Forestry Commission

Recycling Land for Forestry

Proceedings of the Forestry Commission and British Land Reclamation Society Conference

Edited by Andy J. Moffat

Technical Paper 22

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Edited by Andy J. Moffat

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Front cover: View across Maesgwyn opencast coal site, South Wales, restored to multi-purpose forestry. *(Andy Moffat)*

Back cover: Water feature surrounded by woodland at the restored Bramshill sand and gravel quarry, Hampshire. *(Andy Moffat)*

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Summary

This Technical Paper contains eight papers written by speakers at a conference held to discuss 'recycling disturbed land for forestry' in March 1996 at the University of Wolverhampton. While good technical advice exists to help those involved in promoting an increased post-reclamation forestry after-use, there are some real difficulties in the rapid increase in this land-use. The perception of conventional forestry is a stumbling block for some with a more ecological background. Planners, environmental agencies and parts of the minerals industry also remain reticent despite Government policy for a larger forestry cover and increasing support from forestry agencies, notably the Forestry Authority and Forest Research. The papers represent a valuable set of opinions, and a basis from which further energy in promoting a woodland cover on restored disturbed land can be expended.

Preface

At a time when Government policy is directed towards the expansion of woodland cover in the UK, especially around towns and cities, it is important to examine how such expansion can occur on a significant form of land in these areas – disturbed or 'man-made' land. Technical guidance for reclamation of this type of land to forestry was published by the Forestry Commission in 1986, and substantially revised in 1994. However, woodland has remained a poor relation to other after-uses such as agriculture and amenity. Representatives of the British Land Reclamation Society (REGRO) and the Forestry Commission met in 1995 to plan a joint conference which would focus on attitudes to the woodland after-use, mechanisms for its promotion, as well as technical aspects of woodland establishment. The conference was held at the University of Wolverhampton in March 1996, and was attended by over 100 people. The papers in this Technical Paper are the written contributions from all eight speakers at the conference. They reflect attitudes from the planning authorities, minerals industry, NGO ecologists as well as views from The Forestry Authority and Forest Research.

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Chapter 1

The place of trees in the reclamation of disturbed land

Nick Ward

Introduction

In 1995, the Hubble space telescope was used to generate an image showing around 1500 galaxies, most of which had never been seen before. This image covered a patch of sky the size of a grain of sand held at arm's length. The light received was so faint that the 'shutter' had to be kept open for 10 days, and all that time the telescope was focused precisely on the same spot.

The technology we have available to us in the late 1990s is staggering, and yet, for one reason or another, the relatively 'low-tech' process of establishing trees on disturbed land still produces too many failures for comfort. Probably the greatest single contributor is ignorance among practitioners, and yet great strides have been made in developing reliable techniques for vegetation establishment. Often these are based on straightforward basic principles, relating to ground conditions and the fundamental requirements for plant growth.

The penalty for failures extends far beyond the direct costs. So often, communities are blighted by dereliction, or the effects of mineral workings or waste disposal sites. In these cases, restoration of disturbed land is important and urgent. Wounds need to be healed; wounds that are both physical and psychological. Positive action must be seen to be taken to the extent that it is almost an end in itself. Successful regeneration of whole areas can depend upon the implementation of improvements to the local environment.

Trees versus forestry

The title of this paper refers to the place of trees in reclamation work, whereas the overall title of the conference is about recycling land to forestry. However, one cannot have forestry or woodland without trees, but one can have trees without forestry or woodland. The point is that trees can have a great many functions in land reclamation, be they *en masse*, in groups or single specimens. And one should always remember that forestry as an after-use for a site is just one out of a whole range of options, most of which will have some sort of role for trees. I shall return to the possible roles of trees later.

Types of disturbed land

In general terms, there are two categories of land to consider. One is disturbed because of some action, such as mineral extraction, construction activity, or waste disposal which disrupts the land and its use but where there is present an agency for restoration, i.e. the owner or the operator. The second category of land is classed as derelict, where there is usually no one immediately responsible for restoration, for example where an industrial user has closed down a site or has ceased trading. The definition of derelict land – used in Department of the Environment surveys – is 'land so damaged by industrial or other development that it is incapable of beneficial use without treatment' (Department of the Environment, 1993).

