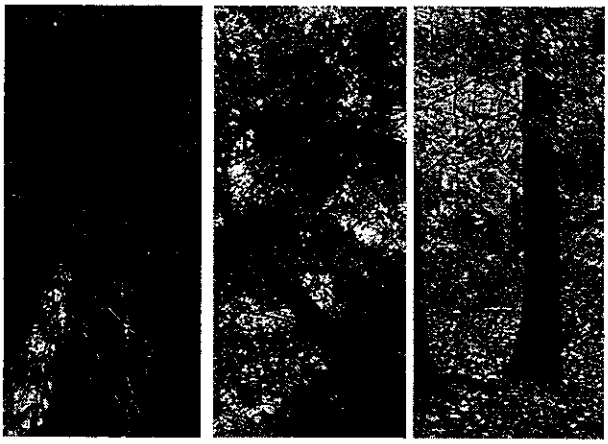
THREESTONEBURN FOREST

APPENDIX 10

CARBON SEQUESTRATION REPORT

Report presented to Scottish Woodlands by The Edinburgh Centre for Carbon Management (ECCM)

An assessment of carbon balances associated with forestry activities by Scottish Woodlands– 2007



Report

15th June 2007

The Edinburgh Centre for Carbon Management

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SUMMARY

CO_2 emissions resulting from clearfelling of 547 hectares of mixed conifer plantation at Threestoneburn are estimated by ECCM to be in excess of 150,000 tonnes.

CO_2 emissions from soil organic carbon at Threestoneburn following clearfelling are unlikely to be in excess of 10% (of soil carbon) assuming appropriate moorland restoration techniques are put into effect during and immediately after felling takes place. Any losses could have a significant impact on the carbon balances resulting from the proposed activities.

If the Forestry Commission restocking proposal at Threestoneburn had been put into effect the long term average CO_2 storage at Threestoneburn would have been approximately 130,000 tonnes.

The long term average CO_2 storage (over 100 years) from tree planting proposals at Threestoneburn is estimated to be approximately 10,000 tonnes.

The long term average CO_2 storage (over 100 years) from tree planting proposals at Camus Eskan is estimated to be approximately 90,000 tonnes.

The net carbon balance based on these activities (excluding soil) (CO2 sinks - CO2 emissions from clearfelling) is estimated to be approximately -60,000 tonnes of CO_2.

1 INTRODUCTION

Threestoneburn is a 712 hectare upland estate in north east England close to Alnwick. 567 hectares of this Estate are currently managed as commercial forest plantation with exotic conifer tree species. The remaining area is open ground (mainly found along upper margins, water courses and forest rides). To date only very small areas of native broadleaved woodland have been established at Threestoneburn Threestoneburn estate has recently been sold by the Forestry Commission to a private landowner. It is the intention of the new landowner to clearfell all the existing conifer plantations in order to restore moorland habitat.

A small area of native broadleaved tree planting is also proposed at Threestoneburn. Other tree planting activities are proposed by the same landowner at Camus Eskan on the West Coast of Scotland.

2 KEY OBJECTIVES

The key objectives of this study are:

- To estimate the carbon losses that may occur as a result of clearfelling proposals at Threestoneburn.
- A review of potential soil carbon emissions (in particular reference to tree harvesting techniques at Threestoneburn).
- To estimate the potential average carbon storage that would have been achieved in the absence of the proposed intervention (based on Forestry Commission restocking proposals for Threestoneburn)
- To estimate the potential carbon uptake that might be achieved by new planting proposed at Threestoneburn.
- To estimate the potential carbon uptake that might be achieved by new planting proposed at Camus Eskan.

3 SITE CARBON REMOVALS (THREESTONEBURN)

In order to avoid future confusion the unit referred to in this report will always be CO_2. Atmospheric carbon dioxide (CO_2) is captured as a result of photosynthesis and stored in the biomass of the trees as carbon. For reference one tonne of carbon is equivalent to 3.67 tonnes of CO_2.

