

Appendix 1

All numbers highlighted are subject to change in a positive direction. Some of the assumptions used in the initial modelling were incorrect, especially in respect of soil carbon emissions. We are currently working with FR to correct the relevant figures but the overall trend will not be impacted by these changes

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THE CARBON ABATEMENT POTENTIAL OF WALES WOODLAND CREATION SCENARIOS

INTRODUCTION

The Welsh Assembly Government's Climate Change Strategy – Programme of Action development is ongoing. The programme currently out for consultation only includes the modest target of 1500 hectares of new woodland creation over 3 years; to be achieved from the FC Wales baseline budget. This is unlikely to achieve any net increase in woodland cover at a Wales level due to ongoing legitimate deforestation to achieve wider policy objectives.

This report highlights that the Assembly Government has the ability to achieve more using this policy option either through direct intervention by adding to the public forest estate or by encouraging farmers and other landowners to plant new woodland. This paper sets out some background and the latest modelling information on potential abatement scenarios.

Forest Carbon Stocks in Wales

Trees - The average UK forest Carbon stock in trees is approximately 200 tCO₂eq ha⁻¹.¹ With 285,000 ha of forest in Wales this implies:

- 57 Mt CO₂eq total Carbon stock in trees.

This is roughly equivalent to ten years of Wales' transport emissions at current levels.

Soils -There is typically significantly more carbon stored in forest soils than in the trees themselves. Woodland usually builds up soil carbon, but it can also be emitted if exposed or cultivated to establish trees. However the objectives of protecting carbon soil stocks whilst increasing the carbon sink in standing biomass or through substitution impacts via harvested wood products are not incompatible. Both objectives can be achieved through careful site selection and management practices.

In total the forest soil carbon stock of Wales is probably around:

- 80 Mt CO₂ eq in total
- 53 Mt CO₂eq under conifers, at about 300 tCO₂eq per hectare, and
- 27 Mt CO₂eq under broadleaves at about 270 tCO₂eq per hectare."

¹ Broadmeadow & Matthews, 2003

Total carbon in Welsh forests and their soils is thus estimated at about 140 Mt CO₂eq. This is more than ten times the annual emissions from industry and services in Wales.

WOODLAND TYPES AND STRATEGY CONTEXT

Woodlands for Wales the Welsh Assembly Government's Strategy for Woodlands and Trees sets out an approach to carbon management and the establishment of new woodlands.

Woodlands for Wales

"New woodlands are created and existing woodlands are managed in a way which balances the achievement of other objectives of this strategy and the yield of usable timber and wood products, whilst also helping to sequester carbon in living biomass."

"Decisions about woodland creation and management take full account of all the ecosystem services the woodland could provide, not just the potential for timber production."

"In the context of *Woodlands for Wales* the objective of diversification is to move away from large single aged, single species, twentieth century plantations. Although there has already been a major programme of restructuring the age of our own woodlands over the last twenty years, there has not been the same concerted effort to diversify the species grown or develop the use of mixtures."

"Clearfelling is avoided where alternative management systems would make a better contribution to ecosystem services."

Carbon Modelling

Carbon modelling using Forest Research's Forest Management Cycle Carbon Calculator, has been undertaken on a number of options. In particular a model has been tested for diverse woodland composed of Oak and other broadleaved trees in mixture with Larch, a deciduous conifer and Douglas fir, a valuable timber tree. This heterogeneity could be achieved at both a stand and a woodland level. In the former example the tree species would be intimately mixed within the stand. The alternative is that small stands of either single species or perhaps two species in mixture would collectively deliver a diverse woodland as a whole.

Another model assumes the creation of new native woodland and does not assume timber production outputs. Both models assume that there will be no clearfelling and therefore meet the Wales Woodland Strategy's clear aspiration of reducing the reliance on clearfelling. This paper concentrates on woodland creation programmes divided equally between these two approaches. A range of other options is included in the Appendix.

SCENARIOS AND CO2 ABATEMENT

Potential woodland carbon outcomes have been presented in a range of forms as the Wales Climate Change Strategy Consultation has been developed. Using the new carbon modelling figures now available, we need to establish how to best to present a coherent option.

