Forestry Commission Scotland

# Energy Forestry Exemplar Trials

## 2nd Annual Update Report

March 2011

# Energy Forestry Exemplar Trials

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# 1. SUMMARY OF ACTIVITIES

As the Energy Forestry Trials enter their third year, we have already added a great deal of to our practical understanding of Short Rotation Forestry in Scotland. Forestry Commission Scotland identified locations for six trial sites, spread throughout Scotland: four of these were planted in 2010, the fifth is being planted now and the sixth will be planted in spring 2012. Forest Resarch has completed baseline assessments of soils, hydrology and biodiversity on the planted sites and studied operational aspects of establishment, including costs.

Dissemination of information about the trials has been ongoing, with several seminars through the year to both Forestry Commission staff and others e.g. regional woodfuel forums and Forest Research updates. There was also a field trip to East Grange, which included members of Forestry Commission Scotland's Management Board and policy department, plus local Forest Enterprise Scotland staff, which stimulated good debate on SRF. A major seminar and field visit for forestry and agricultural businesses is planned for June 2011.

The winter of 2010/11 was even more severe than that of 2009/10, and had a greater impact because four trial sites had been planted by the end of 2010.. The survival of eucalypts in the trials and elsewhere has been poor, but this has given an early indication of the limitations and risks with the genus.

This report summarises the progress made over the year to March 2011, and gives an indication of the programme for the coming year, 2011/12.

# 2. BACKGROUND

Forestry Commission Scotland (FCS) and Forest Research (FR) initiated the network of Energy Forestry (EF) exemplar sites in September 2007. We have developed a programme of work to address the important information gaps on the growth of Short Rotation Coppice (SRC) and Short Rotation Forestry (SRF) in Scotland. The sites are also a practical, operational, demonstration of the potential for SRF and SRC. Information from these exemplar sites will highlight the opportunities for these new crops to foresters and farmers.

SRC can be defined as: *Woody vegetation grown on a repeated coppice cycle of 3 – 4 years* ***specifically*** *for the production of biomass.*

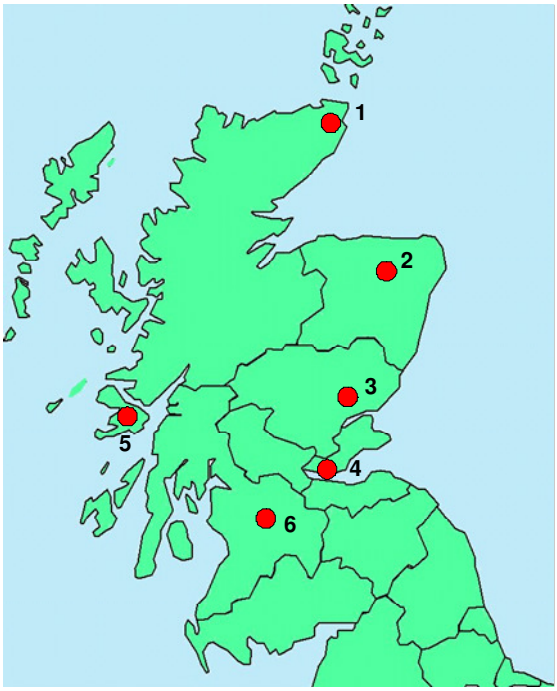
SRF can be defined as: *Single stemmed trees of fast growing species grown on a reduced rotation length (8 – 20 years)* ***primarily*** *for the production of biomass.*

Apart from the rotation length, the key difference in these definitions is that SRC is only fit for biomass, whereas SRF embodies a degree of flexibility. Though its initial objective may be biomass, it has the potential to be grown on as a timber crop should the market dictate that this is a better option at the end of the 'short' rotation.

## 3. THE TRIAL SITES

There are now 6 confirmed sites in Scotland (see map below). These are all ex-agricultural sites with the exception of Mull which is a recently harvested Sitka spruce woodland. .

The new site on Mull is a useful addition to the trials for several reasons. It is in the west, which was clearly a gap in our overall coverage. It is an island and as such is a more isolated community that is likely to benefit from a local woodfuel supply. It is a restock of an existing forest area, a site type which had not been previously included and yet it is probably the most likely potential SRF site to arise in many areas.




1. Sibster, North Highland FD
2. South Balnoon, Moray & Aberdeen FD
3. Alyth (Westfield), Tay FD
4. East Grange, Scottish Lowlands FD
5. Aros, Mull, West Argyll FD
6. Auchlochan, Scottish Lowlands FD

Due to the severity of the 2009/10 winter, the majority of the planting too place later than anticipated, with the research areas on the sites not being completed until May 2010. Despite this, tree survival (other than eucalypts) has been good, though initial growth has been disappointing because of the late planting. This should rapidly improve this year as the seedlings will have a full growing season and are better established.