The ECCM model (version 4) calculates the carbon sequestration potential separately for each species. Standing timber volumes, taken from Forestry Commission yield tables (Edwards and Christie 1981), are used to predict per hectare carbon storage at 5 year intervals. The volume of branches and roots are determined from the standing timber volume. Data on tree density are used to calculate the quantity of carbon stored in woody material. The carbon content of foliage, fine roots and litter are calculated using parameters derived by Cannell *et al.* (1996). The increase in the carbon content of the soil is determined by the estimated quantities and rates of decay of fine roots and litter, and the proportion of the decayed material transferred to the soil.

The model divides the carbon sequestered by the woodland into different carbon pools: stem wood, crown wood, foliage and roots.

Site carbon removals are modelled using the ECCM model (version 4). It is proposed that 567 hectares of conifer plantation are felled at Threestoneburn. Felling would be phased over 3 years. For the purposes of calculating the CO_2 emissions resulting from this felling activity ECCM have assumed the felling will occur in 2009 (mid year between 2008 – 2010). By 2009 tree ages will range from 27 to 42 years. The tree planting is dominated by Sitka spruce with small amounts of Japanese larch and lodgepole pine (Table 1) also present.

Tree Species	Area (ha)
Japanese larch	10.7
Lodgepole pine	35.2
Sitka spruce	521.8
Open ground	145.0
Total	**712.7**

Table 1: Areas of tree species proposed for felling at Threestoneburn.

Yield classes range between 6 - 8 for Japanese larch and lodgepole pine, and between 6 - 20 for Sitka spruce (further details available in Appendix I). It is proposed that felling is phased i.e. done in blocks. Whole tree harvesting will be carried out mechanically. This operation will result in the removal of all above ground biomass from the site (main stem and all brash). Tree stumps will be mulched to ground level but tree roots will be left to avoid additional ground disturbance which might result in additional carbon emissions.

For the purposes of modelling CO_2 emissions ECCM have assumed that any timber will be used for either pulp or pallets. The carbon residence time in these products is modelled as being 0 years from the time of felling (i.e. no carbon is stored in any timber products). In reality some carbon is likely to be stored for up to 20 years in products such as fencing.

It is proposed that brash and other waste products are sold as wood chip to local power stations (in Lockerbie and Middlesborough). The carbon residence in wood chip is therefore also calculated as being 0 years from the time of felling.

Below ground biomass (roots) will be left *in situ*. Carbon stored in the below ground biomass will be emitted back into the atmosphere by a gradual process as the roots decay. However, ECCM have assumed that the carbon residence time in the roots is 0 years from the time of felling (i.e. that all the carbon is emitted at the time of felling).

All of these assumptions are likely to result in an overestimation of the CO_2 emissions. This methodology is therefore considered to be conservative when calculating a carbon balance.

Using these assumptions, combined with data provided by Scottish Woodlands of tree species, areas, yield classes and planting years, ECCM have calculated total emissions that will result from the proposed clear felling at Threestoneburn to be in excess of 150,000 tCO_2 (see Table 2). Any assumptions made by ECCM have been made in consultation with Scottish Woodlands.

Tree species	tCO_2 emissions
Japanese larch	5,364
Lodgepole pine	3,477
Sitka spruce	150,052
Open ground	0
Total	**158,892**

Table 2: tCO_2 of tree species proposed for felling at Threestoneburn.

4. SOIL ORGANIC CARBON

In terms of below ground carbon storage, around 50% of the soil carbon in the UK is contained in deep peats. Organic matter in soil accumulates through the oxidation of plant litter. While planting trees would result in increased litter, and thus, increases in soil organic carbon, there would also be minor losses in soil carbon associated with increases in decomposition rates resulting from aeration caused by root penetration.

