Forestry Commission **Proposal for funding Agreement Number CFS 12-2011-15**

FORESTRY COMMISSION
Description of the Research Project or Services

1.	**Research Purchasing Manager (C&FS)**	**Roger Coppock**
	Relevant PAG	**Wood and Timber Products**

2.	**Name of FR Programme Manager (PgM) or Project Manager (PM) and staff**	**Programme Leader: Steve Lee** **Project leaders:** Steve Lee — *Conifer Breeding* Rob Sykes — *Broadleaf Breeding* Bill Mason/Richard Jinks — *Emerging Species* Joan Cottrell — *Marker Aided Selection* Trevor Fenning — *Tissue Culture* All the above — *Knowledge Exchange* All the above — *Programme Development*
	Name of Institution/company	**FR**
	Official address	Alice Holt Lodge, Wrecclesham Farnham Surrey, GU10 4LH
	Telephone No.	
	e-mail address	Steve.lee@forestry.gsi.gov.uk
	Programme Life (years)	**4 Years.** Total Programme Funding from CFS to fall by 43% over next 3 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

Programme: Genetic Improvement

Incorporating the following 3 Projects:
Tree Breeding (TrB)
Developing Technologies (DeT)
Trees4Future (T4F)

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

1. The Programme involves the production of genetically improved planting stock through the exploitation of the natural genetic variation between trees for the characteristic of greatest economic importance to the end-use.
2. Planting improved stock will impact positively on both growing costs and rotation revenue.
3. The Programme involves the genetic improvement of established conifer and broadleaf species, as well as new emerging species and new origins of traditional species. It involves the use of traditional 'low tech' tree breeding techniques, and also the development of new 'high-tech' methods aimed at improving efficiencies and speed with which selected material reaches the forest.
4. The conifer species subject to a breeding programme are:
    i. Sitka spruce,
    ii. Scots pine,
    iii. Corsican pine,
    iv. Hybrid larch and
    v. Douglas fir;
5. The broadleaf species are
    i. Oak,
    ii. Birch,
    iii. Ash
    iv. Sycamore.
6. There are up to 60 new conifer or broadleaf species being investigated under 'Emerging' species.
7. Historically, FC-sponsored breeding has been for solid wood aimed at the construction (conifer and broadleaf) or joinery (broadleaf) markets. There may be a requirement in the future to breed for new species such willow, poplar or Eucalyptus for new characteristics such as total biomass, calorific value or fibre qualities plasticity.
8. Two areas of new technologies are being developed to improve overall financial efficiencies:
    a. DNA-markers to select the most genetically superior individuals at an earlier age in the laboratory based on DNA characteristics.
    b. Tissue Culture to mass produce highly selected genotypes and deploy them to the field in large, cost-effective number as quickly as possible.

5. Aims and objectives (word limit 500)

5.1 Aim of the research

'**Genetic Improvement'** is designed to increase the financial return invested in planting stock by improving general adaptability (suitability for the site) and the proportion of trees meeting the intended end-use (suitability for market). Tree breeding – regardless of species – offers one of the best Cost:Benefit ratio returns possible in plantation forestry.

Tree breeding requires considerable up-front investment before realising a return. As such it is often carried out by government funded bodies unless the rotation length is particularly short (e.g. 8-years for Eucalyptus in Brazil). The testing of seed origins and selected superior trees (phenotypes) can each take between 15-years (conifers) and 30-years (broadleaves). It may take another 10 years to get appreciable amounts of improved seed from orchards or other means (e.g. cuttings) and then trees must be grown to full rotation (conifers 40 years; broadleaf species 80 to 150 years) before a return is realised often by different organisations to that which carried out the original research.