The progress on each of the individual site is outlined below:

- **Sibster**

The main areas of operational planting on this site were delayed and did not start until late autumn 2010. Therefore, the research plots – planted in spring 2010 – are a year ahead of the main crop in terms of growth. Monitoring of water quality is taking place on the larger operational areas so a bonus from this is that we have a longer baseline under agricultural conditions. The additional data collected before planting of the operational areas will provide a better comparison with the planted site.


Sweet chestnut

Survival has been generally good (80%+) at Sibster, apart from the Sitka spruce, of which 85% has failed. This may be partially due to the dryness of the site in May allied to the late planting, but there was no effect on the broadleaf species other than to slow growth. The site is currently being beaten-up and should progress well this summer.

- **South Balnoon**

The severe vole damage that occurred during 2009 and the subsequent severe winter had been expected to kill large numbers of the broadleaf trees planted in the operational area. However, another growing season has seen the majority of the trees recover, with perhaps as little as 10% of damaged trees dead. The scars from the damage are clearly visible but are healing fast. Many of the sycamore seedlings have effectively been coppiced, as the initial single seedling shoot died and the tree has re-grown multiple stems from the base. This has also occurred to a lesser extent in the ash, though this species generally appears to have been

better at healing the stem damage and growing on as a single stem. The birch and oak are largely intact, with the birch in particular growing well, as is the Sitka planted above the broadleaf area.

Basal re-growth from vole-damaged sycamore.

There appears to be very little current vole damage, or much from summer 2010. This suggests that either the population has crashed or the older bark is less palatable, possibly a combination of both. Voles have also caused very little damage in the research area, obviously helped by the use of vole-guards, but this would not have helped in the deep snow, again indicating a population crash.

Cold weather delayed planting of the research area until May 2010, because of ground conditions. As a result, though most trees except the eucalyptus(?) have survived, growth has been slow. This was not helped by rapid grass growth, though this was kept under a degree of control by an application of Laser herbicide (cycloxydim).

In addition to the SRF trial, the research area also includes a separately funded birch provenance trial (funded separately), which will compliment the SRF trial and provide useful data on a species that has wide biomass potential, particularly in northern Scotland.

- **Alyth (Westfield)**

The research area was planted in late April 2010 and has shown good survival rates (90%+) for all the conifer and broadleaf species, except, as at all sites, the eucalyptus. It also has better than average initial growth, likely to be linked to the high level of soil nutrition that was identified in the baseline soil survey in 2009 [is this just for the broadleaf spp as you indicate below?]. The operational areas of birch, ash and sycamore have also grown well.

Alyth has been a generally problem free site, which shows good potential to grow very well in the coming year.

- **East Grange**

FCS planted the operational areas of East Grange, including SRC, in spring 2009 by machine. All species have continued to grow satisfactorily in their second year, with the Scots pine in particular doing well and with some trees approaching 1 m tall. The SRC has coppiced effectively following its maiden cut, and is also growing well, with clear clonal differences apparent in colour and form.

Planting of the research area was completed in early-May 2010, the late planting caused by winter conditions which postponed ground preparations. Despite this, survival has been very good (98%) in all conifer and broadleaf species. Weed control has been very effective here and has no doubt contributed to the success of the planting.

East Grange research plots.

- **Aros, Mull**

FCS staff have made quick progress with the development and establishment of this site. The site is a sheltered, 6.0 ha, south facing slope, between 30 - 90 m elevation, with an upland brown earth soil. It previously held a Sitka crop with a yield class of at least 20, so is a fertile, climatically benign, restock site, which should grow most species, including eucalypts, very well.

The site has been ditch mounded at a mound density averaging ~3,200 mounds/ha. This is a deliberately higher density than normal (2,700/ha) in order

to increase the SRF yield. The nature of mounding and the inevitable variation within it has necessitated some compromises with experimental layout. Plot size [can you explain what you mean by plot size?] has been reduced to 108 trees and fitted between ditch lines to improve uniformity between plots. As a result of this, it has only been possible to layout three plot replicates compared to the four on the other trial sites. However, this will still give good results and is a higher sampling intensity than most other forest experiments.

Planting of the site should be completed by the first week in April for most species, with just the eucalypts to follow at the beginning of May.

As this is a restock site that is only in its second year after felling, there is a high risk of *Hylobius* damage. To reduce this risk, the plants will receive a top-up insecticide spray immediately after planting and again later in the summer.

- **Auchlochan**

This site has now finally completed the planning process and will be prepared over the coming year for planting in spring 2012. The exact location of the intensive trial has yet to be agreed but it will be in the area of the acquisition adjoining the town of Brocketsbrae, which is currently improved grazing land.

## 4. EUCALYPTS

The winters of 2009/10 and 2010/11 were the coldest for decades and proved to be a survival challenge for all eucalypt species in the trials and elsewhere, with the majority already clearly dead and many others critically damaged.

