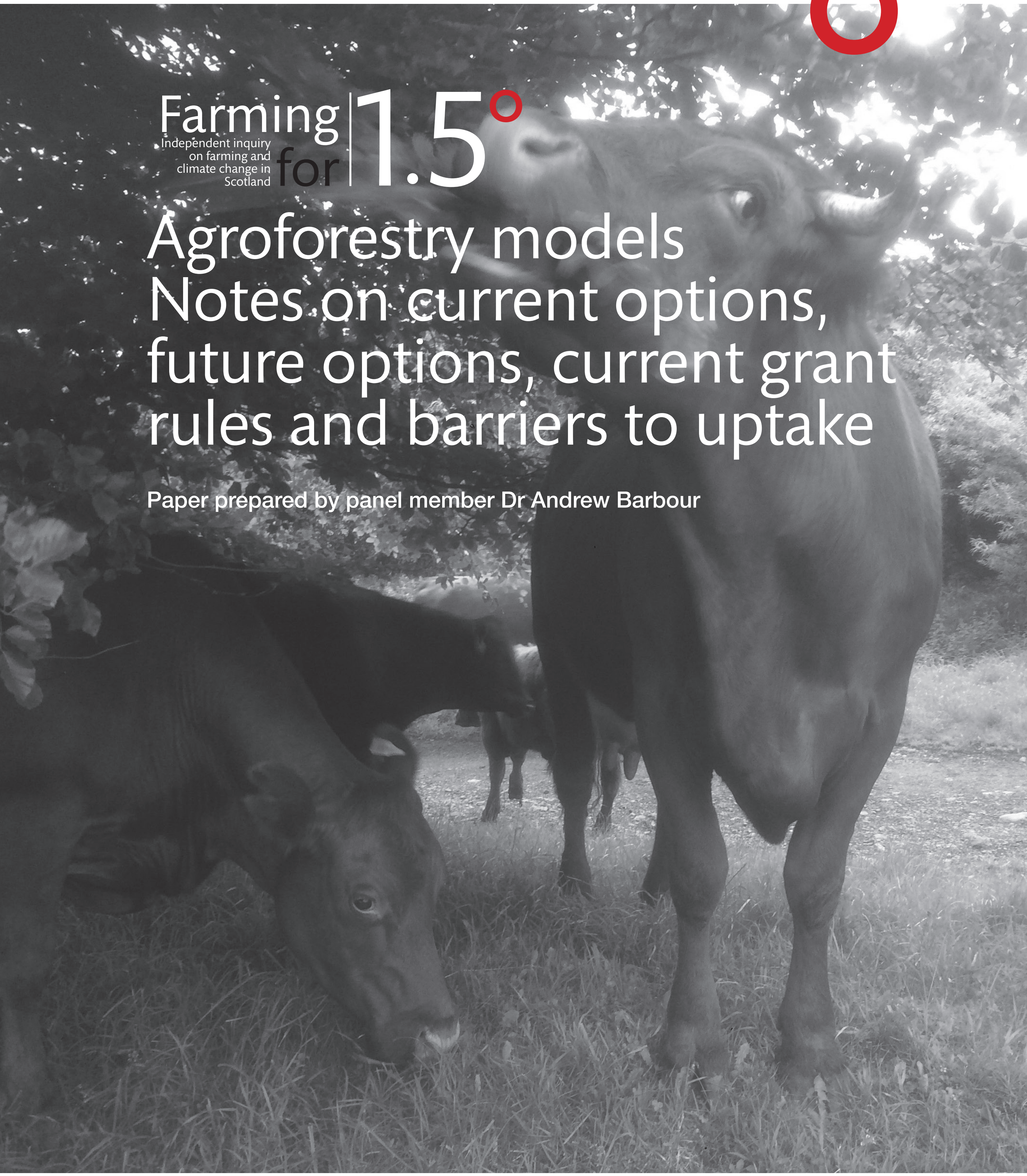

Farming for 1.5°

Independent inquiry on farming and climate change in Scotland

Agroforestry models Notes on current options, future options, current grant rules and barriers to uptake

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INTRODUCTION

There is increasing interest in agroforestry as a mitigation option for farming in a 1.5C future. The WWF report identifies this land use as a major part of its recommended mitigation options and the CCC does likewise. However, the Scottish Forest Strategy avoids the term completely, although it does make reference to the role that woodlands can play in providing shelter for stock. There are currently two agroforestry options within the current Scottish Forestry Grant Scheme but these are limited to better land (grades 3.2 – 4.2) and are based on the establishment model used in the Glensaugh trials of the 1980s (individual tree protection in low density plantings). Similarly, the WWF report restricts this mitigation option to such better land but does this simply because to date there are no references in the literature to upland models of agroforestry as might apply to Scotland. This note looks at this issue and identifies a planting model which would potentially grow quality timber whilst maintaining a field layer for grazing. It also compares current grant provision to what might be needed to accommodate such models.

