The Role and Benefits of Shelterbelts on Farms

A vision for the adoption of 'Optimal Shelterbelts'

John Davis, **Dr Lindsay Whistance** and **David Lewis** introduce an initiative aiming to revitalise the planting of shelterbelts on farms.

Shelterbelts have the scope to deliver multiple benefits, both for the farmer as well as for the 'public good' and have been used for hundreds of years for shelter and windbreaks protecting both crops and livestock from the wind. Other agricultural benefits also include improved animal welfare, helping to prevent soil erosion or water loss and to shelter buildings and people. Studies have indicated increases in productivity of both crops and animals, and wider landscape benefits such as flood alleviation and enhancing of the biodiversity.

Over the last 20 years it seems that very few new shelterbelts have been planted on farms. John Davis, forester, woodland owner and owner of tree-shop.co.uk, hopes to change that. He is promoting a particular design of shelterbelt, which he calls the Optimal Shelterbelt (OSB), which will deliver 50% porosity and creates a significant increase in warmth and humidity in the microclimate created within the sheltered area. John believes that this has the potential to optimise productivity gains, minimising the loss of agricultural land, compared to wider shelterwoods.

It is, however, important to be able to evidence and demonstrate these benefits if OSBs are to be widely adopted by landowners. So a project has been set up to establish a number of OSBs and to measure the resulting increases in both farm productivity and biodiversity. To date, 20 such OSBs have been established in the Cotswolds, with 11 landowners, totalling 6.54km in the planting seasons of 2020/21 and 2021/22. This project is a private initiative facilitated by FWAG-SouthWest,

Background

There are many types of shelterbelts, and a range of definitions of what constitutes a shelterbelt (e.g. Brandle et al., 2009). Common in all definitions is that they act provide protection from the wind. Shelterbelts can therefore include hedgerows of varying designs, single rows of trees or shrubs, several rows of trees and shrubs combined and strips of woodland (sometimes referred to as shelterwoods) which may be greater than 20m width. Many different factors influence the design of a shelterbelt, including local site characteristics, statutory designations, environmental drivers and constraints, owners' objectives, and tradition. These will dictate choice of species and planting density and layout, as well as the subsequent management operations.

There is currently no recognised classification of shelterbelts, or reliable and universally applicable parameters. It is therefore difficult to quantify the benefits they can provide and comparison between different styles of shelterbelt is challenging (e.g. Caborn, 1957; Nelmes, 1999).

Anecdotally, however, shelterbelts are an excellent way for farmers and landowners to start their journey into

Figure 1. A shelterbelt with a sloping profile. (Photo: J. Davis).

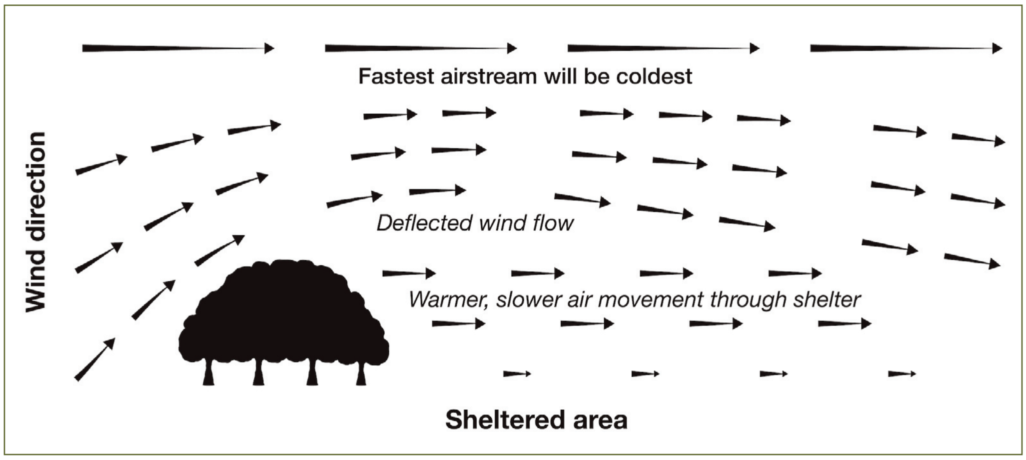

Figure 2. Wind flow and shelter created by a shelterbelt. (Image: J. Davis).

