Green Lanes

A vision for multi-benefit land use on highway verges

Executive Summary

The UK Trunk Road Network is approximately 12,000 km long. Currently the verge of this network is non-productive. An outline analysis was conducted to estimate the potential yield of this area if it was used to grow a short rotation forestry crop to be sold as firewood. Initial estimates indicate that if all assumptions are correct, this area could produce around 45,000 tonnes of seasoned firewood annually – enough to produce 165 GWh of heat enough to heat around 10,000 homes, and save more than 36,000 tonnes of CO_2 annually when compared to natural gas. The sale value of this material is estimated to be in the region of £7.8 million per year (or £650 per linear kilometre of road.) Further additional benefits of implementing this scheme were identified in section 2, which looked at other non-economic benefits of SRF plantations on roadsides.

Further research is strongly recommended to establish whether the assumptions underlying these figures are correct and determine accurate estimates of yield and cost for field scale trials and eventual widespread implementation.

Introduction

The UK has around 395,600 kilometres of roads of which the trunk road network (centrally managed roads) comprise approximately 12,000 kilometres (ONS 2014). These trunk roads carry a disproportionately high proportion of traffic, and are commonly bounded by embankments and verges. While these embankments / verges confer a number of benefits on road users and those near to roads, they are commonly not managed to any great degree. Management of these spaces is typically carried out by mowing the grass / shrub layer and by felling trees and chipping the wood directly back onto the embankment.

This paper seeks to develop an outline case for more direct intentional management of these spaces to consolidate existing benefits while producing biomass fuel from Short Rotation Forestry (SRF). This development could either improve existing benefits, or actively increase the benefits gained from this area.

Method

Assumptions were made about road length, width of verge, and proportion of verge space available (to allow sight lines to be maintained, prevent overhanging etc.) These assumptions were combined with a simple excel based model to derive an indicative annual yield from this course of action, and a potential market value of the fuel derived.

A brief analysis of the effects of this change of land use was also carried out with reference to

- Drainage and bank stabilisation
- Habitat
- Increased protection from road accidents
- Noise abatement
- Pollution abatement
- Visual barriers
- Windbreaks

In each case SRF was compared with existing options of a) open ground / scrub and b) high / semi-mature woodland. For this first pass analysis options were categorised on a high / medium / low score **relative to each other** (further work would need to be carried out to fully quantify the effect.) This analysis was then presented as a matrix showing which land uses are more or less preferable for each situation.

Results

Part 1

The calculation was based on a trunk road network length of 12,000 km with a mean verge width of 15m (on both sides of the road) and an assumed usable area of 50% (retaining 50% for signage, sight lines etc.) This resulted in a net usable area of 18,000 ha for the UK.

Yield was calculated based on the use of silver birch (*betula pendula*) as a SRF crop. Birch is natural pioneer species and is expected to be well adapted to this use for a number of reasons:

- Pollution tolerance (including NO_X, SO_X, but also saline deposition from road gritting. [Hibberd 1989 p50])
- Prolific seeding (reducing need for replanting [FR 2007])
- Relatively fast growing native species (FC 2011)
- Adapted to exposed locations (light demanding and cold hardy [Hynynen, J. *et al*. 2008])
- Relatively light canopy (allows regeneration [Hynynen, J. *et al*. 2008])

Based on the assumptions implicit in the model[1] this would result in revenues of 434 $£.ha^{-1}.a^{-1}$ (or 651 £ per linear kilometre of road per year) realised on a rotational cycle of 15-20 year blocks, or a total annual revenue of approximately £7.8 million per year for the entire trunk road network.

It should be noted that this figure does not include the cost of felling and processing this timber, but that these costs are likely to be low. Based on FC figures (FC 2011b) and modelled yield harvesting, conversion and extraction would cost around 63 $£.ha^{-1}.a^{-1}$ in the case of a 15 year rotation, or 48 $£.ha^{-1}.a^{-1}$ if the rotation was extended to 20 years. Extraction costs are likely to be substantially lower than this estimate due to excellent access on the majority of sites. These results using conservative estimates indicate that splitting,

[1] Assumptions:

- Mean yield of 4 $m^3.ha^{-1}.a^{-1}$ NB this estimate is quite conservative: the Forestry Commission use between 4 and 12 $m^3.ha^{-1}.a^{-1}$ in their yield model (FC 2011)
- Oven dry calorific value of 18.27 $GJ.t^{-1}$ (Phyllis2 database 2016)
- Seasoned calorific value of 3.63 $MWh.t^{-1}$ (25% moisture content)
- 90% of timber usable
- sale price of 47.17 $£.MWh^{-1}$ for firewood (NEP 2016)

drying and delivery of logs would have to be accomplished for between £93 and £97 per m^3 in order to break even (which does not seem unreasonable).