DESIGN PRINCIPALS

Agroforestry here is defined as a landuse which involves growing an agricultural crop on the same parcel of land as a tree/bush crop with both crop types being fundamentally productive in nature – i.e. the tree element has a utilisable yield and isn't just for non-market benefits though these might accrue. For silvopasture, this means on the one hand planting and managing trees so that a field layer can be maintained to provide graze/browse options for livestock. On the other hand, it means growing trees in such a way that will yield utilisable timber in a manner which allows mechanized harvesting. This is in contrast to a habitat restoration approach to increasing tree cover on farmland which is less likely to produce quality timber.

The trials at Glensaugh (JHI farm) produced a good understanding of the effect of canopy cover on grass production (Agforward, report no 613520, 2015) However, the trial was principally aimed at understanding this relationship (in a policy environment of the day which was aimed at limiting production of agricultural produce) and was not intended to produce high quality timber, although the researcher did high prune the trees in his own time for personal interest reasons. The current agroforestry options are based on the establishment approach used in these trials (individual tree protection with double stakes etc). Stem quality is not particularly good and the relatively low planting densities restricts the ability to produce quality timber (200 or 400 stems/ha evenly spaced compares with a traditional 2,500 stems/ha in conventional woodland establishment). Such an establishment method is suitable for smaller areas but is restricted in its suitability for larger areas. An alternative approach is to fence stock out for initial establishment, plant using traditional planting techniques in a row pattern which maintains a field layer for grazing and allow stock entry once the trees reach a height where browsing by sheep (initially). Cattle can be allowed without risk of damage (approx. 5 years for sheep dependent on rate of tree growth, 10 years for cattle).

Silvopasture provides both grazing options and shelter options for stock. Both top shelter and side shelter are important in different weather conditions, with shelter belts having traditionally been used to provide side shelter (lowering wind speeds on adjacent open ground) whilst top shelter has traditionally only been found at field margins or woodland edges (with associated problems of poaching etc). Top shelter is best provided by heavy shading species but this restricts the ability for field layer growth. Conifers and evergreens such as Holly provide good top shelter all year round whilst species such as beech or sycamore provide good top shelter in summer. Light canopied species such as birch or ash provide a canopy type that allows enough light to maintain a field layer but provide less shelter (top or side), particularly in winter. Thus a single species approach will fail to deliver both types of shelter. An obvious solution is to use mixtures of these different type of species for silvopasture, and the use of mixtures is well established in silviculture for normal woodland management purposes.

TREE SPECIES MIXTURES/SUITABILITY

Sitka spruce/Douglas Fir both species are best suited to high density, high forest systems of production, and the field layer is dead at canopy closure (15 years might be a typical age for this). Normal practice is to minimise the amount of edge trees as the heavy branching of partially open grown trees produces large knots and poor quality timber. These species therefore appear unsuitable for silvopasture systems, largely due to the their fast growth rates and lack of field layer present for most of the rotation.

Pine/Birch this is a very traditional mixture (and natural in the pine boreal forests). The pine is a well-recognised timber species and would normally be grown at a maximum initial spacing of 2m so as to produce quality timber. Birch is widely used in Scandinavian forestry but mainly used as firewood in the UK. It has a light canopy and is well suited to maintaining a productive field layer underneath it. Silver birch in particular has a light branching habit and can be grown at wider spacings (3 to 4 m) and still provide useful timber. It is therefore well suited to a silvo-pasture system, as a dominant species grown with pine at lower altitudes (normally below 300m). Hairy birch, suitable for poorer and wetter sites (gleyed and peaty podsol type soils and at higher altitudes than silver birch), also grows well with pine in its native range, but its branches are most persistent and so requires tighter planting densities if it is not to be heavy branched. All three species have genetic improvement programmes (hairy birch at an early stage) and improved pine and silver birch are commercially available.

Oak/Birch both on richer and poorer sites (nvc W11, W16, W17 types) are natural mixes, although not normally commercially grown together. Norway spruce has been a commoner nurse mix with oak in past decades but oak/birch mixes perform like pine/birch mixes in terms of canopy types.

Norway Spruce/Birch this mix is not normally used in commercial forestry but is widespread in boreal woodland in Europe and can be effectively grown together in blocky mixtures, as their growth rates are similar over the early years. Like pine/birch and oak/birch , the mix of canopy types could work in a silvopasture system but the birch would need to be the dominant species and Norway spruce bark is prone to bark stripping by animals in winter. This is probably not a recommended mix for silvopasture but, never the less, could work.