In the first category, restoration is regulated under the planning system. These days, permission for mineral working, or a licence for landfill, is only granted subject to stringent restoration conditions, which will often include tree planting and may require a forestry after-use to be implemented. However, it was not always the case and there are many sites which are being operated, or which have closed down, with very little or nothing in the way of provision for restoration. The Government has recently taken steps to improve on this situation, under the Planning and Compensation Act, 1991 and the Environment Act, 1995. This process of updating older planning permissions continues.

In the second category of land, where dereliction has arisen and there is no one with an obligation to deal with it, a more proactive approach is needed. Reclamation is then commonly carried out by the local authority, with central government grant aid, although it is occasionally tackled by the private sector. Reclamation to forestry is sometimes a possibility. Reclamation for an after-use which includes trees is common.

Tree planting in some form or other is equally relevant to both of the categories of disturbed land described above. Landfills are a special case. Until recently, tree planting on landfills was officially discouraged on the basis that trees could compromise the integrity of a sealing clay cap. Recent research (Dobson and Moffat, 1993) has indicated that it is indeed feasible to plant trees on a landfill site.

The feasibility of tree planting on mineral extraction sites, or on other derelict land, is often affected by what materials are present on the site. Phytotoxic conditions may exist due to extremes of pH or chemical contamination. Options may then include complete removal of the substrate, encapsulation or burying *in situ*, or some form of treatment or amelioration. The vital importance of suitable physical and chemical ground conditions has been hinted at already and I will emphasise this further.

Three key issues

In seeking to establish trees on disturbed land we should always consider three key issues. The first concerns *site conditions*, not only the physical and chemical characteristics, but also other factors such as pressures from grazing animals and people.

The second key issue is simply the *biological requirements of plants*. Some relate to universally applicable requirements for adequate rooting volume, nutrients and water supply, but others relate to species-specific requirements such as pH, light or shelter.

The third key issue is the need to define and work towards *clear objectives* in any reclamation scheme. Defining objectives narrows down the options and provides a framework for design decisions.

If all three of these key issues are properly and fully addressed, at the right stage, the main obstacles to successful tree establishment will be removed or avoided.

The multi-disciplinary approach

Land reclamation or restoration requires an input from a range of disciplines. Tree-related skills are only part of this range, but even so there can be a diversity of perspectives or approaches from within this subset. These differences, such as those between foresters and landscape architects, or horticulturalists and ecologists, to take two examples, are significant and can be valuable. They can also be a hindrance if the practitioners do not remain flexible, with a willingness to learn from others. As John Maynard Keynes said, 'It's not too difficult to have new ideas. It's much more difficult to get rid of old ones.'

The possible roles for trees

Most readers will be conversant with the 'normal' range of objectives referred to in multi-purpose forestry, namely:

- Timber production
- Wildlife conservation/habitat creation
- Landscape quality
- Recreation facilities.

Timber production is likely to be less prominent in the case of disturbed land because of its inherently lower productivity. Furthermore, when a local community has suffered the effects of mineral extraction, industrial closures or landfill for many years, and then finds a site restored with tree cover, there is a case for saying 'enough is enough' and not clearfelling the woodland for the economic gain of others.

The other three objectives listed above are likely to be more important. There are also other roles for trees or woodland in land reclamation, such as:

- A relatively cheap, undemanding and long-lasting vegetation cover giving a use for land which may be surplus to requirements.

- Providing a positive after-use, where there may be a lack of clear need for other more intensive uses, or where steep slopes or poor ground conditions preclude other uses.

- A slope stabiliser, through hydrological or mechanical effects.

- Providing shelter or a sense of enclosure.

- Re-integrating a despoiled site into the surrounding landscape.

- Enhancing the landscape of an area.

- Disguising unnatural landforms created as part of the reclamation scheme, perhaps through pressures to maximise level, developable land, or simply due to unimaginative design.

- A quick 'greening' of an area which may be of overriding importance in efforts to promote confidence and seek economic regeneration.

