- *The future of cutaway peatlands will be a mosaic of wetland, grassland, naturally colonised areas and forestry. Where forestry is recommended, it will be within an integrated landscape.*
- *Drainage is a prerequisite to afforest brown peat fields straight out of production, but the need to aerate the peat is also crucial for the successful establishment of a crop of trees.*
- *Many species have been found to survive and establish well on certain types of cutaway peatland, using adequate silvicultural practices.*
- *Shelter is required to promote the early growth of trees on cutaway peatlands and protect against severe late spring frosts, especially for Sitka spruce. Early growth of Norway spruce is also greatly improved under shelter. Pines show potential on the poorest and most exposed sites, with Corsican pine growing particularly well.*
- *Alder and birch grow well on cutaway peatland, creating an ideal shelter system, while improving the growing medium.*
- *Mowing and weed-wiping have given excellent control of competing vegetation.*

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Establishing a sustainable forest resource on industrial cutaway peatlands: tree performance and silvicultural techniques

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Background

The potential of cutaway peatlands for forestry has been recognised for many years, but the mixed performance of the first commercial plantations, established in the period 1988-92, highlighted the need for a research programme to study all aspects of the afforestation of cutaway peatlands. This led to the establishment of the BOGFOR project which has been supported over the years by Bord na Móna, COFORD, Coillte and the Forest Service.

The objective of the BOGFOR project is to establish a successful forest resource on milled cutaway peatlands in the midlands, and to present appropriate silvicultural guidelines to ensure optimum forest productivity compatible with environmental imperatives. The programme is multidisciplinary, investigating a range of issues such as cultivation techniques, species selection, stock types and vegetation control, as well as hydrological conditions and edaphic and climatic limitations. Through the planting and monitoring of over 200 ha of cutaway peatland forests, established on representative sites throughout the midlands, experience and valuable information are being collected on the best approaches to the afforestation of cutaway peatlands. Initial results have been reviewed by Renou and Farrell (2005).

Industrial cutaway peatlands

Environmental conditions on cutaway bogs are unique. While these sites were previously thought to be relatively uniform and easy to afforest, we have, as a result of the research, come to understand their complexity and to realise that afforestation techniques which have proved successful on other peatlands may not be appropriate on these sites. Each cutaway peatland has unique properties which have implications for tree establishment and growth. Peat depth and peat

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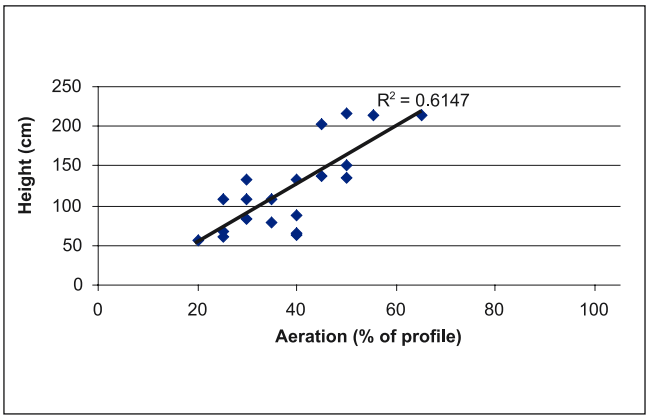
type generally vary, together with a gradient of hydrological conditions.

Site characteristics

Drainage is a prerequisite but research has shown that it is crucial that the peat medium into which the trees are planted is aerated (Graph 1). This is more likely to be the case on peats less than 1 m deep, sloping ground and where the surface is covered by woody pioneering vegetation such as birch or willow. This can also be achieved artificially using site preparation techniques such as bedding or deep ploughing.



Graph 1: The effect of aeration on height of four-year-old Norway spruce.

Photo 1: Late spring frost damage to 4-year-old Sitka spruce, Tumduff, May 2005.

Photo 2: Five-year-old Sitka spruce growing well under naturally established birch, Tumduff, May 2005.

Species suitability and performance

Many species have been found to survive and establish well on certain types of cutaway peatlands, using appropriate silvicultural techniques. These species will grow if shelter, peat aeration and nutrition are adequate.