The processes involved in producing improved planting stock are:

i. *Identifying the most suitable seed origin or provenance;*

A species will grow across a range of site types. If a species is exotic it may not be immediately apparent from site matching which will be best adapted and suitable for market needs. Field testing of seed collected across the distribution of the species may be necessary. Even for native species the locally occurring origin may not the best to meet current or anticipated market needs. There is a need to test seed origin suitability across a range of site types and climates for a reason length of time. This process is nearly complete in conifer breeding but is still being pursued with broadleaf species and new 'emerging' species

ii. *Selection and Testing of superior trees within the chosen origin;*

This process started with conifer species in the early-1960s but has only just started with some broadleaf species and has yet to commence with others. Selecting the superior trees is relatively straight forward but the field-based testing of those trees can be costly and prolonged. Most of the previous research concentrated on trying to reduce field costs (number of site replications; number of replications; plot size) and time of final selections (gradually reduced for conifers from 15 to 20 years, to just 9 years). The ultimate aim is usually to determine the breeding value of selected trees which could be used in further breeding work. This requires investment in trained staff, specialist computer software and databases which are constantly up-dated.

iii. *Breeding together the trees which are proven to be superior*

Superior trees are mated together to give more genotypes from which trees with even better characteristics can be tested and selected. There is considerable infrastructure requirement including seed and pollen stores, and field-based genetic archives (clone banks) where g material is stored for future breeding work. The improved basic material is sold to third parties to create areas where improved seed is produced (seed orchards), or occasionally FR produced improved seed by in-house controlled pollination and subsequent selling on of the valuable seed to forest-nurseries for the vegetative propagation industry.

vi. *Developing technologies*
There are always ways of improving efficiencies. DNA-Markers technology is being developed to short-cut the selection process and Tissue Culture techniques are being developed to mass produce genotypes of high genetic value. Both these techniques have the potential to vastly improve the rate at which selected material is chosen and then mass produced for field deployment.

v. *Knowledge Exchange (KE)*
Information exchange with end-users in the nursery, forest and sawmilling sectors is a highly important part of this Project. This is achieved by means of scientific and trade-journal papers, seminars and presentations to professional bodies. It is estimated that as much as 25% of the CFS budget will be spent in this area.

iv. *Programme Development*
Roughly 10% of CFS funding (net of KE funding and matched funding for other contracts) is allocated to Programme Development. This is time spent looking for related external funding which may or may not require some CFS matched funding.

v. Matched-funding
By prior agreement, CFS may agree to match-fund relevant contracts involving other sponsors (mainly EU). Mutually beneficial objectives with shared core-finding is encouraged. Consequently a number of contracts for which CFS are not the sole funder, and indeed are not involved at all are included here.

5.2 Work Areas
Please list your work Areas as shown in the table below and show how they further sub-divide
Work Areas should be individually costed and be time bound – see 13. below. Please state ke
desired outcomes from each work area. First two years should be detailed, the next two in
outline. See also Note for this Section below.

Tree Breeding (TrB)

TrB	**Work Area 1**	**Conifer Breeding** *Steve Lee, Rob Sykes, TSU staff*
	Work package 1.1	Selection and testing
	Work package 1.2	Breeding and production
TrB	**Work Area 2**	**Broadleaf Breeding** *Rob Sykes, Steve Lee, TSU staff*
	Work package 2.1	General
	Work package 2.2	Direct BIHIP involvement
TrB	**Work Area 3**	**Emerging Species** *Bill Mason, Richard Jinks, TSU staff, Matt Parrott, Joan Webber*
	Work package 3.1	Research
	Work package 3.2	EU REINFFORCE contract *CFS match funding*
	Work package 3.3	Arboreta *Bill Mason, Richard Jinks* *100% funded by FC(E)*
	Work package 3.4	FC Tree Collection Project. *Bill Mason, Richard Jinks* *100% funded by FC(E), FC(S),and FC(W)*
TrB	**Work Area 4**	**Knowledge Exchange** *Steve Lee, Rob Sykes, Bill Mason, Richard Jinks*
	Work package 4.1	Conifer Breeding
	Work package 4.2	Broadleaf Breeding
	Work package 4.3	Emerging Species
TrB	**Work Area 5**	**Programme Development** *Steve Lee, Rob Sykes, Bill Mason, Richard Jinks*

Devloping Technologies (DeT)