Approaches to the establishment of trees

The approach to establishing and managing trees on a site should vary according to ground conditions, the objectives of the scheme and the resources available. A range of approaches is possible and any may be valid, depending on the circumstances. One can think broadly of three approaches, namely:

- The *forestry approach ....*
  - driven by economics
  - a belief that to be justified it must be cheap
  - wide spacing, small plants, notch planting, possibly low inputs of ameliorants
  - acceptance of relatively slow results
  - long-term management relatively easy.

- The *landscape approach....*
  - not commercially viable
  - accepting that tree establishment is often only a small proportion of total reclamation costs
  - close spacing, higher inputs
  - more intervention needed in the long-term
  - quick results are often sought : pressures for rapid results can lead to greater use of larger plants.

- The *ecological approach ....*
  - a low-cost approach, working with nature rather than against it
  - relies on natural processes, such as natural regeneration and succession
  - low on inputs
  - uncertain results and perhaps slow
  - long-term intervention optional.

Whichever approach is adopted, and it could be a mixture of approaches within one site, the three key issues mentioned earlier must be properly addressed to secure success, i.e. ground conditions, biological requirements and clear objectives.

A final word

The reader of these conference papers is unlikely to need convincing that trees and sometimes forestry can have a place in the reclamation of disturbed land, but enthusiasm should be tempered with realism. It can be that tree planting, and certainly large scale forestry, is actually inappropriate for certain sites. It is not quite the universal panacea.

Thinking again of the superlative technology of the space age, let us all strive to learn from others, apply the research, consider the basic biological requirements of plants, and be seen to succeed. Too often in the past, money and reputations have been squandered through failed attempts to establish trees and forests on disturbed land, and yet the knowledge and technology is available to all.

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Chapter 2

The conversion of disturbed land to woodland : the planning perspective from Bedfordshire

John Niles

The extent of minerals and waste operations in Bedfordshire

Minerals extraction and waste disposal are important activities in Bedfordshire. Although there are no deep mines, many other minerals are dug from opencast quarries. In 1990, over five million tonnes of minerals were extracted in Bedfordshire and six million tonnes of waste deposited in the holes created; most of this was put in the holes formed during the digging of brickclay. Quarrying activities present a wide range of problems associated with the winning of minerals and subsequent land restoration.

Minerals

In 1961, approximately 3 million cubic metres of clay, yielding 1600 million bricks were produced. Today, the industry still uses 1 million tonnes of Oxford clay each year and has reserves of approximately 100 million tonnes. Stewartby Brickworks, reputedly the world's largest, has the capacity to make 375 million bricks per annum. Bedfordshire also provides sand and gravel for aggregates derived from river gravels. Sand dug from the Lower Greensand deposits is used for a variety of purposes including foundry work, glass making, horticulture and filtration. Sand and gravel extraction usually gives rise to wet pits, but sand extraction gives rise to dry pits and steep quarry faces. Each presents different problems and opportunities for restoration. In 1992, aggregate production amounted to 1.91 million tonnes and industrial sand to 0.2 million tonnes.

Chalk deposits are less extensive, being confined to the south of the county. However, one quarry is 173 ha in extent and 62 m at its deepest. Each year, one million tonnes of chalk are pumped as a slurry 120 km along a pipeline to two cement works in Warwickshire and a further 20 000 tonnes are used to produce agricultural lime. Fuller's Earth, a rare mineral, occurs only sporadically in Bedfordshire and permitted reserves will be exhausted in 8-10 years.

Waste disposal

The above activities have resulted in some of the largest holes and consequently some of the biggest landfill sites in Europe. At Brogborough, the original clay pit covered 185 ha and was dug to 20-25 m in depth. It is now almost full of refuse and the landfill gas is fed to a power station. Built in 1990, its four generators now feed 11.7 MW of electricity into the National Grid.

There is an obligation to reduce the amount of waste going to landfill, to develop clean technologies and improve disposal techniques. EU Member States are also required to become self-sufficient in disposal. This is expressed in the Environment Act 1995 and in various European Directives (e.g. EEC Dir 91/156). In Britain, 90% of waste currently goes to landfill.