planting trees on farms. Like any wood creation scheme, shelterbelts have the scope to deliver multiple benefits. For example, they have been used for hundreds of years to shelter both crops and livestock from the wind. Exmoor's treed hedgerows – mostly beech on top of a bank – are only one example (devonhedges.org, 2015). Other agricultural benefits include helping to prevent soil erosion, as in East Anglia, or for water loss and sheltering buildings and people (e.g. Řeháček et al., 2017; Dollinger and Jose, 2018). They can capture gaseous emissions, such as ammonia, from intensive and extensive animal systems (Bealey et al., 2014). They can also provide flood alleviation (Lunka and Patil, 2016) and enhancement of biodiversity and the overall landscape (e.g. Wolton et al., 2013; Amy et al., 2015; Lecq et al., 2017; Sollen-Norrlin et al., 2020).

Despite their various benefits, it is thought that very few new shelterbelts have been planted on farms over the last 20 years. There are a number of reasons for that, in particular, lack of grant funding and of research data to evidence the benefits that shelterbelts can offer. It is currently not possible to quantify the number of shelterbelts existing in the UK as there is no official definition of what constitutes a shelterbelt, and areas of land planted as shelterbelts may have other purposes than just providing protection from the wind. Areas of woodland that do not benefit from grant funding tend not to be recorded in the government's reported statistics. It seems likely that most shelterbelts will not have qualified for grant funding in the past as they were probably narrower than 20m. Lack of data means that these are educated guesses.

The extent and type of the benefits that shelterbelts can provide will, of course, depend on their siting, size and design. This is particularly important when it comes to trying to optimise the reduction of the wind speed. For each shelterbelt, the specific combination of its density, height and leaf distribution and thickness, will influence the reduction in wind speed and turbulence and in turn its shelter performance. The siting, size and width, the choice of species, and their planting density, all influence these characteristics and in turn the effectiveness of the shelterbelt to provide protection from the wind.

The interaction of a shelterbelt with the wind is complex, as is trying to quantify the effectiveness of a shelterbelt. Research effort has included field measurements, wind tunnel modelling, and measuring the optical porosity of the shelterbelt. (Caborn, 1957; Nelmes, 1999). Whilst to date, none of these research approaches have fully answered this challenging engineering problem, they have enabled a set of design criteria to be developed to help with the establishment of effective shelterbelts. Using these criteria, John Davis, a forester, tree nurseryman and woodland owner has been promoting the 'Optimal Shelterbelt', based on research that was commissioned in conjunction with Oxford University 25 years ago. These shelterbelts are 5m wide and densely planted at the equivalent of 6,500 trees and shrubs/ha and designed to achieve a sloping profile (see Figure 1) to minimise turbulence. The design principles of a shelterbelt and its influence on the wind are shown in Figure 2, built on traditional knowledge and tested principles of porosity, height and turbulence.

> "Very few new shelterbelts have been planted on farms over the last 20 years."

The OSB design (Figure 3) has the scope to provide productivity gains with the added benefit of minimal loss of agricultural land; and siting these shelterbelts by existing hedges can further increase their appeal, by utilising existing field layouts.

The project team to help make this vision a reality includes Lindsay Whistance and colleagues from The Organic Research Centre (ORC), David Lewis from the Royal Agricultural University and Maisie Jepson, Jenny

Figure 3. Field boundary and a windy site for improving yields. (Photo: B Goldstone)

Phelps MBE, Sarah Wells from FWAG SouthWest, Bryan Goldstone, plantsman and forestry contractor, and the 11 landowners, with John Davis coordinating. In addition, the project team have been able to secure funding and support from a range of public, charitable and private organisations and landowners.