Other species gean grows well with birch, as well as ash. Ash and larch, because of disease constraints are ruled out here although both species would form obvious choices in silvopasture systems. Sycamore, as a heavy shade species, would be a choice with ash, but high growth rates make it an unsuitable species to grow with birch and therefore is a less suitable species for silvopasture systems. Both sycamore and larch are species used in the Glensaugh trials (the other was pine).

PLANTING PATTERNS

Traditional plantation establishment involves planting trees in rows at 2m spacing (this may vary slightly dependent on species and objectives). Yield models have been developed in the UK for all the major conifer species based on this approach, with very little data on broadleaves. The initial densities used in this plantation model are a compromise between cost of establishment, the need to thin (often a cost operation) and the desire to obtain early canopy closure so as to restrict branch growth and promote stem quality. However, an obvious option in developing a silvo-pasture model is to leave some rows unplanted so as to maintain grass growth unhindered by canopy closure until later in the rotation. This approach, a form of alley cropping, gives plenty of design flexibility for different species mix with the option to still form a full canopy cover crop, but at a later stage of the rotation. If alleys are centred on final crop tree spacings, then what is being 'lost' in the alleys is equivalent to some earlier thinnings. What is being gained is increased field layer growth potential. Alternatively, an approach where the alleys are centred on a lower % of final crop is also possible, still leaving the chosen density of final crop trees to grow on under 'open canopy' conditions once final thinnings have been taken. Light canopied species would be planted on the outer rows to encourage field layer growth in the alleys.

The performance of such an alley row design would still lend itself to the use of yield tables, working on a pro-rata basis, with some caveats born in mind. An alley row system has in effect a very large amount of edge trees which will be partially free grown until felled. Individual tree volume increases with increasing inter- tree planting distance up to a certain point due to the larger crowns that wide spaced trees can grow. So carbon models based on a normal plantation model would tend to underestimate the carbon captured by an alley row planting model. Wider spaced plantings have a slightly reduced yield potential for a given age as canopy closure comes later and less solar energy is captured by the trees. So yield tables cannot be used in a very accurate way but can be used to indicate with confidence the scale of carbon that can be captured by the trees. A further restriction of the yield tables is that they have been developed for single species stands and not for mixes, with the usual approach in practical forestry to treat the different species as though they were in pure stands and then pro-rata the results.

Table 1 and 2 show how the effect of different planting patterns on final crop volume and CO_2 values using the yield class tables for two different starting densities for pine and birch mixes, with pure pine yield class data as the control. These are just examples and either different yield models and/or different planting patterns could be utilised. Because there is not the same extensive data set for broadleaved species in the UK, it is more difficult to make the same type comparison with birch/gean or oak/birch mixes. However, there is some data for oak and table 3 gives an indication of carbon values in a low initial planting density, using a birch;oak mix.

Table 1

Different Levels of Final Crop Canopy Cover: planting pattern options using mixtures in an alley row cropping approach, based on an 8 row pattern with pine/birch at 2m spacing.

Pine YC 8 at 2.0m initial spacing with thinning	Trees/ha at yr 0	Trees/ha at 100 yrs	Vol/ha for final crop	CO_2 value per tree and per ha for final crop
100% pine stocking for final crop, no birch	2500	280 pine	379m3 pine	1516kg/pine tree = 424 t/ha total
75% stock with 3 rows pine, 3 birch, 2 rows unplanted	1875	184 pine (64% of possible canopy) 156 birch	249m3 pine 47m3 birch	278 t/ha pine + 442kg/ birch tree, 69 t/ha = 349t/ha total
62% stock with 3 rows pine, 2 rows birch, 3 rows unplanted	1500	140 pine (49% of possible canopy) 156 birch	189m3 pine 47 birch m3 birch	212t/ha pine + 69 t/ha birch = 281 t/ha total

Table 2

Low density planting with pine:birch based on a 13m final crop spacing

Pine YC 10 at 4.5m initial spacing with thinning	Trees/ha at yr 0	Trees/ha at 100 yrs	Vol/ha for final crop	CO_2 value per tree and per ha for final crop
100% pine, no birch	487	165	410m3 pine	2796kg/pine tree, 461 t/ha
33% pine with 67% birch, (pine at final crop spacing in a 3 row pattern with birch on outer rows)	487	165 pine, 165 birch	410m3 pine 50m3 birch (460m3 total), assumes birch does not impede pine growth rate	2796kg/pine, 442kg/birch @ 72.9t/ha = 533t/ha total
10% pine with 90% birch (pine at 1/3rd final crop density, birch at 2/3rd)	487	54 pine, 111 birch (165 total)	134m3 pine, 33m3 birch (167m3 total) 40% canopy cover	2796kg/pine, @ 150t/ha, birch 442kg/birch @ 49 t/ha = 199 t/ha total

Notes: birch is assumed to be 0.3m3 per tree at 100 years age (approx. maximum age for birch). Birch are assumed to form the outer rows in all patterns, planted in an intimate mix. CO_2 value for trees is calculated using the formula: freshweight of tree x density of dry timber/m3 (pine @ 51%, birch @ 67%) x carbon % (50%) x allowance for root weight (120%) x conversion to CO_2 (3.67). (assumes a freshweight: m3 ratio of 1:1. Note that in reality this varies slightly).