Bedfordshire can offer large holes for waste disposal in impermeable clay which provides excellent containment sites. The South East Waste Regulation Advisory Committee (1995) has monitored landfill activity and void space and their figures show that Bedfordshire is a net importer of waste. In 1995, 5 933 000 tonnes of waste were disposed to landfill, of which 77% was imported. The consequence of this is that large brickpits, once thought to be unfillable, are rapidly being filled. Waste disposal is a profitable activity and holes are in great demand. In some cases, as a result of filling above the original ground level, the holes will become hills as the landforms are altered during the restoration process. These activities offer opportunities for landscaping and tree planting. However, this is not without its technical problems and local opposition to such extensive activity is often considerable.

By any standards the figures above are impressive, and these industries have a significant effect on the economy and environment. On the one hand, they can destroy or damage areas of environmental, archaeological and landscape value. On the other, they present opportunities for imaginative, innovative and exciting restoration projects. Such opportunities have not always been taken but there are some notable exceptions. The planning process exists to influence the operation and to reconcile the many views and opinions.

The statutory planning framework

The main policy document regulating development in Bedfordshire up to the year 2011 is the *Structure Plan* (Bedfordshire County Council, 1995). The plan contains long-term themes for land-use planning and is the fundamental basis on which thinking and action is based. It includes policies on minerals and waste. The overriding philosophy is 'to improve both the physical environment of Bedfordshire and the quality of life for its residents'. It also states that 'Development proposals will be judged against, and local authority proposals framed in relation to, both this control policy . . .'.

There follow 18 more specific statements against which development proposals will be judged. These include the conservation of existing woodland and hedgerows, an increase in tree cover and the conservation of land resources. One of the most fundamental, relating to tree planting is Policy No. 10 which has a target to double the area of woodland between the years 1990 and 2015. Other policies in the Plan deal with matters concerning agricultural land, landscape and wildlife. Some activities not dealt with here may appear as Local Plans, drawn up by the district and borough councils. These have to conform to the Structure Plan but contain more local detail and points for action.

Further guidance is given through the Planning Policy Guidance and Regional Planning Guidance Notes published by the Department of the Environment. There are 21 of the former and 10 of the latter in current circulation and all Statutory Plans must agree with the principles contained in them. Many refer to forestry and agricultural matters (Council for the Protection of Rural England, 1994). There are also 14 Mineral Planning Guidance Notes and No. 7 *The reclamation of mineral workings* deals specifically with restoration and tree planting (Department of the Environment, 1996). In paragraph 80 it states that 'in areas of the "Community Forests", the National Forest, and in preferred areas as identified in indicative forestry strategies, structure plans and minerals local plans should give consideration to inclusion of policies for the after-use of mineral sites to forestry and amenity woodland'.

In most Shire counties, the County Councils are the authority for minerals and waste planning. Each authority has minerals officers responsible for both the strategic work and the processing of applications, associated development, and restoration and waste disposal. Other specialists may be available to advise on related matters such as trees and woodlands. If they are unavailable, it may fall to the minerals officer to judge if the conditions relating to these matters are being met. This is clearly not satisfactory where specialist knowledge is required and although consultants may be appointed for the purpose this does not happen in every case.

In Bedfordshire, the *Minerals and waste local plan* (Bedfordshire County Council, 1996a) is a statutory plan which regulates the activity and covers the period up to the year 2006. Its functions are :

- To identify the need, amount and location for extraction of each mineral and for the location of waste sites.
- To balance the allocation of these sites with the environmental constraints in the county.
- To ensure the sensible and prudent use of the mineral and waste resources in the county.
- To prevent sterilisation of these resources.
- To encourage reduction in the use of raw materials and greater recycling of waste products.
- To minimise the effects of extraction and waste development on the environment.
- To seek enhanced public and environmental benefits when considering site restoration and after-use.

It also contains a list of 'preferred areas' for the various activities, drawn up following consultation with a number of organisations.