The total production of energy from this material is calculated to be enough to heat around 10,000 homes[2] resulting in a substantial displacement of fossil-fuel based heating (saving 36,400 $tCO_2.a^{-1}$ when compared to burning natural gas, or 50,800 $tCO_2.a^{-1}$ when compared to heating oil [BEC 2016b]).

Part 2

Drainage and bank stabilisation

Woodland is generally more favoured for bank stabilisation and runoff mitigation than scrub / shrub layers (Hall & Cratchley 2005) Woodland canopies typically intercept rainfall more efficiently vertically, reducing the rate of infiltration and the velocity with which rain hits the soil. This delaying process coupled with greater rates of evapotranspiration has a tendency to increase the time available for water to infiltrate the soil. This effect, combined with a substantially greater root structure results in reduced runoff, decreased erosion / silting of drains, and a decreased risk of landslip.

The key variables assessed from this factor are: Continuity of cover (bare soil is vulnerable), scale of flora (trees are generally better) and the number of discrete layers within a site (a tree layer and a shrub layer is assumed to be preferable to a tree layer on its own.)

	open ground / scrub	Short Rotation Forestry	high / semi-mature woodland
Drainage and bank stabilisation	No tree cover	Potential for bare earth post-felling Birch has a light canopy so potential for good understorey / regeneration	Good stabilisation from mature trees Low light levels on forest floor may result in single canopy layer

Habitat

Highway verges have been cited as areas of valuable habitat for a range of heathland / scrubland species (Bellamy et al. 2001). They are of particular value as they are rarely disturbed, and are not frequented by pedestrians (and their dogs). While this value is recognised, tree cover does exist on a substantial quantity of the study area and this is of variable quality. High forest is usually less biodiverse than multi aged woodland edge type habitat, and this habitat type is more commonly associated with ungulate populations (primarily deer) which can cause a hazard to traffic.

The key variables assessed from this factor are: diversity (more diverse habitat assumed to be more valuable) and the level of cover provided for large mammals (impacting on road safety)

[2] Based on median gas usage of 16.5 MWh of gas used per property annually (OFGEM 2011) NB this is likely to include gas cookers and as such may be a little high.

	open ground / scrub	Short Rotation Forestry	high / semi-mature woodland
Habitat	Undisturbed scrubland habitat Low / light cover	Peri-woodland habitat Light cover - similar to scrubland	Heavy shade results in lower biodiversity Greater cover for deer populations

Increased protection from road accidents

Trees provide a resilient physical barrier to impacts from vehicles that have left the carriageway. Where barriers are not in place or no embankment exists, it seems reasonable to assume that some form of living barrier would improve safety. In this case, ability to stop a moving vehicle is assumed to be proportional to stem diameter or planting density (which when combined become basal area [$m^2.ha^{-1}$] - a common forestry statistic). It is likely that many smaller stems are generally preferable to a few large ones as these will reduce the speed of any vehicle over a larger distance resulting in less damage and injury (though a minimum thickness will obviously apply before they become useful).

The key variable for this factor is the effectiveness of the site flora as a physical barrier, and its relative density (hard or soft)

	open ground / scrub	Short Rotation Forestry	high / semi-mature woodland
Increased protection from road accidents	No barrier	Many smaller stems: soft barrier (though this will vary throughout the rotation.)	Fewer larger stems: hard barrier

Noise abatement

“Greenspace has the ability to mitigate noise in urban areas. Planting "noise buffers" composed of trees and shrubs can reduce noise by five to ten decibels for every 30m width of woodland, especially sharp tones, and this reduces noise to the human ear by approximately 50%. To achieve this effect, the species and the planting design must be chosen carefully.” (FR 2016)

