWAS.

National and International polices relating to pesticide use
Both UKWAS and the UK Woodland Assurance standard also have, as a core principle, the adoption of policies that will lead either to a minimisation or elimination of pesticide use. This is also required by both UK national Government and European Union policy on the Sustainable Use of Pesticides which calls on member states to minimise the risks to the environment from using pesticides and reduce their use, including substitution with non-chemical alternatives. Forest Stewardship Council pesticide policy, requires minimisation and eventual elimination of all pesticide use, and has developed a specific list of chemical that it views as 'highly hazardous', and are therefore banned in FSC (and hence UKWAS) certified estates.

The vegetation management and sustainable use of pesticides element of this project will provide expert support to allow the Forestry Commission and forest industry to fulfil these national and international policy requirements, minimise pesticide use, and maintain pesticides as a strategic tool for managing pest, weeds and disease in British forests.

Country strategies
In addition to cross cutting national and international policy, the Regeneration and Sustainable Silviculture programme provides vital underpinning support for many aspects of the three country strategies. For example:-

FC Scotland Strategy (*Scottish Forestry Strategy*)
- Improving the understating of climate change impacts on woodland ecosystems and silviculture.
- Maintaining preventative measures and readiness for diseases and other threats.
- Harnessing the carbon sequestration potential of new woodland, particularly on fertile, low carbon soils.
- Increasing long term carbon retention through low impact silvicultural systems and promoting woodland regeneration.
- Encouraging the development of short rotation forestry.
- Encouraging the production of high quality timber.
- Promoting silvicultural practices to grow the hardwood (broadleaved) sector.

- Diversifying planted woodlands.
- Supporting the creation of new native woodlands.
- Maintaining the silvicultural expertise required for the sustainable management of productive forests and the growing of high quality timber.

FC Wales Strategy (*Woodlands for Wales*)

- More woodlands and trees are managed sustainably (to UKWAS standards).
- Woodland ecosystems are healthy and resilient (diversification, resilience to climate change, diseases).
- Woodland cover increases (regeneration).
- Woodlands adapted to climate change.
- Woodland management achieving high standards of environmental stewardship (protection of soil and water).
- Woodlands of special conservation value are in favourable management (PAWS restoration).

The FC England Strategy is currently under review, but it might not be unreasonable to assume that there will be an ongoing requirement for sustainable management and regeneration of the resource, for protection from invasive pests, weeds and diseases, for adaptation of forest management to ensure resilience to climate change, for increasing the sequestration potential of woodlands and for the reduction of costs. FC England have also identified 'how to comply with new EU regulations on pesticide use' as a key research question.

Funding for the Regeneration and Sustainable Silviculture programme will allow the Forestry Commission to continue to respond effectively to the practical challenges facing managers and landowners resulting from these important Country, UK and European policy drivers.

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

Summary of impacts if the work were not to go ahead

Given the essential underpinning role that expertise on regeneration has for sustainable woodland management in the UK, the risks or impacts of not carrying out this programme include the inability to make scientifically informed responses to the effects of predicted climate change on regeneration processes, the loss of opportunities to develop scientifically based management systems for ensuring cost effective regeneration, and the loss of the Forestry Commission's reputation as the nation's tree authority at local, regional and international levels.

Not undertaking or fully funding the vegetation management project will result in a loss of core Forestry Commission expertise in pesticide use and minimisation, and severely impact the ability of the Forestry Commission to respond to the European and National Policies outlined in section 7 above, as well as raising a very significant risk of loss of UKWAS certification. The Forestry Commission's ability to respond to future challenges such as new invasive alien species as a result of climate change, will also be severely reduced. Many key pesticides and application methods for the forest industry are likely to be lost, and no expertise will exist to identity replacements. This would likely result in both an inability of the forest industry to manage key, chronically damaging pests, weeds and diseases either effectively or economically, and the inability to respond to potentially catastrophic outbreaks of new pests and diseases.

Not re-registering PG Suspension would mean the loss of all UK approvals for this FC owned biocontrol agent, and no opportunity of extending the use of biological stump treatment to Sitka spruce.