Sitka spruce

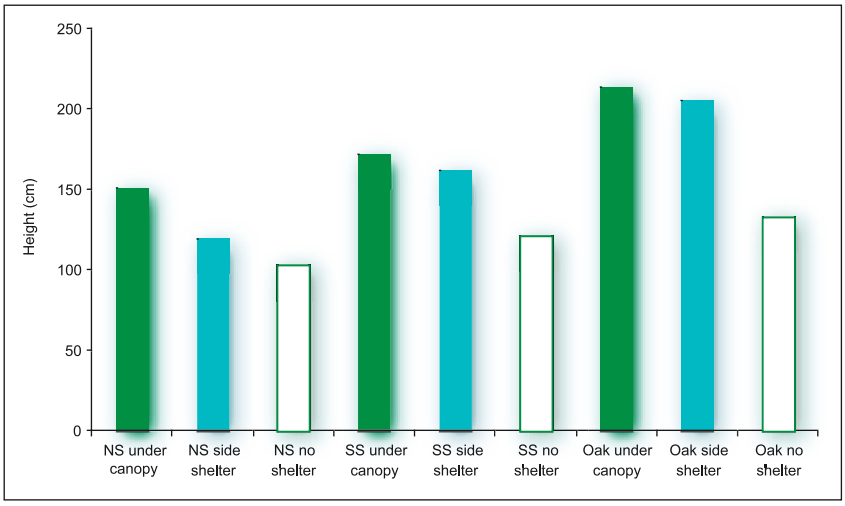
Most cutaway peatlands are located in the midlands and at lower elevations than their surroundings and are therefore subject to late spring frosts. Sitka spruce (*Picea sitchensis* Bong. Carr.) is very sensitive to frost (Photo 1); it is not therefore recommended for planting on these sites unless underplanted in alder or birch stands. Where Sitka spruce has been planted under shelter or on sites where no severe late spring frosts have been recorded, its growth rate has been the most promising of all species. After five growing seasons, average heights ranged from 150 to 200 cm (Photo 2). Yield classes of 22 m^3 ha^{-1} yr^{-1} and greater are possible, based on performance of young plantations.

Norway spruce

While Norway spruce (*Picea abies* L. Karst.) grows more slowly than Sitka spruce, it is less sensitive to frost and has been successfully established on some cutaway peatlands (Photo 3). Average heights after five growing seasons ranged from 100 to 150 cm, and estimated yield class from 14 to 18 m^3 ha^{-1} yr^{-1}. Like Sitka spruce, its growth is greatly improved when underplanted among shelter trees (Graph 2).

Pedunculate oak

Shelter is even more critical for oak which suffers from leader die back when planted on exposed cutaways (Graph 2). Pedunculate oak (*Quercus robur* L.) has, however, shown superb growth and form when planted under a naturally colonised birch area with average heights ranging from 180 to



Graph 2: Height after five growing seasons of Norway spruce (NS), Sitka spruce (SS) and pedunculate oak growing under different levels of shelter at Tumduff.

Photo 3: Five-year-old Norway spruce demonstration area, Blackwater.

Photo 4: Four-year-old pedunculate oak under naturally established birch, Tumduff.

250 cm after five growing seasons with several specimens having reached 400 cm (Graph 2 and Photo 4).

Pines

Pines have also been established successfully, particularly on the most acidic and nutrient poor peat. Good results have been achieved with most pine species. Outperforming them all, Corsican pine (*Pinus nigra maritima*) is growing extremely well on all cutaway sites, with heights ranging from 80 to 200 cm after four growing seasons. Its form is excellent (Photo 5) and it appears to be less prone to pine shoot moth (*Ryaciona buoliana*) than other pines. Being less sensitive to frost than spruce, pines, especially Scots pine (*Pinus sylvestris* L.), have a role to play in the afforestation of cutaway peatlands, either commercially or for biodiversity provision (Photo 6).

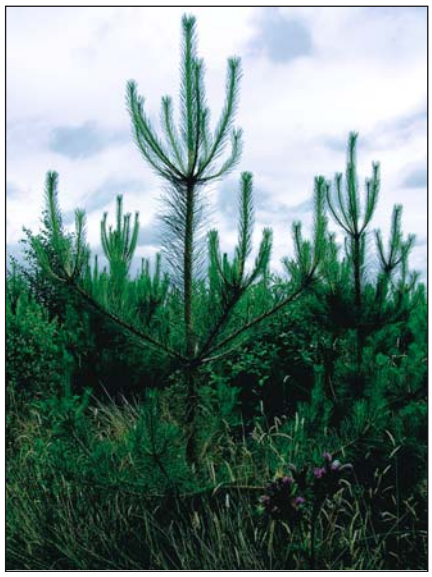


Photo 5: Five-year-old Corsican pine on oligotrophic (nutrient poor) acidic cutaway peatland.

Photo 6: Nine-year-old Scots pine, Tumduff.

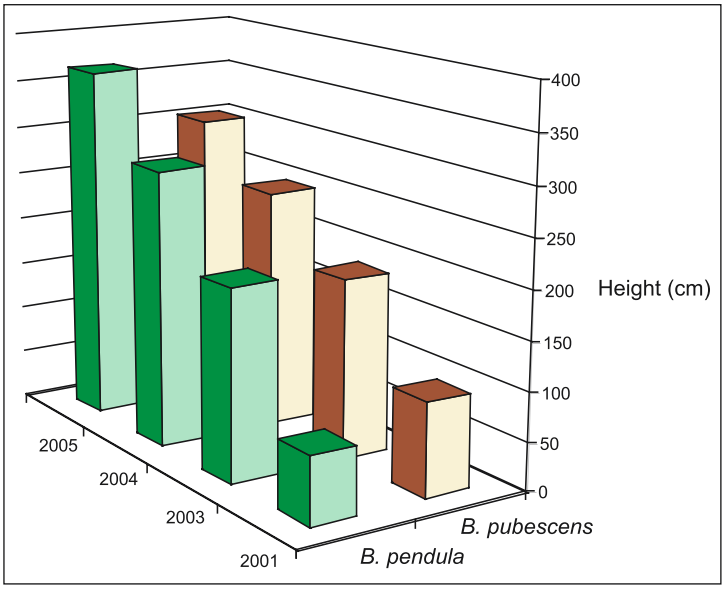
Photo 7: Nine-year-old alder (*Alnus glutinosa*), Tumduff.