The three trial species have a recorded maximum shoot frost tolerance of:

| Species | Maximum frost tolerance (°C) |
|---|---|
| *Eucalyptus glaucescens* | -16 |
| *Eucalyptus gunnii* | -18 |
| *Eucalyptus nitens* | -12 |

Temperatures in most inland parts of the Scotland and many coastal areas got well below -10 in both winters, but particularly during 2010/11. On the trial sites, the highest absolute minimum recorded was -13°C at East Grange, and the lowest -17°C at South Balnoon. However, these are still air temperatures and wind chill

will make them significantly lower. Added to this must be the duration of the cold and the depth of freezing in the soil. Eucalypt roots, in common with all tree species, have poorer cold tolerance than the shoots. These factors have combined to produce a disastrous winter for Eucalypts:

- *E. nitens*, which initially it survived under the insulation of deep snow at Alyth and South Balnoon, was killed after the snow had melted. There are no survivors on any of the trial sites.

- *E. glaucescens* has also been killed in Scotland and at the DECC site of Roan Farm, Canonbie, where it is known that temperatures fell to -17°C. At more southerly sites in England it has largely survived, confirming its frost tolerance.

- *E. gunnii* has survived where planted in England except at Roan Farm. Trees in Scotland are almost all dead, except for one, anomalous survivor of the original experimental planting at South Balnoon in 2008. Many mature, long-established *E. gunnii* trees in parks and gardens throughout Scotland have also died, testament to the unusual severity of the cold.

Live *E.nitens* - Alyth 14.12.10

Dead *E.nitens* - Alyth 15.03.11

Similar deaths have occurred in private commercial plantings, in places for the second year in a row. This has inevitably cast doubts on the suitability of eucalypts and dampened initial enthusiasm. The private sector is pressing ahead with some new planting this year, but at a lower level than previously. A third hard winter would almost certainly stop further eucalypt planting in Scotland for the foreseeable future.

We will be replacing one set of *E. nitens* plots with Alpine Yellow Gum, *E. subcrenulata*, with a recorded frost hardiness of -16°C. Though it has a slower growth rate than *E. nitens*, this species is still significantly more productive than most other tree species, and is considered a valuable timber tree in its native Tasmania. Its use in the trials should help show whether eucalypts are still worth considering for commercial planting.

## 5. OTHER SPECIES

The research trials contain the same suite of species, given in the table below. *Nothofagus* was originally included but a reliable seed source never materialised. Common alder has been planted as a substitute, which will be a useful native comparison with the exotic red and Italian alders.

The table below shows the species planted:

| **Species** | **Common Name** |
|---|---|
| *Acer pseudoplatantus* | Sycamore |
| *Alnus glutinosa* | Common alder |
| *Alnus incana* | Italian alder |
| *Alnus rubra* | Red alder |
| *Betula pendula* | Silver Birch |
| *Castanea sativa* | Sweet chestnut |
| *Fraxinus excelsior* | Ash |
| *Larix kaemferi* | Japanese larch |
| *Picea sitchensis* | Sitka spruce |
| *Populus tremula x tremuloides* | Hybrid aspen |

All species are only at the end of their first growing season, so critical comparison of growth and survival is not possible. However, first impressions outlined below are already showing interesting results.

Broadleaves have established better than either Sitka or larch throughout the trials. This is perhaps not unexpected given the relatively dry soils of the agricultural land used, which ESC would have rated as more suitable for broadleaves than Sitka, but we expected larch to have performed better. High nutrient levels in the soil, resulting from the history of agricultural inputs may inhibit mycorrhizal associations in these conifers. This may reduce the ability of the trees to take up nutrients despite the overabundance of soil nutrients.

The best growth on all sites is from the hybrid aspen, which seems perfectly at home everywhere. Other top performers are ash, sycamore and birch, which have established well and seem likely to take off this season, provided that weed control is adequate. The alders have survived but initial growth has been slower, perhaps also due to some degree by nutrient levels. Sweet chestnut has survived well and grown robustly on all sites, though growth in the southern sites is taller than in the north. Even so, growth at Sibster, Caithness is still remarkably good for a species native to southern Europe.

The inclusion of Japanese larch may, with hindsight, prove to be a poor choice given current problems with *Phytophthora ramorum*. However, this could be less of a problem with short rotation crops as the shorter time horizon reduces the risk of infection .

## 6. RESEARCH SUMMARY

This is a brief résumé of what has been achieved. A more detailed summary of some of the research work done and proposed for the coming year can be found appended to this report.