While the size of most verge areas are dictated by constraints other than their noise abatement properties, woodland or tree cover does appear to provide a more effective barrier to sound than other land uses. The effectiveness of such a screen will depend on the height and density of the canopy, the existence of gaps - either due to felling or decreased understorey cover, and the species composition: evergreen species will provide year-round cover while deciduous species will not. Obviously to screen effectively, foliage must be higher than the level of the carriageway - banks sloping down, away from the road will be at a comparative disadvantage.

	open ground / scrub	Short Rotation Forestry	high / semi-mature woodland
Noise abatement	No barrier	Depends heavily on topography, planting density and species composition	

Overhanging branches / dangerous trees

This is only typically a problem in high forest sites. Sites without trees, or sites where the trees are felled pre-mature are unlikely to be affected. It is also worth noting that birch in particular does not form heavy side branches and is unlikely to pose a risk.

	open ground / scrub	Short Rotation Forestry	high / semi-mature woodland
Overhanging branches / dangerous trees	None	None	Possible (if not likely)

Pollution abatement

Traffic using main roads emits a number of pollutants such as nitrogen/oxygen compounds (NO_x) sulphur/oxygen compounds (SO_x) ozone (O_3) and a range of particulates (typically categorised as pm_{10} and $pm_{2.5}$). UK roads are gritted during the winter months and this increases the salinity of surrounding soils, both directly from the gritting operation, and also from spray drift in wet weather. These elevated levels of pollutants pose a challenge to any planted crop, however tree planting is an effective way of capturing and temporarily immobilising pollutants (Xu 2008) rather than allowing drift onto adjacent land.

	open ground / scrub	Short Rotation Forestry	high / semi-mature woodland
Pollution abatement	No barrier	Good barrier from early/mid rotation	Potentially a good barrier, but depends on aerodynamics (see FC 2006)

Visual barriers

Trees provide an attractive visual barrier to motorists using the road (guarding against distractions) as well as screening the road from adjacent areas. Obviously coniferous / evergreen species will provide a more consistent barrier during the year, but even relatively narrow plantings of deciduous trees can provide a barrier which changes throughout the year. Broadleaved species have been commonly used to screen coniferous forestry blocks within the UK forestry industry since the 60s (Hodge 1995).

	open ground / scrub	Short Rotation Forestry	high / semi-mature woodland
Visual barriers	No barrier	Good barrier from early/mid rotation	Good barrier, assuming understorey is intact.

Windbreaks

The use of trees to provide areas sheltered from the wind stretches back to antiquity. The degree of shelter is variable, depending on the height of the trees in question, the "porosity" of the barrier, and the number of openings. The type of shelter provided by different species tends to vary - throughout the year in the case of broadleaved species. SRF planting will typically provide a low to medium density windbreak, and be completely absent for a period of time after felling. This is in contrast to high forest which will (depending on species) provide a medium to high density barrier. Typically, higher density barriers have a greater effect over a smaller area, but gaps will tend to concentrate wind speed depending on the density of the rest of the planting (FC 2006). High sided vehicles will benefit from reduced wind speeds on the carriageway, and this kind of barrier will tend to trap litter and other light debris in the verge area. Routine management of this area also presents an opportunity for a comprehensive litter picking exercise at the same time.

	open ground / scrub	Short Rotation Forestry	high / semi-mature woodland
Windbreaks	No barrier	Medium density windbreak, but may cause funnelling in felled areas	High density windbreak but may cause turbulence around edges

Summary

Results were scored (0 Red, 1 Yellow, and 2 Green) and totalled based on different land uses as shown below.

	OG[3]	SRF	LRF
Drainage and bank stabilisation	0	1	2
Habitat	2	2	1
Increased protection from road accidents	0	2	1
Noise abatement	0	1	1
Overhanging branches / dangerous trees	2	2	1
Pollution abatement	0	2	2
Visual barriers	0	2	2
Windbreaks	0	1	1
Total	4	13	11

The scores of tree-dominated land uses were broadly comparable, and both were substantially greater than those of open ground. While further detailed research is needed, at first glance, it appears that SRF is a viable alternative use for verge planting, in terms of land use functionality.