Native pioneering species: alder and birch

The other promising species are alder and birch, with average heights after four growing seasons of 330 and 350 cm respectively. Common alder (*Alnus glutinosa*), downy birch (*Betula pubescens*) and silver birch (*Betula pendula*) are pioneer indigenous species that grow well on these sites and enable quick establishment of forest conditions.

Alder is a fast growing tree species on cutaway, creating an ideal shelter system, while improving the growing medium and reducing late spring frost damage. It also shows potential as a biomass crop (Photo 7). Growth and survival rates of both downy and silver birch have been

Photo 8: Four-year-old downy birch, Blackwater.



Graph 3: Mean height of *B. pendula* and *B. pubescens* from twenty four plots over five growing seasons.

excellent, provided that vegetation competition and browsing are taken care of. The height and diameter growth of *Betula pendula* has been greater than *Betula pubescens* (Graph 3 and Photo 8) and it also appears to be less at risk of losing its apical dominance as it grows taller (Renou and Farrell in prep.).

The need for shelter to promote the early growth of trees on cutaway peatlands is undeniable. Planting alder and birch in advance of a crop more sensitive to frost or exposure such as Sitka spruce, Norway spruce or oak seems the most appropriate silvicultural practice.

In some cases cutaways are naturally colonised by birch woodland which can also be used in this way. Equipment to carry out ‘strip’ cleaning within such woodland has recently been examined.

Other species

Ash (*Fraxinus excelsior*), beech (*Fagus sylvatica* L.), sycamore (*Acer pseudoplatanus*) and yew (*Taxus baccata*) have not performed well across a range of cutaway peatland types. Beech had particularly low survival rates (being especially susceptible to hare damage), while sycamore and ash performed poorly in general. Hybrid larch (*Larix* x *eurolepis*) and western red cedar (*Thuja plicata*) are two species which have performed erratically but sufficiently promising to justify further planting on dry sites.

Photo 9: Mower used to control vegetation on afforested cutaway peatland.

Fertilisation recommendation

Fertilisation at planting is a prerequisite on these soils as they are critically low in phosphorus. A split application of phosphatic fertiliser is the most effective for early growth. 175 kg ha^{-1} of rock phosphate should be applied in strips at planting and the same amount broadcasted after two years. Splitting the application also reduces the risk of phosphorus being leached by surface runoff (Renou et al. 2000). An application of 250 kg ha^{-1} of muriate of potash at the same time as the second phosphorus treatment is also beneficial. Re-fertilisation before canopy closure is necessary on very poor sites, where the nutrient content of the peat is very low (Renou and Farrell 2004).

Photo 10: The weed-wiper machine can be used to control vegetation on cutaway where mowing is not feasible.

Vegetation control

Neither residual nor foliar herbicides can be directly sprayed on these sites because the former are strongly adsorbed on organic matter and the latter should not be applied to wet foliage, when rain is imminent or when there is a danger of drift. In open, windy peatland areas, there are usually few days in the early growing season when ideal spraying conditions occur. Vegetation can be a severe problem following fertilisation, especially with rush (*Juncus effusus*) (McCorry and Renou 2003). Mowing and weed-wiping are two techniques which have given excellent results. In the context of reducing the use of herbicides in Irish forests, mowing has been the preferred method. A small, all-terrain vehicle (quad) is used to tow a purpose-built flail between the rows of trees (Photo 9). The best time for mowing is mid-summer when growth rates are highest. Weed-wiping can also be used where mowing is not feasible (e.g. when the vegetation is too tall). The machine consists of a carpeted roller wetted with a contact herbicide (e.g. glyphosate) by a manually-controlled pump (Photo 10). The vegetation is wiped twice, the second time in the opposite direction.

Conclusion

While further investigations are essential, the current assessment indicates that with appropriate drainage, site preparation and fertilisation, a sustainable forest crop can be established successfully on cutaway peatlands. Cutaway peatland sites are suited to a variety of species which can provide options for entering a range of markets in the future. The estimates of potential productivity suggested here are based on the performance of relatively young plantations. These can only be verified by continued monitoring of growth. Further research is imperative in order to obtain refined predictions of productivity, potential wood production and overall performance in relation to species and site.

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