Non-statutory procedures

Some activities not dealt with in the *Structure Plan* and other plans may be covered by non-statutory plans or strategies. Examples of these in Bedfordshire are the *Nature conservation and rural strategies* (Bedfordshire County Council, 1994; 1996b), *Trees and woodland action plan* (Bedfordshire County Council, personal communication) and the *Marston Vale Community Forest Plan* (Marston Vale Community Forest, 1995). These all include policies and objectives relating to trees and woodlands. In the Marston Vale, for example, the intention is to increase the area of woodland from the present 3% to 30% using restored land as one of the main opportunities for achieving this target. There are currently 1250 ha of active or exhausted mineral workings and associated land within the Community Forest boundary and further areas have consent for future extraction. These represent about 10% of the Community Forest area, and a considerable opportunity for tree planting if technical and financial constraints can be overcome.

These plans are a successful means of obtaining the desired results as they are produced only after consultation and discussion between a number of interested partners. Already, one of the redundant brickworks sites at Lidlington, consisting of a lake, heaps of rail ballast, rail sidings and derelict land, is being restored to public open space. It will include areas of tree planting, grassland, wildlife interest, fishing and public access. This has been achieved as part of the Strategy for the Marston Vale (Marston Vale Partnership, 1993). It is a good example of the way in which local authority expertise, local industry with its heavy machinery and experience in earth moving and the voluntary help of local people can combine to bring about improvements in the landscape while providing a wildlife habitat and public recreation. The project also qualified for a derelict land grant from the English Partnerships which helped in financing the initial ground survey.

Planning conditions and the role of the local authority forester

At both National and local level, the many Plans and Strategies which exist recognise the value and importance of trees and tree planting. A recent government publication, *This common inheritance. Britain's environmental strategy* (Her Majesty's Government, 1990), suggested a doubling of the area of woodland nationally and this has long been part of Bedfordshire's countryside strategy (Bedfordshire County Council, 1989). The *County structure plan* (Bedfordshire County Council, 1995) includes the proposal to double the area of woodland, at present 5% or 6000 ha, and this aim has been fundamental to a great deal of the decision-making in recent years. However, despite wide support through policy statements, there is no legislation to enforce tree planting and its extent remains to be agreed through the non-statutory processes or by negotiation and persuasion during the consultation period.

Following the submission of an application for mineral extraction, it is essential to ensure that tree planting is properly considered as an option during discussions. It should not be left for subsequent approval after the main planning conditions have been granted but raised before the application is submitted. It is more difficult to persuade the applicant to modify proposals once permission has been granted and work has begun. The extent and position of the planted areas need to be agreed along with other matters such as soil movement, landscape profiles and treatment of the restored site. If for some reason, the exact location of tree planting and landscaping cannot be agreed, the percentage of the area which is to be wooded can be written into the conditions.

Existing landscape features must be kept, if possible, and protected during subsequent operations. Trees and hedgerows often characterise an area and can help during restoration by linking the old landscape into the new. It is at this early stage that other, wider, objectives need to be considered. The planting of buffer zones where excavations take place near houses and other work may be agreed to meet local objections. Local people are frequently affected by quarrying and associated operations, and should be involved in discussions. They can influence the content of the landscaping plans by making representations to the mineral planning authority. Their support for improved landscaping, better access and recreational facilities can have considerable weight. In addition, many non-statutory land designations need to be considered. In most cases they include in their objectives the provision of access, recreational facilities and landscape improvement.

Such designations may be seen as a straight jacket which restricts even further the activities of minerals operators. If sensibly used, they can help to resolve conflicts and ensure that mineral extraction and restoration is compatible with landscape improvement, habitat creation and increased public access. They also give a measure of reassurance to local people who often feel powerless to stop or influence events.

Landfill sites

Landfill sites are usually filled above the original ground level to allow for settlement and to provide drainage. In such cases, the main consideration is to fit the new landform into the surrounding landscape. There are strong arguments for the use of tree and hedge planting which can contribute to the screening and integration of the new landforms, and link them with the adjoining undisturbed areas. There is considerable disagreement as to the extent to which tree planting should take place on these sites.