Table 1 Abatement from Establishment of 1,000 Ha of New Woodland

Woodland Type	New native woodland on gley soils replacing pasture (no harvested wood products)	New mixed productive conifer and broadleaved woodland on loam soils replacing pasture (actively harvested for wood products)
Cumulative Abatement over 50 years to 2060 Kilotonnes CO ₂ eq	590	660
Average Annual Abatement per year Kt CO ₂ eq	11.7	13.1
Incentive cost per Ha	£3000	£2500

Potential Large Scale Programme of Woodland Creation

The cumulative and long term carbon abatement potential is best communicated by the presentation of the impacts from a large scale programme of woodland creation at a rate of 5,000 ha per annum over 20 years. This would create an additional 100,000 ha of new woodland taking Wales woodland area to 385,000 ha, a 35% increase on the current level, to a woodland cover of about 19%.

For the sake of clarity it is useful to acknowledge explicitly that such a programme might raise spatial planning and agricultural production questions. However whether there is any net trade-off or the degree of any trade-off of the achievement of other objectives is open to discussion. It is conceivable that the trade-offs are perceived rather than real as there is some evidence that there is further scope for optimisation in not only agricultural production but also for wider ecosystem service delivery by increasing woodland cover and by more 'trees in the landscape'.

Table 2 Analysis of Accumulated Abatement from 10 and 20 year Programmes of Woodland Creation at 5,000 ha per Year, Including Soil Impacts

	D1 - YC 4 Broadleaves Unmanaged		F - Mixed Continuous Cover Woodland		Total	
	Gley Soil		Loam			
Planting Programme, per yr.	2500		2500		5000	
Length of Programme	10	20	10	20	10	20
New woodland k ha	25	50	25	50	50	100
Total Mt CO ₂ eq Abatement to 2020	-1.6	-1.6	-0.3	-0.3	-1.9	-1.9
2030	1.1	-0.5	3.6	3.2	4.6	2.7
2050	10.9	16.2	13.1	21.0	24.0	37.2
2060	14.6	24.3	16.6	28.4	31.2	52.7

EMISSIONS FROM SOILS DURING WOODLAND CREATION

This table shows that based on carbon modelling undertaken by Forest Research, based on woodland management assumptions the negative figures for soil carbon emissions in the initial years after establishment are quickly abated. Further explanation of this dynamic will be set out in the Review of Carbon and GHG Balance of UK Forests, soon to be published by Forest Research. Native woodland establishment on a Gley soil is assumed to result in net emissions until year 3 and mixed woodland on Loam until year 2. This means that although woodland established in the later years of a programme [5000 ha per year over ten years] will be contributing modest emissions by 2020, the cumulative programme level impact is positive.

However as has recently been recognised at a UK level, woodland creation options have the most potential to contribute to the longer term 2050 targets, *if action is taken soon*.

In addition, the overall GHG benefit of land use change to woodland is well accepted²:

“For Wales in 2005, land use change to forestry and grassland sequestered 2146 Kt carbon dioxide equivalent”

² CLIMATE CHANGE AND AGRICULTURE

Options for Mitigation of Greenhouse Gas Emissions from Agricultural Activity in Wales

Havard Prosser et al Technical Services Division Welsh Assembly Government June 2008

The complexity of soil issues was also acknowledged:

“Assuming that the relationship between loss / gain soil carbon and time is linear is simplistic, and while this provides a way to allow yearly data to be presented, the true relationship is exponential. This is an important factor if we consider that an agri-environmental scheme typically has a life span of 10 years, whereas a change of land use from arable to woodland requires a time span of 100 years for soil carbon to achieve optimum levels.”

Table from Options for Mitigation of Greenhouse Gas Emissions from Agricultural Activity in Wales

Management Option (as reported in the scientific literature)	Estimated emission/sequestration rate (t CO ₂ e ha ⁻¹ yr ¹)
Grassland to woodland – soil only	- 0.73
Arable to woodland – soil only	- 1.82
Oak woodland - biomass only	- 13.9
Conifer woodland – biomass only	- 36.6

The site types and management practices considered in the above scenarios are some of the most beneficial possible in terms of soil carbon management. However there may be further scope to improve best practice on soil management to reduce the early year's emissions even further. For illustrative purposes, the carbon abatement potential, without any soil impacts, is set out in the following table.