DeT	**Work Area 6**	**Tissue Culture** *Trevor Fenning, Margaret O'Donnell, Steve Lee, Joan Cottrell*
	Work package 6.1	Sitka spruce
DeT	**Work Area 7**	**DNA-technologies** *Steve Lee, Rob Sykes, TSU, Joan Cottrell, Stuart A'Hara*
	Work package 7.1	Sitka spruce Marker Aided Selection
DeT	**Work Area 8**	**NovelTree EU contract** *CFS matched funding* *Steve Lee, Joan Cottrell, Stuart A'Hara, Tom Connolly, Andy Peace*
	Work package 1 to 6	WP1 to WP6
DeT	**Work Area 9**	**ProcCoGen** *new* **EU contract** *CFS matched funding* *Steve Lee, Joan Cottrell, Stuart A'Hara, Tom Connolly*
	Work package 1 to 6	WP1 to WP6

DeT Work Area 10 Knowledge Exchange	*Steve Lee, Trevor Fenning, Joan Cottrell, Stuart A'Hara*
Work package 10.1 Tissue Culture	
Work package 10.2 DNA-technologies	
DeT Work Area 11 Programme Development	*Trevor Fenning, Steve Lee, Joan Cottrell*

Trees4Future (T4F)

T4F Work Area 12 Trees4Future EU contract	***CFS matched funding***
Work package 12.1 Common access to databases	*Steve Lee*
Work package 12.2 Access and Benefit Sharing	*Steve Lee*
Work package 12.3 Thematic research Networks	*Steve Lee*
Work package 12.4 Call for access	*Steve Lee*
Work package 12.5 Statistical and genetic data analysis platform	*Tom Connolly*
Work package 12.6 Compatibility of modelling tools	*Steve Lee, Stephen Bathgate*

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)

Scotland: Timber production (conifer and broadleaf) is a 'Key Theme' in the *Scottish Forestry Strategy*. There is a desire to maximise the economic potential of Scotland's timber resources; encourage continued investment in timber processing by sustaining a predictable and stable supply of good quality timber; promote the use of timber as a renewable, versatile raw material; increase the efficiency of the timber supply chain to improve sector competitiveness, and minimise the social and environmental impacts of timber transport.

Tree breeding has a key role to play in all these areas. A constantly improving planting stock with a greater proportion of stems able to meet the necessary high-quality end-use requirements will contribute significantly to the economic potential of a given stand. Efficiencies will be apparent in the forest, in the sawmill and in the transport sector.

Wales and England: the need for a truly sustainable production of quality timber is seen as an Outcome in the '*Better Woodlands for a Better Wales'* and *'Strategy for England's Trees, Woods and Forests'* documents. Every hectare of planted land will be more valuable if planted with the latest improved material – regardless of species.

In all countries it must be remembered that increasing the productivity of plantation ground allows more land to be given over to other activities satisfying more diverse objectives, and yet still meeting previous market requirements.

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

i. The risks associated with low-tech tree breeding are small and are restricted to the biological restrictions of the species e.g. age of first flowering; frequency of flowering years; delays in making final assessments; problems of pollen and seed storage. We know the techniques work (low risk) the problem is the length of time and up-front investment before results are realised and the risk of financial commitment being withdrawn prematurely (medium to high risk).

ii. The risks associated with more high-tech 'Developing Technologies' are greater if the science can not be made to work. This is unlikely with Tissue Culture which is now common across a number species around the world (medium). The risk of failure is greater with DNA-technologies (high) but this is justified by the large potential returns. These techniques are also becoming more common in animal and agricultural breeding and the technologies are transferrable across disciples.

iii. Not carrying out tree breeding means considerable revenue foregone. This is regardless of species and applies to high- and low-tech options.

iv. Any response to a changing climate would require growers to obtain improved material from other countries, potentially a high-risk strategy if not backed up with domestic-based research into adaptability and long-term performance.

v.