There are some uncertainties about the rate of accumulation of carbon in soils, given the variability in turnover rates of soil organic matter and transfer of organic carbon from litter to soil. There have also been concerns raised over the potential losses of soil carbon from organic soils (Cannell *et al*, 1993) following reforestation. Organic matter decomposes 50 times quicker in the oxygenised soil compared with the anaerobic soil of undrained peatlands (the fractional loss from aerobic decomposition changes from 0.1 % to 5 % per year) (Cannell and Milne, 1995). However, studies have been carried out on peatlands which have been drained and ploughed before afforestation, which can significantly affect the hydrology of the site. Studies undertaken in the UK have shown both losses and gains of carbon from afforestation on organic soils, dependent on the establishment techniques and the site hydrology (Chapman *et al*, 2001).

The dominant soil types found at Threestoneburn are shallow peats and peaty podsols. These soils are likely to constitute significant carbon reservoirs which might be threatened by the proposed clear felling activities. Whole tree harvesting is likely to have a significant negative impact on carbon balances because no residues (brash) are left on site. However, no measurement of soil organic carbon has been done at Threestoneburn. The measurement of soil organic carbon is very difficult because of the high spatial variability which is likely to be further increased on disturbed / clearfelled sites. Decreases which might occur in soil carbon following clearfelling are likely to result from increased soil respiration due to increased microbial activity and / or increased water fluxes in the soils (due to loss of canopy cover) which may result in the increased export of particulate and dissolved carbon in drainage waters. However, Johnson and Curtis (2000) and Johnson (1992) conclude that forest harvesting is unlikely to result in carbon losses in excess of 10%.

In order to mitigate against soil carbon emissions following clear felling at Threestoneburn, Scottish Woodlands propose the following:

- Root plates will remain in ground in order to minimise ground disturbance.
- Phased felling.
- Use low impact technologies and controlled access of forest machinery in order to minimise soil disturbance.
- Blocking drains in order to raise the water table.
- Encourage rapid revegetation of the entire site.

It is probable that the majority of soil carbon emissions will occur during the first year after harvesting. In the long run it is likely that less aeration brought about by the rising of the water table will result in lower oxidation rates in the peat layer / organic soil material and reduced soil carbon emissions.

5. BASELINE SCENARIO (THREESTONEBURN)

Prior to selling Threestoneburn, the Forestry Commission restocking proposals for Threestoneburn included the following key considerations:

- Planting line on Hedgehope Hill taken downhill to a more appropriate line
- Scrub broadleaved planting in area between productive forest and S.S.S.I.
- Broadleaved planting along main watercourses.
- Mixed species planting
- More open space / rides between planting blocks.

For the purposes of this report, ECCM have assumed that 70% of the original area (454 of 567 hectares) will be restocked (Table 3) of which 20% will be left as open ground.

Species	Proportion	Area	Yield class
Sitka spruce	63	286	12
Other conifers (modelled as Scots pine)	10	45	8
Larch	1	5	6
Mixed broadleaves (modelled as downy birch)	6	27	4
Open ground		91	
Total		**454**	

Table 3: Forestry Commission restocking proposal at Threestoneburn

Based on the Forestry Commission restocking proposals, ECCM estimate that the potential average CO_2 storage over 100 years at Threestoneburn is approximately 133,905 tCO_2. This calculation has been done using the ECCM model (version 4).

6. POTENTIAL CARBON SINKS

Two carbon sinks (carbon sequestration resulting from tree planting) are proposed by Scottish Woodlands. Planting is proposed at Threestoneburn and at Camus Eskan which is under the same ownership as Threestoneburn. ECCM have been commissioned to assess to overall balance between the emissions from clearfelling at Threestoneburn and carbon sinks at Threestoneburn and Camus Eskan.