Table 3

CO_2 values for oak:birch mix, aiming for a 60% canopy cover for the oak element at final crop spacing of 12.6m with YC 6 oak. Initial planting is of 2 outer rows of birch, 1 inner row of oak planted at 2m spacing, with 3 rows unplanted in a 6 row repeating pattern. All birch removed as thinnings.

Oak YC 6 at 2m spacing with thinning	Trees/ha at yr 0	Trees/ha at 100 yrs	Mean volume of final crop oak	CO_2 value per tree and per ha
1/3rd oak, 2/3rd birch, 3 rows unplanted in a 6 row pattern	500	63	3.53m3/tree	10496kg/tree, 661 t/ha

SCALE

Given the need to harvest timber in saleable volumes, the scale of any such plantings needs to be at a scale that allows the effective use of machinery (note that harvesting costs will be slightly higher in lower density plantings due to less volume/area to harvest). In practice today, that would require a minimum size of between 5 to 10 ha minimum to ensure adequate volume to allow management/marketing. Such a scale is a useful management unit for stock on most farms with rough grazings. Adequate open ground design for stock management need to be considered, with open ground around gateways and rides orientated to allow stock to easily move to gates.

Depending on landscape features, a mix of blocks and open ground would allow the rotation of stock between parcels of land so as to efficiently use forage and utilise shelter opportunities/ needs.

CARBON VALUES

Indicative values of an alley row type approach are given above for a pine/birch mix at two different planting patterns and for an oak/birch mix where all birch and some oak are removed as thinnings. The pure stand of pine yields a total production of 727m3 over its 100 rotation and an alley cropping pattern would deliver less thinnings, approximating in a pro-rata fashion to the planting pattern. However, a significant proportion of earlier thinnings do not go into long term sequestration uses (e.g. pallet, chipwood) and so a significant part of the carbon captured in a conventional planting is not sequestered safely. Thus an alley system performs better in terms of carbon capture than might appear just from a yield analysis. In addition, an alley planting pattern should improve stand stability for windblow due to the large edge element in such stands and therefore offers (for the pine) long term sequestration options as standing timber (assuming well drained soils).

GRANTS

There are nine Scottish Forestry planting models (plus two low density agroforestry options) but none suit a larger scale agroforestry approach using an alley row or similar cropping system. The small or farm woodland model has a stocking density of 2500 stems/ha over at least 80% of the area, with a maximum of 10 ha size. The native pine and upland birch models involve a starting density of 1600/ha, with productive broadleaves at 3100/ha. There is a low density broadleaved model at 500 stems/ha, with constraints on area in any given scheme. Open ground allowance is now 15% for upland birch and native pine, but only 10% for productive broadleaves. The models are quite prescriptive in terms of the mix of species allowed (e.g. pine allows for 70 to 85% pine, with 10 to 15% other suitable species). A more flexible approach to mixtures would be needed in an agroforestry model. An alley cropping model would also need explicit recognition by the FD to avoid penalties when checking planting densities in such a system. The unplanted rows would need to be defined as allowable internal open ground with the designed open ground identified in the planting contract separately. Planting densities in an alley planting pattern are close to those currently used in the grant system.

BARRIERS TO UPTAKE

There are various barriers to uptake: cultural resistance to trees in the farming community, lack of knowledge on silviculture in the farming community, perception that trees bring problems to livestock (e.g. flystrike), resistance to agroforestry in the forestry sector, until recently the lack of a 'champion ' in the NGO sector (SA and the English part of the Woodland Trust are to some degree rectifying this), inertia and risk averse culture in Govt. Forestry Dept., much reduced capacity in the 'forestry' academic community (only UHI offer a degree course in forestry), lack of engagement in the agricultural academic community and the lack of obvious drivers to force uptake or development of agroforestry (e.g. the lack of a sequestration element to agricultural emissions calculations).

The silvopasture models identified above are suitable for a range of soil types and so could apply to a range of farm types where scale allows and where there is a livestock enterprise. Therefore the scale of opportunity is large. Agroforestry in the arable sector (e.g. apple trees in wide alleys) is arguably more about benefits other than carbon capture and presents another suite of barriers to uptake, with probably a more limited application.