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

Who will benefit from this research? i. Forest Managers ii. Saw millers iii. Nursery managers iv. Construction industry v. Landscape planners vi. Society in general
How will they benefit from this research? i. The trees will grow faster and be of higher quality and so each hectare of land will produce a large quantity and a better quality, of the required end product increasing profitability of the plantation. ii. Financial margins will be improved at the sawmill. iii. Nursery managers will be able to offer a choice of planting stock to customers according to planting objectives iv. More timber from less space leaves other sites for best use in respect to conservation, recreation, enjoyment of open space. v. Society will be able to use low-carbon options more as good quality home-grown timber is used to displace other high-carbon construction materials.
What will be done to ensure that they have the opportunity to benefit from this research? i. Improved material will be deployed; ii. Improved material will be tested in the market place; iii. Improved material will be promoted.
Potential for innovation and new markets? i. Low probability of future privatisation of improved resource via a co-operative or similar scheme; ii. Sale of improved seed to nurseries; iii. Sale of improved material for establishment of seed orchard.

10. Communication Strategy

Publications: There is already a culture of good relations with the nursery, forest management and saw milling industries. This will be continued. There will be periodic publication of papers in peer reviewed scientific press.
Reports: **i.** Information notes; ii. Articles in popular press such as ICF Journal, iii. Trade Journals iv. Establishment of demonstration plots.
Seminars/conferences: i. Seminars and meetings with nursery and forestry managers via FR country liaison officers; ii. Representation at BIHIT – main board and species groups.

iii.	Meeting with professional groups such as ICF, RSFS, RFS etc.
iv.	Representation at international meetings e.g. EU, IUFRO.
v.	Joint secretary of the Conifer Timber Quality Steering Group (with Barry Gardiner)
Decision support systems:	
i.	Plans to add choice of planting stock to the on-line Sitka spruce DSS for wood quality;
ii.	Plans for an ESC-based DSS indicating best species and provenance selection according to climate predictions and site variables.
Website:	
i.	To be retained and up-dated as appropriate.
ii.	New pages to be added on species choice in a changing climate (Emerging Species)
Peer review papers:	
Scientific papers for domestic and international audience on:	
i.	The value of improved planting stock – conifer and broadleaf;
ii.	Progress with testing emerging species
iii.	Progress with broadleaf breeding

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)*

Note: Split of CFS money between Tree Breeding and Developing technologies not agreed at time of writing. Figures presented here based on impressions gained by Programme Leader in discussions with country reps.

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
Project: Tree Breeding (TrB)		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	
TrB Work Area 1	**Conifers:** Pollen and Seed. Continue to manage pollen and seed stocks including up-dating the respective databases.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
TrB Work Area 1	**Conifers:** Continue to manage field-based clonal archives	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
TrB Work Area 1	**Conifers:** Estimation of breeding values (BV) based on field data for Sitka spruce parents and full-sib families and manage BV database.		X	X	X	X	X												
TrB Work Area 1	**Conifers:** Establish new replicated field-based trials for 50 Sitka spruce clones held in liquid nitrogen cryo store													X	X	X	X		
TrB Work Area 1	**Conifers:** In conjunction with 'Wood Quality' colleagues, measure existing semi-mature full-sib trials for timber stiffness. Determine heritabilities + relationship with other traits + guidance for future assessment.	X	X	X	X	X	X												
TrB Work Area 2	**B'leaves:** Continue to develop and manage clonal archives	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
TrB Work Area 2	**B'leaves:** Complete development of web-based plus-tree database in conjunction with BIHIP	X	X	X	X	X													
TrB Work Area 2	**B'leaves:** Develop plans for future of birch seed orchards and clonal archives.	X	X	X	X	X													
TrB	**B'leaves**: Analyse and publish data on birch	X	X	X	X	X													