Risks in carrying out the work

The significant reduction in funding over the 4 year period covered by this proposal might result in an inability to carry out field research on any significant scale and potentially the loss of core expertise in adapting regeneration practices to climate change, which underpin the Forestry Commission's core strategic priority of adapting forest management to climate change.

Given the lack of duplication of expertise and the wide range of topics covered in this programme, there is little flexibility to cover any unexpected staff absence due to secondments, etc., so these might result in a significant delay to proposed outputs.

As part of the PG Suspension product re registration process, there is a likely to be a requirement for an additional CFS cash budget of £15K to pay for application fees in 12/13, and depending on final CRD requirements, there might be a requirement to fund additional ecotoxicology trials which are not costed in this proposal.

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

Who will benefit from this research?
All parts of the UK forest industry practising sustainable forest management.

How will they benefit from this research?
Regeneration underpins the practice of sustainable woodland management throughout the UK. Carrying out this programme of research will allow the Forestry Commission to retain essential expertise on regeneration, and permit scientifically informed responses and policy to be made addressing the effects of predicted climate change on regeneration processes. It will also provide opportunities to develop scientifically based management systems for ensuring cost-effective regeneration throughout the UK forest industry.

What will be done to ensure that they have the opportunity to benefit from this research?
Please see the communication strategy outlined in section 10.

Potential for innovation and new markets?
Innovation is key to all the research activity outlined in this proposal. In terms of the generation of additional revenue from the development of new markets, fungicides used for the prevention of infection from *Heterobasidion annosum* comprise over 90% of all pesticide use in the UK. The research into improving the effectiveness of the Forestry Commission owned biofungicide PG suspension will prove commercially lucrative and open up considerable new markets if efficacy could be increased on Sitka spruce.

10. Communication Strategy

Precise methods of communication over the four year period will be dependent on results and opportunities that arise, but currently planned outputs (see section 14 for details) are as a minimum:-

Publications:
1 FC Field Book / Practice Guide – pest, weed and disease control in forestry.
1 tree seedling ID guide.
2 FC Practice Notes –
silvicultural options for wind farm sites;
impacts of climate change or bramble management or CCF.

Reports:
1 internal report / contingency document on aerial spraying.
21 internal progress reports.

Seminars/conferences: 3 per year – e.g. regeneration systems, new species, srf etc.

Decision support systems:
Website: 2 new major website additions – seeds database; establishment techniques for future species Existing project web pages will also be maintained (not listed as milestone).
Peer review papers: 9 journal papers – germination of *Araucaria araucana*; dormancy in *Pseudotsuga menziesii*; seed predation; long term impacts of vegetation management; bramble management; biodegradable mulches; critical period of weed competition; reducing herbicide inputs / direct seeding; adapting planting stock and planting to climate change.

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. Deliverables and associated costs to Forestry Commission

Work Area number	Output	Year 1				Year 2				Year 3				Year 4				Output	Total Cost
		Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Unique Identifier	
	Seed and Seedling Biology																		
1.1	Maintain and update seeds database on website																		
1.1	Prepare detailed project plan for the investigation of impacts of projected climate change on seed dormancy breakage.																		
1.2	Submit a paper on the embryo growth curves and thermal time models for germination of *Araucaria araucana* seeds.		X																
1.2	Draft a paper on the re-imposition of dormancy in *Pseudotsuga menziesii* seeds.				X														
1.1	Conduct laboratory and field investigations for model development.																		
1.2	Report on progress with the development of models for predicting impacts of climate change on dormancy breakage of key species. Final report and review end of year 4.				X				X				X				X		
1.1	Prepare detailed project plan for the investigation of impacts of projected climate change on germination and seedling establishment.																		
1.2	Complete journal paper on seed predation.		X																
1.2	Finalise the Tree Seedling ID Guide for publication.			X															
1.1	Conduct laboratory, glasshouse and field investigations for model development.																		
1.2	Report on progress with the development of models for predicting impacts of climate change on seedling regeneration. Final report and review end of year 4.				X				X				X				X		
1.1/1.2	Seek external funding and report on progress with programme development.				X				X				X				X		