Table 3 Analysis of Accumulated Abatement from 10 and 20 year Programmes of Woodland Creation at 5,000 ha per Year, *Excluding* Soil Impacts

	D1 - YC 4 Broadleaves Unmanaged		F – Mixed Continuous Cover Woodland		Total	
	2500	2500	2500	2500	5000	5000
Planting Programme, per yr.						
Length of Programme	10	20	10	20	10	20
New woodland k ha	25	50	25	50	50	100
Total Mt CO ₂ eq Abatement to 2020	1.2	1.2	11.3	11.3	12.5	12.5
2030	7.8	8.6	38.3	47.2	46.1	55.8
2050	15.7	27.6	65.1	116.0	80.7	143.6
2060	14.6	30.9	66.9	125.8	81.5	434.8

AVOIDANCE OF AGRICULTURAL EMISSIONS

The effect of avoided agricultural emissions has usually been ignored in assessing woodland creation policy, partly because it is assumed that displaced food production emissions will simply take place elsewhere. Potential changes in food consumption as well as the potential for further agricultural production optimisation might mean that this should not be taken as a given and that the avoided emissions from agriculture should be considered. Eighty five percent of Wales' agricultural emissions, estimated at 1,642 KtC eq or 6,026 ktCO₂ eq, in 2005 are associated with grazing livestock.³ If the area of grass in Wales is 1.37 million ha then it might be estimated that about 4 tCO₂ eq is emitted per hectare.

A study for Natural England used the CALM carbon model and gives the following emissions (tCO₂ eq;

Dairy	11.44
Grazing (LFA)	2.50
Lowland Grazing	7.05

Table 4 - Avoided Agricultural Emissions in Relation to Woodland Abatement for 20 year Programme of Planting 5,000 ha per Year

	Total Woodland Abatement	Avoided Agricultural Emissions		
Assumed Agric. Emissions tCO ₂ eq/ha		2.5	5.0	7.0
Total Mt CO ₂ eq Abatement to 2020	-1.9	0.8	1.5	2.1
2030	2.7	2.8	5.5	7.7
2050	37.2	8.0	16.0	22.4
2060	52.7	10.6	21.3	29.8

CARBON VALUATION AND DISCOUNTING

Analysis of Carbon valuation from the models is available. It is worth noting that while the Shadow Price of Carbon escalates at about 2% per annum to account for the expected higher costs in future, the future value is also discounted at 3.5% and then 3% after 30 years. This means that emissions in the present from soil carbon will play a more significant role in NPV calculations than more distant future positive figures.

A rough application of SPC and discount factors to the flow of Carbon for the mixed woodland option suggests a total NPV of about £14k. This comfortably outweighs the likely public cost of woodland creation in Wales.

³ Policy Options for Reducing GHG Emissions in Wales

COSTS

Woodland creation of the type discussed here, through Better Woodlands for Wales is based on planting grants of £1,700 for “Quality Mixture” and £1,800 for Native Woodland. These are based upon “Standard Costs” of £4,086 and £4,149 respectively. Uptake of these grants is low and current levels of woodland creation are below 500 hectares per annum. While little information exists on the demand curve for woodland creation it has been assumed that higher grant levels would be required. This could be achieved through a paying a higher percentage rate through the Rural Development Programme. Under the CAP healthcheck, grant-aid can now be increased to up 90% of planting costs.

It is worth noting that some native woodland creation occurs by natural processes on less intensively utilised farmland. Not all of this will be environmentally desirable but much of it may be, for instance on bracken sites. The scale of this in Wales has not been systematically examined. It represents woodland creation at nil public cost. Such land will usually attract Single Farm Payment, with in some cases “perverse” requirements for scrub cutting by farmers encouraged by the potential loss of payment for “ungrazeable” areas. While natural woodland creation by this route is slow, it also avoids the up-front carbon emissions associated with intervention to plant trees.

There may also be a possibility of additional funding through voluntary carbon finance; the “additionality” of individual projects will be crucial to this. The Forestry Commission is developing a Code of Good Practice to facilitate this. However it needs to be emphasised that there are currently no mechanisms in the UK to allow UN fungible carbon credits to be created through forestry.

CONCLUSION

In the medium to long term there are clearly significant carbon abatement opportunities from large scale woodland creation which might abate 50 million tonnes of CO₂ eq by 2060. Mixed and native woodland managed by continuous cover systems will deliver a large and diverse range of other benefits. Early emissions from soils distort the short-term picture.

SUMMARY IN THE FORMAT OF THE WALES CLIMATE CHANGE STRATEGY:

Summary description

Creation of new multi purpose woodland at an increased rate of 5000 ha per year, over 20 years which would also sequester carbon and reduce other emissions through substitution of fossil fuel for energy and production of emission intensive building materials.