The regulatory position

Current government funding through Countryside Stewardship funds hedgerow improvement up to 1.5m width; and the current woodland grant scheme in England, the English Woodland Creation Offer (EWCO), only funds shelterwoods that are a minimum of 10m width and 1ha in total. Prior to the introduction of the EWCO the minimum width required was 20m so EWCO can be considered as a step in the right direction.

There is further room for optimism with the expected introduction of Defra's new Environmental Land Management Schemes (to be called ELMS), and the likelihood that all types of tree planting on farms, including individual trees, hedgerows and small strips of woodland to more formal agroforestry planting schemes will be eligible for grant funding. Furthermore, with the removal of the Basic Payment Scheme there are no longer any financial penalties for exceeding 1.5m in width.

To date, the funding for this OSB demonstration project has relied on 'blended finance', generously provided by the Cotswold AONB, by the Great Western Community Forest, by the Environment Agency, and by Protect Earth, an environmental tree planting charity, by the Woodland Trust and the Dulverton Trust.

Benefitting crop and livestock productivity and welfare

It is obvious that a natural greenhouse effect, such as a designed shelterbelt, will benefit crops within the sheltered area. Although there is a complex and dynamic relationship between shelter and crop responses, global literature reviews indicate improved yields with shelter (e.g. Nuberg, 1998).

Livestock, such as sheep, cattle and horses can also benefit in terms of better welfare. A key component of sheep farming profitability is lamb mortality and ewe rejection, both of which can benefit from appropriate available shelter (e.g. Gregory, 1995), and this is one reason why much lambing nowadays is preferred within indoor shelters – a costly alternative to in-field shelter.

For healthy beef cattle with a dry winter coat, their lower critical temperature (LCT) is around 0°C (depending on body condition) but for a wet animal it can rise to 15.5°C with cold winds further reducing effective temperatures. The rule of thumb for wet animals is that 2% more food is required to maintain body weight for every 1°C below LCT, and so animals exposed to cold, wind and rain without shelter can require substantially more feed to maintain core body temperature – risking both a poor welfare and a resource inefficient system. (Morgan et al., 2011; Rusche and Walker, 2021).

Benefitting biodiversity

Modern farming represents varying degrees of monoculture as each rotation attempts to maximise annual crop production. This will require differing amounts of soil disturbance, chemicals, fertilizers and pesticides, while the boundary hedgerows represent those areas of beneficial 'non-disturbance' of soils. Widening field boundaries to 5m, and planting carefully selected tree species for both shelter and biodiversity purposes, supports and improves the provision of the habitats offered by the existing hedgerow network, such as it is. Wildlife corridors are becoming the theme of many national biodiversity strategies. Hedgerow shelterbelts can become one of the essential facilitators. There is also emerging advice that for hedgerows to optimise biodiversity, they need to be allowed to grow 10-20m into the field. The main focus of the OSB initiative is on balancing productivity and environmental benefits with land removed from food production.

The design of an OSB

The OSBs currently being tested are composed of 4 rows of trees at 3.25 trees per linear metre. Eighteen different species are used for each OSB: 6 tall trees (Scots pine, grey alder, common alder, aspen, black poplar, hornbeam); 6 intermediate trees (field maple, silver birch, bird cherry, goat willow, rowan, crab apple); 6 shrubs (hawthorn, buckthorn, alder buckthorn, hazel, spindle berry, guelder rose). These species were chosen for a number of reasons. First, all were well suited to the site conditions. Second, they will support a lot of biodiversity and are compatible with local landscape and the preferences and requirements of Cotswold National Landscape, formerly Cotswold AONB. Third, the species were chosen for their leaf distribution and density to achieve the desired porosity.

The trees are planted in groups of 3 between 2 rows and 5 shrubs of a species between 2 rows, consistent to provide visual uniformity and optimum porosity and to mimic the clustering of species in naturally occurring mosaics. The outer 2 rows facing the prevailing wind are composed of shrub and intermediate species and are spaced at 1m apart and 1.5m between the rows. The remaining 2 rows are the tall trees and are spaced at 2m and 1.5m between the rows. The species and planting layout are the same on all the OSBs, supporting performance analysis across sites. The design principle of the OSB is shown in Figure 4. This spatial design is not novel and was taught for many years by the Oxford Forestry Institute from many years of practical experience developing shelterbelts across the Commonwealth, particularly in India and Africa.