6.1 Threestoneburn

After clearfelling at Threestoneburn Scottish Woodlands propose to plant 72.21 hectares of native woodland. Planting is proposed primarily along watercourses using native species. Yield classes supplied to ECCM by Scottish Woodlands. Total planting areas and tree species information supplied to ECCM by Scottish Woodlands. Planting areas for individual tree species based on assumptions made by ECCM derived from data provided by Scottish Woodlands (Table 4).

The long term average CO_2 storage (over 100 years) from tree planting proposals at Threestoneburn is forecast to be approximately 10,000 tCO_2.

Tree species	Area to plant (ha)	Stocking density (stems / ha)	Yield class	Tonnes of CO_2 (Average storage over 100 years)
Downy birch	12.64	1100	4	2,827
Alder	12.64	1100	4	2,336
Willow	12.64	1100	4	199
Ash	12.64	1100	4	2,915
Rowan	12.64	1100	4	1,298
Hawthorn	4.51	1100	4	232
Mixed shrubs	4.51	1100	4	47
Total	**72.21**			**9,849**

Table 4: Proposed planting and potential CO_2 storage at Threestoneburn.

6.2 Camus Eskan

Scottish Woodlands have identified another site in West Scotland at Camus Eskan (under the same ownership as Threestoneburn) for tree planting. This is a 442.89 ha site of which 267.33 ha will be planted. There is an existing area of broadleaved woodland (37.2 ha) at this site which has not been included as part of these calculations.

Yield classes supplied to ECCM by Scottish Woodlands. Total planting areas and tree species information supplied to ECCM by Scottish Woodlands. Planting areas for individual broadleaved tree species based on assumptions made by ECCM derived from data provided by Scottish Woodlands (Table 5).

Tree species	Area to plant (ha)	Stocking density (stems / ha)	Yield class	Tonnes of CO_2 (Average storage over 100 years)
Hybrid larch	18.30	N/K	16	9,473
Lodgepole pine	8.90	N/K	10	5,283
Norway spruce	9.40	N/K	12	3,467
Scots pine	8.90	N/K	10	3,463
Sitka spruce	147.92	N/K	16	57,304
Downy birch	14.78	1100	4	3,306
Alder	14.78	1100	4	2,732
Willow	14.78	1100	4	233
Ash	14.78	1100	4	3,409
Rowan	14.78	1100	4	1,518
Total	**267.33**			**90,185**

Table 5: Proposed planting and potential CO_2 storage at Camus Eskan.

The long term average CO_2 storage (over 100 years) from tree planting proposals at Camus Eskan using the ECCM model (version 4) is forecast to be approximately 90,000 tCO_2.

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APPENDIX I

Compart-ment	Year of planting	Fell year	Age at year of felling	Age category (to nearest 5 years - rounded up)	Species	Area (ha)	Yield class	Tonnes of CO_2
6348	1982	2009	27	30	SS	17.9	18	6058
6348	1982	2009	27	30	SS	0.9	8	72
6348	Not relevant	2009				18.6		0
6349	Not relevant	2009				25.7		0
6350	1982	2009	27	30	SS	25.2	16	6948
6350	1982	2009	27	30	JL	0.8	8	226
6350	1982	2009	27	30	SS	2.2	20	804
6350	1982	2009	27	30	JL	0.6	8	48
6350	1982	2009	27	30	SS	8.6	12	1138
6350	Not relevant	2009				9		0
6351	1974	2009	35	35	SS	19.4	16	6196
6351	1975	2009	34	35	SS	12	14	3612
6351	1975	2009	34	35	SS	4.1	14	1234
6351	1975	2009	34	35	JL	1	8	336
6351	Not relevant	2009				1.7		0
6352	1974	2009	35	35	SS	26.1	14	7857
6352	1982	2009	27	30	SS	1.9	16	524
6352	1974	2009	35	35	SS	11.5	12	2294
6352	1974	2009	35	35	SS	0.8	0	0
6353	1974	2009	35	35	SS	31.2	16	9964
6353	1974	2009	35	35	SS	6.7	10	1273
6353	1967	2009	42	45	SS	8.3	14	3969
6353	1967	2009	42	45	LP	1	6	246
6353	1974	2009	35	35	SS	7.7	12	1536
6353	1967	2009	42	45	JL	2.2	8	895
6354	1967	2009	42	45	SS	20.4	12	7158
6354	1974	2009	35	35	SS	11.4	16	3641
6354	1975	2009	34	35	SS	30.2	10	5736
6354	1967	2009	42	45	JL	2.6	8	1057
6354	Not relevant	2009				2.8		0
6354	1975	2009	34	35	SS	2.1	12	419
6354	1975	2009	34	35	JL	1.4	6	317
6354	1975	2009	34	35	SS	1.1	0	0
6355	1975	2009	34	35	SS	18.5	14	5569
6355	1974	2009	35	35	SS	3.2	16	1022
6355	Not relevant	2009				3.6		0
6355	1975	2009	34	35	SS	1.8	6	407
6356	1975	2009	34	35	LP	19.6	6	3054
6356	1975	2009	34	35	SS	9	8	1231
6356	Not relevant	2009				1.5		0
6357	Not relevant	2009				44.4		0