Who's affected?

Most of the land involved will be currently in the hands of farmers, the policy would be achieved through grant aid for woodland creation.

Who needs to deliver?

Forestry Commission Wales in conjunction with private landowners especially farmers.

Links to other actions

New woodland creation will in the medium term be strongly linked with, and complement woodfuel initiatives. Woodland creation grants are linked to agri environment and other agricultural measures.

Cost

Annual investment to achieve this programme would be approx. £17.5M. This is based on an average cost per hectare of £3500, which lies between current grant levels and standard costs which form the basis of RDP funding.

Carbon savings

Nearly 40 Mt of CO₂ eq is estimated to be accumulated by 2050 through growing trees soils, products and substitution for fossil fuels. A further approximate 20 Mt of CO₂ eq would be avoided in Wales through reduced agricultural emissions.

Other benefits

A Win-win option. There will be soil carbon benefits which have been quantified in the carbon calculations. Water management benefits can result from riparian woodland creation and reduced runoff in upper catchments. New woodland can perform adaptation functions, creating habitat networks and benefiting biodiversity. Where woodland is located close to where people live it can provide social benefits through recreation, improved health and community involvement.

Challenges

A significant increase in woodland creation will require effective communication with partners in the farming community who will mainly carry it out, and the wider public who will see landscape change including an increase in new woodland with a conifer content. While enormously different from afforestation in the past this may need effective presentation.

Case Examples Wales

Case	Trees				Soil		Carbon tCO2e					Commentary
	Species	YC	Management regime	Rotation	Soil	Prev. land use	2010	2035	2060	2085 5	2110	
A	Sycamore/Ash/Birch	6	Overstocked woodland. Then thin 5 year cycle.	No clearfell	Gley	Un-managed forest	30	-50	-110	-110	230	
C	Sycamore/Ash/Birch	8	Standard thinning	80	Loam	Rough Pasture	-40	230	590	730	640	
D(1)	Sycamore/Ash/Birch	4	No thinning	No felling	Gley	"	-50	230	590	760	840	
F(1)	Oak	6	ATC (selection)	No clearfell	Loam	"	-40	170	440	570	600	
F(2)	Sycamore/Ash/Birch	6	ATC (selection)	No clearfell	Loam	"	-40	210	390	420	450	
F(3)	Douglas fir	14	ATC (selection)	No clearfell	Loam	"	-40	480	1007	1220	1500	
F(4)	Japanese larch	14	ATC (selection)	No clearfell	Loam	"	-40	430	790	1040	1020	
F	Mix Oak, DF,JL,SAB		ATC (Selection)	Non Clearfell	Loam	"	-40	320	660	810	890	
F	Mix Oak, DF,JL,SAB		ATC (Selection)	Non Clearfell	Peaty Gley	"	-60	200	560	760	870	
G(1)	Sitka spruce	12	Standard thinning	55	Gley	"	-40	440	810	810	1120	
G(2)	Douglas fir	12	Standard thinning	65	Gley	"	-40	480	960	1110	1350	
H	Sitka spruce	12	ATC (shelterwood)	No clearfell	Loam	"	-40	430	790	790	850	
I(1)	Sitka spruce	12	ATC (selection)	No clearfell	Loam	"	-40	450	810	1120	1120	
I(2)	Douglas fir	12	ATC (selection)	No clearfell	Loam	"	-40	490	910	1180	1330	

Breakdown of the Carbon Accumulation Model for a new mixed multi-structured Woodland of Oak, Sycamore, Ash, Birch, Douglas fir, and Japanese larch

Accumulation Over 100 Years		tCO ₂ eq
Fossil fuel emissions from operations		-100
Soil Carbon		150
Carbon in Standing Trees		250
Leaf litter and other debris on the forest floor		60
Harvested Wood Products storing carbon		130
Fossil fuel emissions displaced due to utilisation of wood fuel co-fired with coal to generate electricity		40
Fossil fuel emissions displaced due to utilisation of wood fuel in small-scale domestic heating systems, in place of fossil fuel		110
Substitution for electric heating		70
Emissions displaced due to utilisation of (some) roundwood and sawn timber as structural material, generally in place of pvc and concrete - medium option	Options	200
Emissions displaced due to utilisation of (some) roundwood and sawn timber as structural material, generally in place of PVC, concrete and brick - high option		330
Total Medium Product Substitution		910
Total High Product Substitution		1040