- **Hyrdrology** (Appendix 1)

  - We are assessing water resources at Alyth and water quality at Sibster.
  - Monitoring equipment has been installed into the ash and sycamore operational areas and into a grass field control at Alyth.
  - Equipment problems had delayed the start of monitoring at Alyth, but these are now resolved.
  - We have now been monitoring two burns for water quality at Sibster for over a year; one fed from the SRF area and the other unaffected by SRF planting for comparison.
  - Samples are currently taken fortnightly and this will continue for the first three years, along with annual invertebrate samples.
  - From initial samples, we have identified high numbers of enteric coliform bacteria linked with the previous agricultural land use, livestock farming.
  - We will produce comprehensive site reports on initial findings in year three.

- **Soils**

  Samples have been taken from all the sites, except Auchlochan. They are awaiting further analysis, which shall be done over the coming months. A detailed report will be produced at the end of 2011.

- **Technical Development** (Appendix 2)

  - In addition to the mechanical planting studies done at East Grange in February 2009, over the last year TD have studied mechanised herbicide application in SRF, inter-row flail mowing, maiden cut of SRC, and 'gapping-up' of SRC.
  - Initial planting studies formed the basis of a report produced by TD in September 2009[1].
  - TD will report on the results of this year's work by the end of June, 2011.
  - TD are planning further work comparing establishment methods on other trial sites for the coming months.

- **Biodiversity**

  The bird survey of the four planted site trial sites has been completed by the BTO and a report produced. The report will be published on the internet in the near future, but the main conclusions from it are:

  - Current bird populations have been unaffected by the initial planting of the sites.
  - Most birds present are associated with features that existed prior to planting e.g. hedges, water, scrub woodland.
  - 80 bird species were found on and around the trial sites overall.
  - 46 species are all-year residents, 15 are winter visitors, and 19 are summer visitors.
  - East Grange had the greatest diversity, with 49 species present in the breeding season. This is likely to be due to the site's varied habitats, particularly the hedges, the scrubby, disused rail embankment and the burnsides.
  - The least diverse site was South Balnoon with only 31 species present.

- **Silviculture**

  - Initial assessments were taken of the planting stock to check for quality prior to planting.

[1] Forest Research, 2010. Short Rotation Forestry Establishment Report (www.forestry.gov.uk/website/forestry.nsf/byunique/infd-85ufmb)

- First year height, diameter and survival have been assessed on the four planted sites.
- All failures have been beaten-up to achieve 100% stocking.
- Ongoing establishment will be checked regularly through the growing season.
- Further comprehensive growth measurements will be done in October/November 2011, and annually thereafter.
- Automatic weather stations are in place on all the planted sites, including Mull. These require downloading at three monthly intervals. A further weather station is ready to be put out at Auchlochan as soon as the location is agreed.

## 7. DECC TRIALS

A series of trials based upon the FCS model commenced in England during 2010, funded by the Dept. for Energy and Climate Change (DECC). These trials exactly replicate the research plots in Scotland, but the operational plantings are pure eucalyptus. Site locations range from Totnes in Devon to Roan Farm, just outside Canonbie on the Scottish border, which is a useful surrogate southerly site for FCS.

As with the FCS trials, progress with species other than eucalypts has been good, with high survival rates and robust initial establishment. As might be expected, the more southern sites are showing slightly faster growth rates, but there is a balance here between summer warmth and drought that will be interesting to compare across the whole suite of trials as they progress.

The same eucalypt species as in Scotland are also present. *E. nitens* has been totally killed on all sites except Devon, and even here there is some damage. *E. glaucescens* and *E. gunnii* have survived virtually unharmed from Yorkshire south, but been killed at Canonbie.

## 8. WORK DUE IN 2011/10

The main tasks for the coming year are completing the planting on Mull, the planning, preparing and planting at Auchlochan, and the replanting of the eucalypt plots. The plant supply required for this is already underway at Delamere and Bush Nurseries.

In addition, FR will continue with the ongoing assessments of species' performance, climate and hydrology.

A seminar and field visit to give an update and practical information on SRF/woodfuel to forestry and agricultural businesses is planned for June 2011.

## 9. CONCLUSION

The Energy Forestry Exemplar Trials are major programme of work, which is starting to make a significant contribution to improving our knowledge of SRF and SRC in Scotland. Planting in 2010/11 has seen the trials become a reality on the ground. Baseline data on soils, biodiversity and establishment operations has been acquired, which will particularly help in monitoring environmental change and carbon balance as the crops progress. A second, abnormally severe winter has caused devastation of eucalypt plantings, which is a worthwhile result in that it helps determine use boundaries and clarifies the potential risks. This network of sites is very important to demonstrate to practitioners, researchers and policy makers throughout Scotland what we think is possible and the best ways of achieving this. This is a long-term programme following the development of the sites over the rotation, giving us the information we need to produce and disseminate best practice.