Forestry Commission **Proposal for funding Agreement Number CFS 18-2011-15**

Work Area number	Output	Year 1				Year 2				Year 3				Year 4				Output	Total Cost
		Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Unique Identifier	
	Integrated forest vegetation management and the sustainable use of pesticides																		
2.1	Provide representation and expert support for maintenance of pesticides as strategic tools for GB forestry.																		
2.2	Prepare internal report on representation and expert support work.				X				X				X				X		
2.1	Carry out research on integrated forest vegetation management and the sustainable use of pesticides, including new experiments on pesticide critical gaps or enrichment.																		
2.2	Report on progress with research on integrated forest vegetation management and the sustainable use of pesticides.				X				X				X				X		
2.1	Complete first draft of revision of FC Field Book 8 and Practice Guide 15 to produce new standard work on pest, weed and disease control in forestry.				X														
2.2	Produce journal paper reviewing the long term impacts for growth and carbon sequestration of early vegetation management.								X										
2.2	Review best practice and requirements of new legislation, and produce a short FC contingency note on emergency use of aerial spraying.						X												
2.1	Complete assessments and analysis of trials on improving efficacy of PG Suspension on spruce.																		
2.2	Produce internal report to CFS on results of trials on improving the efficacy of PG Suspension on spruce.				X														
2.1	Complete product registration for PG Suspension.					X													

Work Area number	Output	Year 1				Year 2				Year 3				Year 4				Output	Total Cost
		Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Unique Identifier	
2.2	Complete analysis and produce journal paper on bramble in CCF / natural regeneration.				X														
2.2	Complete analysis and produce journal paper on biodegradable mulches.								X										
2.1	Complete analysis of critical period of weed competition experimental series.																		
2.2	Produce journal paper on the effects of weed competition and the critical period of weed competition.												X						
2.2	Depending on results, produce FC Practice Note on impacts of climate change on vegetation management, or vegetation management in continuous cover forestry, or bramble management.												X						
2.1	Commence update of pest, weed and disease control in forestry (FB8 / PG15), depending on changes to legislation and results of pesticide critical gaps experiments.																		
2.1	Complete analysis of reducing herbicide inputs and direct seeding experiments.																		
2.2	Depending on results, prepare journal paper, or review and updating of existing guidance on practicality of direct seeding for restocking / regeneration situations.																X		
2.1/2.2	Seek external funding and report on progress with programme development.				X				X				X				X		

Work Area number	Output	Year 1				Year 2				Year 3				Year 4				Output	Total Cost
		Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Unique Identifier	
	Regeneration systems																		
3.1	Commence review of future silvicultural options for wind farm sites. Depending on extent of existing information, produce project plan or conspectus for Practice Note.				X														
3.1	Review silvicultural options for wind farm sites.																		
3.2	Draft FC Practice Note on silvicultural options for wind farm sites.												X						
3.1	Review plant production and establishment silviculture requirement for novel species adapted for future climate change. To include liaison with countries over likely future species choice.																		
3.2	Update future species web pages for establishment techniques, identify any evidence gaps requiring future research.								X										
3.1	Draft experiment plans and carry out research on adapting planting stock and planting practices to climate change. Discuss project plan / experiment plan with CFS customer.																		
3.2	Report on progress with research on regeneration systems.				X				X				X				X		
3.2	Depending on results, draft internal report or journal paper / Information Note on adapting planting stock and planting practices to climate change.																X		
3.1/3.2	Seek external funding and report on progress with programme development.				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:
1) Produce journal paper reviewing the long term impacts for growth and carbon sequestration of early vegetation management. First draft is about 80% complete, but has been stalled due to various staff resource issues. Unlikely the paper will be complete by 31st March. However, faster than expected progress with the output *'Complete analysis and produce journal paper on bramble in CCF / natural regeneration'* which was originally due to be delivered in 2012 /13. Agreed that this is a substitute and delay (1) until 2012/13. Signed……..Research Provider Date…… Signed……  …….C&FS Date…1st Feb 2012.
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