Work Area 2	seed origin trials around GB.																		
TrB Work Area 2	**B'leaves**: Maintain and measurerecently planted birch genetic gain trials.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
TrB Work Area 2	**B'leaves**: Active participation in the running of BIHIP at the Main Committee and Species Group stages including help/advice on IP issues, possible re-branding, and role of new development officer.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
TrB Work Area 3	**Emerging species:** Establish x5 new field trails to investigate survival, adaptability and growth of over 40 new species. Part funded by EU REINFFORCE and CFS.	X	X	X	X	X	X	X	X	X	X	X	X						
TrB Work Area 3	**Emerging species:** Visit existing species and provenance trials. Maintain, assess and analyse as necessary	X	X	X	X	X	X	X	X	X	X	X	X						
TrB Work Area 4	**Knowledge Exchange (Conifers):** Scientific paper and FC '*Guidance Note*' on appropriate planting of VP and seed orchard stock.	X	X	X															
TrB Work Area 4	**Knowledge Exchange (Conifers):** FC '*Guidance Note'* on suitable sources of Douglas Fir for GB			X	X	X	X												Dropped see Section 15
TrB Work Area 4	**Knowledge Exchange (Conifers):** SJ Lee to attend IUFRO meeting in USA to learn about resistance breeding. Report on return.		X	X															
TrB Work Area 4	**Knowledge Exchange (Conifers):** Summary report to CFS on Knowledge exchange relating to Conifers.				X				X				X				X		
TrB Work Area 4	**Knowledge Exchange (Broadleaves):** Summary report to CFS on Knowledge exchange relating to Broadleaves.				X				X				X				X		
TrB Work Area 4	**Knowledge Exchange (Emerging species):** Continue to develop web-page advice on suitable species and origins according to ESC-type inputs.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		

TrB Work Area 4	**Knowledge Exchange (Emerging species):** presentations to professional bodies on suitable alternative species and provenances.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
TrB Work Area 4	**Knowledge Exchange (Emerging Species):** Summary report to CFS on Knowledge exchange relating to Emerging Species				X				X				X				X		
TrB Work Area 5	**Programme (Project) Development:** Time to seek outside funding, write bids, network, negotiate with partners and EU etc.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Project: Developing Tech. (DeT)																			
DeT Work Area 6	**Tissue Culture:** Develop working protocols for SE/cryo of Sitka spruce	X	X	X	X	X	X												
DeT Work Area 6	**Tissue Culture:** Investigate commercialisation of SE/cryo protocols							X	X	X	X	X	X						
DeT Work Area 6	**Tissue Culture:** Investigate demand for SE/cryo protocols for new species.							X	X	X	X	X	X	X	X	X	X		
DeT Work Area 7	**DNA-technologies:** Measurement and analysis of traits in large-scale MAS field trial.						X	X	X	X									
DeT Work Area 7	**DNA-technologies:** Maintenance of MAS field trials				X				X				X				X		
DeT Work Area 8	**Novletree EU contract:** Search for DNA-markers (WP2) linked to field performance (WP1).	X	X	X	X	X	X												
DeT Work Area 8	**Novletree EU contract:** Attendance at EU workshops, training events, dissemination activities (WP5)	X	X	X	X	X	X												
DeT Work Area 9	**ProCoGen EU contract:** Now approved. No start date yet – Jan 2012?					X	X	X	X	X	X	X	X	X	X	X	X		

DeT Work Area 10	**Knowledge Exchange (Tissue Culture)**				X				X				X				X		
DeT Work Area 10	**Knowledge Exchange (DNA-technologies)**				X				X				X				X		
DeT Work Area 11	**Project (Programme) Development:** Time to seek outside funding, to write bids, network, negotiate with Partners etc.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Project: Trees4Future (T4F)																			
T4F Work Area 12	Contract approved. No start date yet. January 2012? Yet to be itemised but in the areas of :																		
	Common access to databases																		
	Access and Benefit Sharing																		
	Thematic research Networks																		
	Call for access																		
	Statistical and genetic data analysis platform																		
	Compatibility of modelling tools																		

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

Signed……..C&FS Advisor
Date…….

Proposal Approved CFS Date 31st August 2011

15. Agreed Changes

Description of change:
Work Area 4 Knowledge Exchange (Conifers): FC 'Guidance Note' on suitable sources of Douglas Fir for GB in 2012/13 to be dropped as will be covered by the species web-pages Bill Mason and Richard Jinks are preparing. Signed……Research Provider Date…… Signed…  .C&FS Date…7th May 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