Appendix 1:

# Report on Studies to Assess the Hydrological Impacts of Energy Forestry

## 1. Background

Concern has been raised that the establishment of energy forest crops could have an adverse impact on water resources. This arises from the potential high water use of SRF, which could reduce water supplies and ecological flows. Another issue is the impact on water quality, with energy forestry crops expected to benefit water quality compared to the previous agricultural land use due to reduced soil disturbance and chemical and pathogenic inputs. There is also a need to confirm that the potential pollution risks associated with the final harvesting phase can be minimised by best practice measures.

## 2. Objectives

- To quantify the effects of selected SRF species on water resources.
- To evaluate the impact of SRF on water quality.

The field experiment on water use is being conducted at Alyth, Tayside (partially funded by CFS via the Forest Hydrology Programme), and on water quality at Sibster Farm, Caithness (funded solely by FCS). Separate reports will be prepared at the end of year three, evaluating the impacts of the initial planting on water quantity and quality at the respective sites.

## 3. Water Resources – Alyth

The two experimental sites were planted with Ash (*Fraxinus excelsior L.*) and Sycamore (*Acer pseudoplatanus*) in March 2010; the grass control was left unplanted (Figure 1).

Monitoring equipment was installed at all three sites in July 2010, consisting of theta probes to measure soil moisture content and tensiometers to measure soil hydraulic potential. A network of rainguages was put in at the two planted sites and an automatic weather station was installed at the grass control site. With the

exception of the weather station all monitoring equipment was connected to logger boxes which were programmed to collect data every 10 minutes.

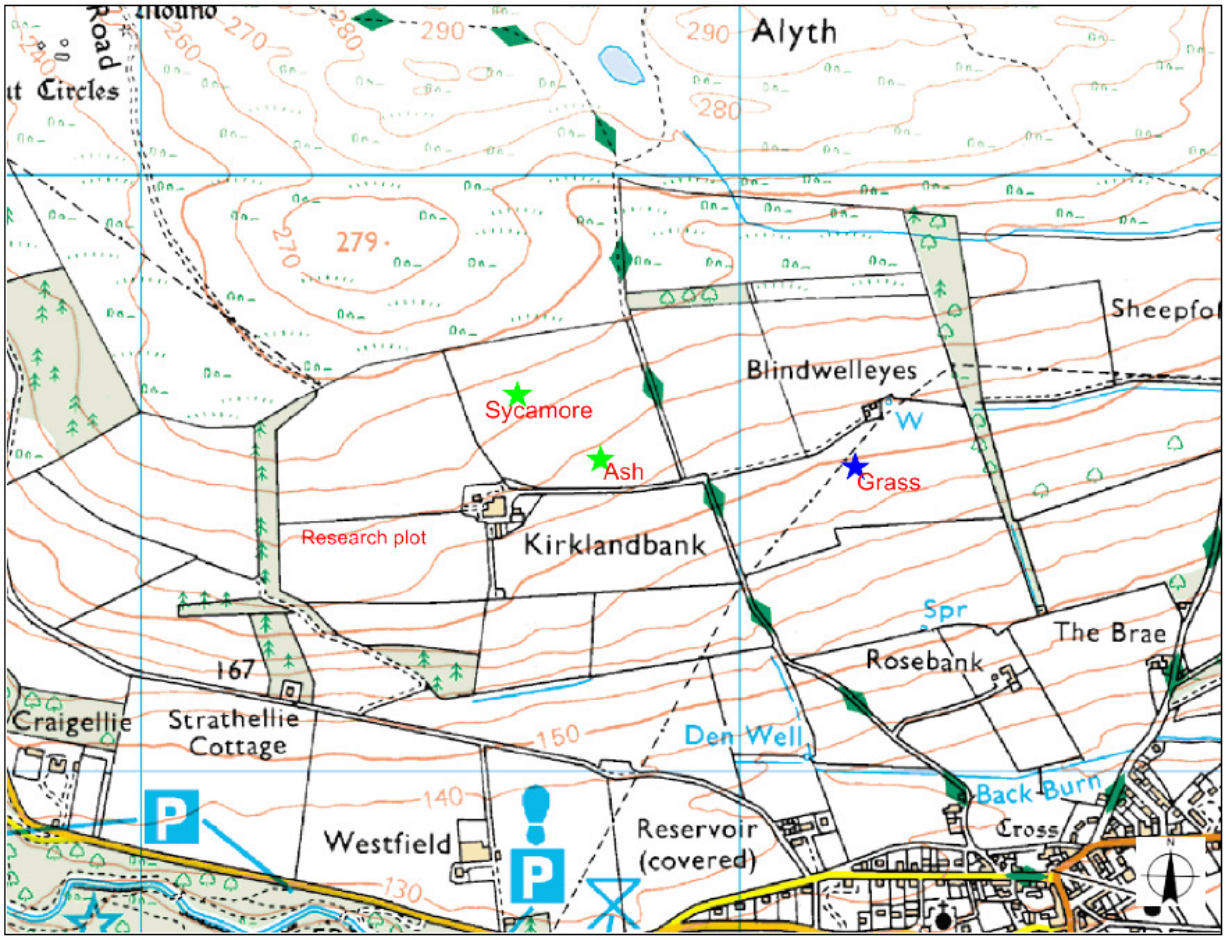



Figure 1: Alyth water use experiment – location of monitoring equipment within experimental plots planted with Sycamore and Ash (★) and grass control unaffected by SRF planting (★)



Following installation electronic problems were identified with the logger box setup and this together with the heavy snowfall over winter led to a delay in baseline data collection. The problems were resolved and baseline data has been collecting since early 2011.