Compart-ment	Year of planting	Fell year	Age at year of felling	Age category (to nearest 5 years - rounded up)	Species	Area (ha)	Yield class	Tonnes of CO_2
6358	1972	2009	37	40	SS	21.1	14	8139
6358	1977	2009	32	35	SS	5.8	12	1157
6358	Not relevant	2009				2.9		0
6359	1972	2009	37	40	SS	36.4	16	15242
6359	Not relevant	2009				2.2		0
6360	1971	2009	38	40	SS	36.5	12	10011
6360	1971	2009	38	40	SS	9.1	10	2312
6360	1971	2009	38	40	LP	3.1	6	626
6360	1979	2009	30	30	SS	3.1	10	397
6360	1971	2009	38	40	JL	0.6	6	159
6360	1971	2009	38	40	SS	0.6	12	165
6360	Not relevant	2009				1.5		0
6360	1971	2009	38	40	LP	0.4	6	81
6360	Not relevant	2009				0.3		0
6361	1971	2009	38	40	SS	8.7	14	3356
6361	1971	2009	38	40	SS	8.7	8	1646
6361	Not relevant	2009				5.7		0
6362	1972	2009	37	40	SS	15.4	12	4224
6362	1974	2009	35	35	SS	9.4	16	3002
6362	1967	2009	42	45	SS	6.4	14	3060
6362	1967	2009	42	45	LP	0.6	6	148
6362	1967	2009	42	45	JL	1.5	6	440
6362	Not relevant	2009				2.6		0
6363	1977	2009	32	35	SS	13.6	16	4343
6363	1974	2009	35	35	SS	16.8	14	5057
6363	1967	2009	42	45	SS	4.3	12	1509
6363	1972	2009	37	40	SS	4.1	12	1124
6363	1972	2009	37	40	SS	1.4	12	384
6363	Not relevant	2009				1.5		0
6363	Not relevant	2009				2.3		0
6363	Not relevant	2009				0.6		0
6363	1977	2009	32	35	SS	6.4	12	1277
6364	1979	2009	30	30	SS	17.9	12	2369
6364	1979	2009	30	30	LP	10.5	8	1209
6364	Not relevant	2009				7.3		0
6364	Not relevant	2009				6		0
6364	1979	2009	30	30	SS	10.9	14	2218
6364	1982	2009	27	30	SS	3	12	397
6364	Not relevant	2009				2.1		
6364	Not relevant	2009				1.5		

Compart-ment	Year of planting	Fell year	Age at year of felling	Age category (to nearest 5 years - rounded up)	Species	Area (ha)	Yield class	Tonnes of CO_2
6364	Not relevant	2009				0.8		
6364	Not relevant	2009				0.4		
Total						**712.7**		**158892**

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