[3] Open Ground, Short Rotation Forestry and Long Rotation Forestry

Conclusions

Based on the assumptions in this initial calculation, there appears to be a business case for examining roadside land use and whether it can be modified to provide a sustainable energy source. Uncertainties do exist, specifically:

- Species suitability – is *betula pendula* the most suitable on all sites, or would other species be more productive? Can we estimate productivity more accurately?
- Management prescription – is SRF the best option, or would coppice based or longer rotational forestry schemes work better?
- Are the relative merits of different land uses as detailed in section 2 justified and can they be quantified?
- Is firewood the best use for this material? What effect would this have on air quality if used in log stoves, and would it be more cost effective and sustainable to look at production of other biomass fuel types (i.e. hog fuel / chip / pellets)? How would this affect the economics?
- Is data available on processing and transportation costs, and if not how can this be obtained?
- How would the forestry regulatory body (FC) view this kind of development? Would this planting be eligible for grant schemes, and to what degree would it be necessary to apply for felling licences? How would this differ in England Scotland and Wales?

It is strongly recommended that further research be conducted to determine the answers to these questions and inform policy decisions about whether field scale trials and eventual widespread rollout are justified.

References

BEC 2016. *Typical calorific values of fuels*. Online, accessed 2/2016. Available from: www.biomassenergycentre.org.uk/portal/page?_pageid=75,20041&_dad=portal&_schema=PORTAL

BEC 2016b. *Carbon emissions of different fuels*. Online, accessed 2/2016. Available from: www.biomassenergycentre.org.uk/portal/page?_pageid=75,163182&_dad=portal&_schema=PORTAL

Bellamy, P. E., Shore, R. F., Ardeshir, D., Treweek, J. R. and Sparks, T. H. (2000), Road verges as habitat for small mammals in Britain. *Mammal Review*, 30: 131–139. doi: 10.1046/j.1365-2907.2000.00061.x

FC 2006. *The Principles of Using Woods for Shelter*. Online, accessed 2/2016. Available from: http://forestry.gov.uk/pdf/fcin081.pdf/$FILE/fcin081.pdf

FC 2011. *Tree Species A document listing the tree species included in the 2011 Production Forecast*. Online, accessed 2/2016. Available from: www.forestry.gov.uk/pdf/PF2011_Tree_Species.pdf/$FILE/PF2011_Tree_Species.pdf

FC 2011b. *English Woodland Grant Scheme Operations Note 9 (standard costs)* Online, accessed 2/2016. Available from: www.forestry.gov.uk/pdf/ewgs-on009-standard-costs.pdf/$FILE/ewgs-on009-standard-costs.pdf

FR 2007. *The Potential for Direct Seeding of Birch on Restock Sites*. Forest Research Information Note. Online, accessed 2/2016. Available from: www.forestry.gov.uk/pdf/FCIN084.pdf/$FILE/FCIN084.pdf

FR 2016. *Benefits of greenspace: Noise abatement*. Online, accessed 2/2016. Available from: www.forestry.gov.uk/fr/infd-8aefl5

Hall, Graham; Cratchley, Roger (2005) : The role of forestry in flood management in a Welsh upland catchment, *45th Congress of the European Regional Science Association: "Land Use and Water Management in a Sustainable Network Society",* 23-27 August 2005, (https://www.econstor.eu/dspace/bitstream/10419/117443/1/ERSA2005_105.pdf)

Hibberd B.G, ed. 1989. Forestry Commission Handbook 5: Urban Forestry Practice. TSO London.

Hodge, S. ed. 1995 Handbook 11: Creating and managing woodlands around towns. TSO London

Hynynen, J. *et al*. 2008. Silviculture of birch (Betula pendula Roth and Betula pubescens Ehrh.) in northern Europe. *Forestry* (**83**)1 pp103-119. Online, accessed 2/2016. Available from: http://forestry.oxfordjournals.org/content/83/1/103.full

NEP 2016*. Energy Cost Comparison*. Online, accessed 2/2016. Available from: http://www.nottenergy.com/energy_cost_comparison/energy_comparison_data/january_2016

OFGEM 2011. *Typical domestic energy consumption figures (factsheet 96)* Online, accessed 2/2016. Available from www.ofgem.gov.uk/sites/default/files/docs/2011/01/domestic-energy-consump-fig-fs_1.pdf

ONS 2014. *Road Lengths in Great Britain 2014*. Online, accessed 02/2016. Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/428857/road-lengths-in-great-britain-2014.pdf

Phyllis2, database for biomass and waste https://www.ecn.nl/phyllis2 Energy research Centre of the Netherlands

Xu, Y. 2008 *Modelling the effects of roadside trees, results and conclusions*. Report for the London Borough of Harrow. AEA, Harwell, Oxon.