The measurements will allow estimates to be made of water use via transpiration and interception processes.

Initially fortnightly visits will be made to the site to download data and maintain equipment, but this may reduce to monthly following the baseline period. The intention is to continue measurements throughout a complete SRF rotation.

## 4. Water quality - Sibster

Two water sampling points were selected, one in a stream draining the experimental area (dominated by the proposed SRF trial) on Sibster Farm and the other in the Achingills Burn, a stream unaffected by the SRF planting and therefore suitable as a control (Figure 2).

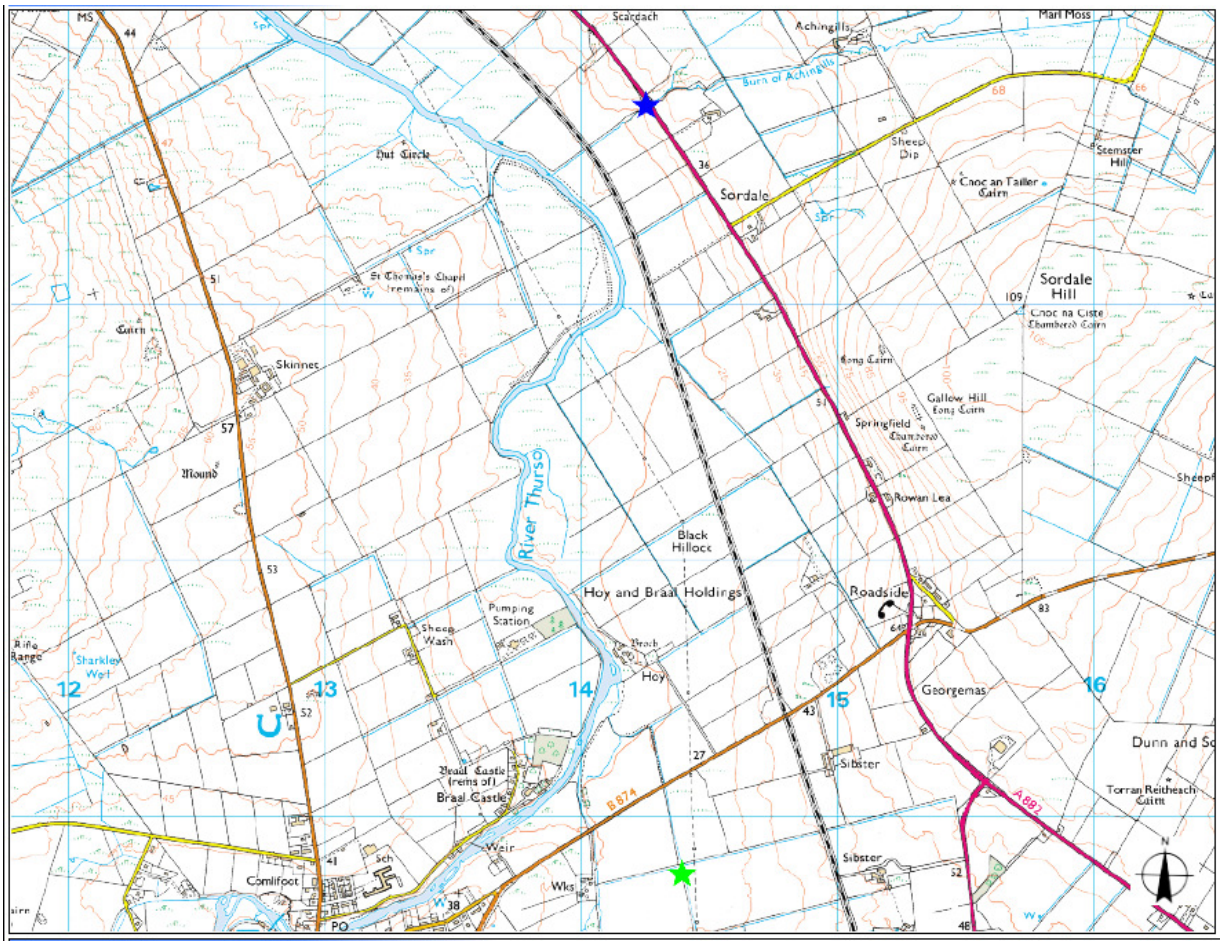



Figure 2 Sibster water quality experiment – Location of water sampling points and water level recorders in operational area on Sibster Farm ★ and control catchment unaffected by SRF planting ★