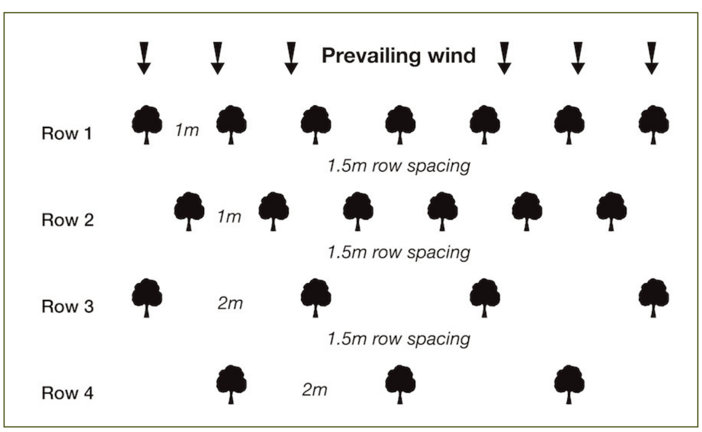

Figure 4. Design and planting layout of the OSB. (Image: J. Davis).

Ten-year project measuring outcomes

The effects on agricultural productivity, biodiversity and natural capital will be measured on all the 20 sites using agreed scientific protocols, which are in development. It is hoped that the results, quantifying any changes attributable to the presence of the OSB, will be of great interest to landowners and many categories of professionals. There will also be scope for assessments of flora, fauna, and etymological, soil carbon and mycorrhizal activity. The availability of grants and other financial support will also be considered together with their impact on the financial viability, which will be calculated – this is a key consideration for many landowners, as is the case for most investments that they make.

The project team aim to provide regular peer reviewed articles and publicity. They will start measuring microclimate effect within five years of planting although meaningful increases will probably occur within 10-20 years, depending on the site. The team will be developing methods for measuring porosity and reporting any correlation between porosity and outcomes. This may lead to comparative analysis between different regional approaches and observed outcomes.

Costs and lessons learnt so far

Twenty OSBs have been planted totalling 6.54 km and 20,232 trees on sites provided by the 11 landowners, who were all interested in having and in proving the shelter principles on their farms. The total cost to date is £159,521. This equates to an average cost per linear metre of £24.40, and of £7.89 per tree, excluding VAT, but includes all maintenance / beating up to date. Various systems of protection and weed control were adopted with considerable difference in costs for each prescription. Participating landowners vary from organic to conventional, which gave experience with differing regime requirements, and with systems requiring more or less maintenance and beating up.

After the first season, the project team realised that they had significantly underestimated the amount of hare and deer predation in the Cotswolds, particularly with the loss of stalking during Covid lockdown. They also learned that the working hours pressure upon the landowners is much greater in current circumstances than was anticipated, e.g. one tenant farmer farming 1,000 acres of Cotswold brash barely has time to get off the tractor, let alone weed and care for additional trees. Therefore, the project team took over all the landowner's responsibility for beating up and maintenance. They believe from this experience that professional maintenance to establishment is the sensible way of delivering maximum growth, and least losses, in the shortest time.

"Professional maintenance to establishment is the sensible way of delivering maximum growth, and least losses."

The planting prescriptions included: 2 OSBs with deer /rabbit fencing and Ecotex biodegradable matting; 1 OSB with deer /rabbit fencing and spraying; 10 OSBs with 1.2m guards and biodegradable matting; 5 OSBs with spiral guards and spraying; 1 OSB with spiral guards and woodchip (100% organic); 1 OSB with 1.5m guards, biodegradable tree mats, and woodchip.