A sampling programme was initiated in September 2009 to provide baseline data prior to SRF planting; fortnightly water samples are being taken for water quality analysis at our laboratory in Alice Holt and same day microbiological analysis at Scottish Water's laboratory in Inverness. Results from the microbiological data showed relatively high numbers of coliforms, *Escherichia coli* and *Enterococci*, when sampling began reflecting the most recent land use at the time, namely mixed beef and cereal farming.

Automatic water level recorders were installed in March 2010 and the data generated will be used to calculate the volume of runoff and convert chemical concentrations (mg/l) converted to fluxes (kg/ha).

Water sampling will continue at fortnightly intervals for a period of three years to assess the initial impact of the land use change on water quality. Thereafter, the intention is to reduce the frequency of sampling to monthly until the SRF crop reaches harvesting age.

Nadeem Shah,
Hydrologist, Forest Research
18.03.11

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## Appendix 2:

# Technical Development SRF Project Update 2011

## Summary

This report summarises work carried out by Technical Development during 2010-2011 into Short Rotation Forestry (SRF) establishment operations in Scotland. During 2008-2009 Technical Development undertook a time study of establishment operations in SRF and SRC at the Forestry Commission trial site at East Grange with follow-up studies on the management operations on these sites carried out in 2009-2010.

During 2010-2011, time studies have been carried out into establishment operations for SRF in the north (Sibster Farm, Caithness) and west (Aros, Isle of Mull) of Scotland, allowing output comparisons with the site at East Grange. Time studies have been completed on the following operations:

- Mechanised SRF planting
- Single furrow ploughing cultivation for SRF
- Mechanised herbicide spraying in SRF
- Observations of excavator mounding ground preparation were made at Aros, Mull

**Figure 1** Keen Planter carrying out tree planting at Sibster Farm Caithness

# 1. Introduction

Knowledge of Energy Forestry (EF) establishment and management (particularly SRF) in Britain is increasing due to experience gained from Forestry Commission Scotland EF trial sites across Scotland. With increasing interest and markets for Energy Forestry there is a need for greater understanding of outputs and costs of SRF operations.

Information in this report is the result of operational time studies carried out at Sibster, Caithness (ND 152 596) and Aros, Isle of Mull (NM 541 456).

# 2. Work method

Work methods are described in Work Plan FR09026 (Ireland 2009a), and follow FR standard operating procedures for operational time studies.

# 3. Results

**Work carried out in 2010-11:**

- Mechanised SRF planting
- Single furrow ploughing cultivation for SRF
- Mechanised herbicide spraying in SRF
- Observations of excavator mounding ground preparation were also made at Aros

Details of SRF establishment studies carried out at Sibster are shown in Table 1.

**Table 1** Study site descriptions

| Study Number | Study Type | Species | Previous land use | Study area ha | Terrain | Soil type | Weather Conditions | Grid reference |
|---|---|---|---|---|---|---|---|---|
| 1 | Mechanised SRF Planting | SP, BI, BE, NS, SYC, EL | Arable | 1.55 | 2.2.2 | 1c | High winds occasional rain | ND 1562 6005 |
| 2 | Single Furrow Ploughing | NA. Only ground preparation | Arable | 0.34 | 2.2.2 | 1gc | High wind Heavy rain | ND 1554 6001 |
| 3 | Chemical Spraying | Larch<br>Sycamore | Arable | 0.53 | 2.2.2 | 1c | Sunny light wind | ND 1513 5909 |
| 4 | Chemical Spraying | Larch<br>Sycamore | Arable | 0.73 | 2.2.2 | 1gc | Windy, light rain | ND 1550 5940 |

## 4. Mechanised SRF planting

Planting at Sibster was carried out with the Keen Planter, the planting specification is shown in Table 2.

**Table 2** Planting specification

| Study Number | Date of Study | Operation and Species | Planting Stock | Planting Machine | Number of Operators | Target Stocking Density (trees/ha) |
|---|---|---|---|---|---|---|
| 1 | 17th November 2010 | SP, BI, BE, NS, SYC, EL | Bare root stock | Keen Planter | 1 (plus driver) | 2500 |

The Keen Planter machine specification is shown in Table 3.

**Table 3** Machinery specification – Keen Planter

| Planting machine | Keen Planter |
|---|---|
| Prime mover | McCormick MTX175 Tractor |
| Rows planted per pass | 1 |
| Operators | 2 (1 prime mover driver 1 planter) |
| Capital cost (£): Planting machine | 4000 |
| Capital cost (£): Prime mover | 64000 |
| Operator/s cost (£): | 1 tractor operator at £10/hr. 1 planter operator at £10/hr = total £20/hr |

Mechanised planting using the tractor-towed Keen planter is shown in Figure 2. Figure 3 shows a tree planted by the Keen Planter, with the machine's packing wheels visible behind and the planting furrow.

**Figure 2** Keen Planter


**Figure 3** Tree planted by Keen Planter

## 5. Mechanised Planting Outputs

Outputs and costs of mechanised planting using the Keen Planter at Sibster are shown in Table 4.

**Table 4** Summary of Outputs and Cost – Mechanised Planting

| Study Number | *ipment Used* | Study area ha | Cost per hour | | | Output (ha/Shr*) | Cost (£/ha) |
|---|---|---|---|---|---|---|---|
| | | | Planting machine (£/Shr) | Prime mover (£/Shr) | Total system (£/Shr) | | |
| 1 SRF Mechanised establishment on ex-arable | Keen planter + tractor | 1.55 | 11.50 | 20.57 | 32.08 | **0.18** | **178.22** |

* Shr: Standard hour: standard time includes allowances for rest and other work.

Figure 4 shows the mechanised planting at Sibster, with trees in regularly spaced furrows.

**Figure 4** Mechanised planting results

**Figure 5** Obstacles during planting

Planting outputs from the East Grange EF site (Ireland 2009b) were comparable with those recorded at Sibster. Mechanised planting outputs at East Grange ranged from 0.13 ha/shr to 0.34 ha/shr (Ireland 2009b).

The output of 0.18 ha/shr is at the lower end of the range of outputs recorded at East Grange. During the Sibster planting observations were that output reduced due to the species mixture planted. The mixed species planting required several species to be organised and planted by the operator in the same time. This meant the forward speed of the tractor had to be reduced to allow the operator

time to organise the different species during planting. Also the presence of stone obstacles, close to the soil surface caught on the trencher of the planting machine (Figure 5), disrupting the planting. Stocking density assessment for mechanised planting at Sibster is shown in Table 5.

**Table 5** Species plot data

| Plot | BE | NS | Syc | SP | BI | Larch | Totals |
|---|---|---|---|---|---|---|---|
| Plot 1 | 13 | 6 | 2 | 4 | - | - | 25 |
| Plot 2 | 5 | 7 | 7 | 6 | - | - | 25 |
| Plot 3 | 10 | 12 | 1 | 3 | - | - | 26 |
| Plot 4 | 2 | 6 | 2 | 6 | 7 | - | 23 |
| Plot 5 | 4 | 5 | 4 | 6 | 6 | - | 25 |
| Plot 6 | - | 5 | 5 | 1 | 10 | - | 21 |
| Plot 7 | 5 | 2 | 2 | 9 | 7 | - | 25 |
| Plot 8 | 2 | - | 3 | 7 | 10 | 2 | 24 |
| Plot 9 | - | - | - | - | 2 | 21 | 23 |
| Plot 10 | - | - | - | - | - | 24 | 24 |
| **Average trees/ plot 24.1** | | | | | | | |

## 6. Mechanised Ground Preparation

In addition to mechanised planting at Sibster ground preparation was also carried out using an agricultural single furrow plough. Figure 6 shows the ploughing carried out at Sibster, prior to manual planting.

**Figure 6** Single Furrow Ploughing at Sibster

**Figure 7** Vole activity in planting furrows

SRF establishment time study at Sibster was interrupted by snow during December 2010. Technical Development returned to the site after carrying out mechanised

planting and ploughing studies. On returning to Sibster evidence of vole activity over the site was observed, Figure 7.

## 7. Ploughing Outputs

Outputs of the single furrow ploughing study carried out at Sibster are shown in Table 6.

**Table 6** Summary of Outputs and Cost - Single Furrow Plough

| Study Number | *ipment Used* | Study area ha | Cost per hour | | | Output (ha/Shr*) | Cost (£/ha) |
|---|---|---|---|---|---|---|---|
| | | | Single Plough machine (£/Shr) | Prime mover (£/Shr) | Total system (£/Shr) | | |
| 1 SRF Single Furrow Ploughing on ex-arable | SRF Single Furrow Ploughing on ex-arable | 0.34 | 10 | 20.57 | 30.57 | **0.41** | **74.56** |

The single furrow ground preparation, resulted in soil deposition on one side of the plough furrow, compared to the furrow formed by the mechanised planter. The plough furrow could potentially impede access for subsequent mechanised operations such as herbicide spraying by ATC.

## 8. Mechanised Herbicide Application

Following planting, weed control at Sibster was carried out with propyzamide using an ATC-trailed herbicide sprayer as shown in Figure 8.

**Figure 8** ATC-based herbicide sprayer