Selecting the optimum weed control and protection against animal pests is a learning curve for the project. Of the prescriptions tested, the project team's recommendation now is 1.2m biodegradable guards and biodegradable matting, using the same species and planting layout as originally planned. If possible, and wherever there is heavy deer pressure, the project team would now recommend deer fencing.

If there is brash and tree removal requirement, chipping is recommended and the woodchip becomes a very effective additional cover if used on top of tree mats. But woodchip alone did not provide an effective way to supress weed growth. On one farm several hundred tonnes of woodchip alone with spiral guards were used but with no matting and this proved to be ineffective, and weeds grew through varying depths of woodchip applied. Beating up has been 10% overall, but a great deal more on some of the lower-guarded specifications, and the 2022 drought has caused further losses. The project team now beat up with 1.2m guards throughout. Some of the different types of tree shelters and matting are shown in Figure 6.

With a sensitivity towards existing structures, two of the OSBs were planted against well-developed hedges. For these OSBs, there were only three rows of trees as the existing hedge was adequate to remain as the fourth row.

Figure 5. Not much of a hedge to start (left); existing field boundary (right). (Photo: M. Jepson)

Figure 6. Various tree shelters and weed matting used as tree protection. (Photos: M. Jepson)

Planting in or against an existing hedgerow is less straightforward than traditional tree planting on farmland. From these experiences the project team are developing reasonable time planting standards and guarding parameters, which will be published in due course.

Siting for optimum microclimate effect

Site selection is done with the landowner to optimise position and value. The minimum length is 100m, below which the eddy effect at the ends negatively impacts on gains. The microclimate created for sheltering effect can extend to 20 times the height of the tall trees, so that a 10m tall OSB with a porous sloping profile should create acceptable shelter for 200m in its lee.

Shading will be one consideration. Existing shelterwoods can create excessive shading, which may diminish crop yields at the field edges, although shelter gains can benefit the crops further into the field, compensating for field edge losses. OSBs function more like a tall hedge, and will be sited to influence the prevailing wind. Since in most parts of England and Wales, the prevailing wind is westerly, a North/South planting can usually be found among existing hedgerows and so reduces potential shading issues. The data and experiences of establishing OSBs will be used to develop guidelines for best practice.

Conclusions and government targets towards net zero

No one knows the exact total length of UK hedgerows. One estimate is 236,000 miles (380,000km) in 1993 (PTES, no date, a). There are thought to have been 500,000 miles (805,000km) in 1946, but there has been massive hedge removal in the last 50 years as farmers sought to bring their smaller fields and holdings up to economic size units (PTES, no date, b). Although the remaining hedgerow mosaic is still a very valuable resource of biodiversity, much of it is in a degraded state and awaiting improvement. By way of hypothetical illustration, if all 106,000 farm holdings in England planted one OSB (an average OSB is $500m^2$), this would lead to 176 million more trees being planted. This represents one third of the government's woodland creation target for England and would offer a reasonable and achievable method of repopulating the landscape, in a popular way for the landowning community.

Next steps

We would welcome *QJF* readers becoming more involved. Shelterbelts could become a mainstream consideration for woodland creation offering increased farming productivity and biodiversity. Until now, grant funding for all types of shelterbelts below 10m width falls outside grant funding rules.

Further advice can be given to John Davis (07714284312 / john@treeshop.co.uk). Your knowledge and contacts can help move the project forwards, and with your consent, may be used in discussions with policymakers.

Acknowledgements

We would like to thank Maisie Jepson, Sarah Wells, and Jenny Phelps MBE, and the FWAG SouthWest team for adopting this project, for securing funding and for supporting throughout, with many difficult stages of application and detail. This project would not have happened without the earlier support of the Departments / Schools of Engineering and of Plant Sciences (at that time the Oxford Forestry Institute) of Oxford University, and to Dr Colin Wood, Dr Sarah Nelmes and Mr Frank Thompson in particular, who carried out both the wind tunnel and the field trials between 1995/97, and whose findings and corroboration have finally brought this work to practical fruition and utility. The project team are grateful to the Dulverton Trust for start-up funds to enable the development of testing protocols and purchase of field equipment.

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