In Bedfordshire, the large areas involved offer tremendous opportunities for increasing the tree cover. Regrettably, the necessary imagination and enthusiasm needed is often lacking. Operators are generally keen to co-operate but have been prevented by guidance in Waste Management Paper No. 26 (Department of the Environment, 1986), which has governed much of the decision-making to date. It is a generally unhelpful document. The Department of the Environment themselves acknowledge that the restrictions to tree planting on landfill sites in the publication are based on very little evidence, but it is still current and is used to argue against tree planting on landfill sites. A report recently produced by the Forestry Commission (Bending and Moffat, 1997) will, hopefully, encourage a better standard of restoration and more tree planting. The standard of restoration on many landfill sites, which are supposed to have been restored, is poor and many are still in need of considerable integration with the adjoining land! It is encouraging that the latest consultation draft of Paper No. 26 is much more comprehensive and helpful (Environment Agency, 1996).

These days there is less need to convince those involved in the minerals operations of the need for proper treatment and movement of soils, drainage and profiling. Mistakes have been made as a result of insufficient cap thickness, slopes which are too shallow and inadequate cultivation for tree growth. Techniques are developing rapidly and there is a need for all those involved to keep up to date. This is made easier by an increasing number of publications which give guidance on these matters such as *Reclaiming disturbed land for forestry* (Moffat and McNeill, 1994) and other research reports (Moffat, 1995).

Landfill operators do not usually object to land raising to give greater slope as this can increase void space and the volume of waste which can be tipped, but planning authorities have to balance this requirement against many other factors. The ideal of replacing soils by loose tipping (see Moffat, Paper 4) is increasingly recognised but sometimes difficult to achieve in practice, especially on smaller sites. However, the greater availability of large, powerful, wheeled and tracked tractors with subsoiling equipment does mean that adequate cultivation should be possible in all cases and is vital to the success of any restoration scheme.

Interim restoration, involving limited initial planting, is often suggested as an alternative to extensive afforestation. On landfill sites this may allow the repair of hollows and other initial subsidence and access to gas regulation equipment. In these cases there might be a commitment to further tree planting at a later date when the gas production has passed its peak. Where this is clearly a reasonable operational requirement, the procedures can be agreed and written into the planning permission. This may be acceptable because the operator usually has a long-term commitment to management in order to obtain the necessary certificate of completion. Restoration to agricultural use as a first stage is another possibility, especially if there is a firm commitment to plant up the areas over a period of time. This may help to overcome potential objections from the Ministry of Agriculture, Fisheries and Food especially where extraction is proposed on sites of high grade agricultural land. Such details can be included in the planning conditions.

Agricultural considerations

There may be opposition to the proposals for tree planting from the owners of the land being quarried. Although tree planting is now more readily accepted as an after-use, there is still a reluctance where farming landowners are concerned. They see restoration to agricultural use, usually grass, to be easier and cheaper than tree planting. They prefer this option as they are more familiar with the operations involved and feel better able to maintain the site after the operation is finished. They are less confident or often not interested in woodland maintenance and management. They may also argue for a smaller planted area as trees can limit their future agricultural options and affect the value of the land. In such cases the local authority forester or landscape architect needs to be sure of the justification for planting and the need for it in the local context, in order to counter these arguments.

In the 1970s, land was invariably restored to agriculture. Extravagant claims were made by some companies as to their ability to restore agricultural land back to its original quality in attempts to obtain permission for digging on better agricultural land. Often, restoration was poor so that, in the river valleys, flooding occurred and elsewhere the ground was so compacted that it was of little use. In the 1990s, overproduction of cereals, concern about high fertiliser inputs on restored land, the increasing extent of Nitrate Vulnerable Zones and the effect of irrigation on water supplies may affect our approach to restoration management.

Changing perspectives and alternative land-uses

At one time, the restoration alternatives were relatively straightforward. Land was returned to agriculture with occasional water areas and trees. Nowadays, other options must be considered. Policy MW32 in the *Minerals and waste local plan* (Bedfordshire County Council, 1996a) is complex and states:

'The County Council will require proposals for mineral extraction and waste disposal to be accompanied by proposals for the high quality restoration of the site within a reasonable time scale. Normally this will be for agriculture, forestry, nature conservation or amenity/recreation but the County Council will support other beneficial uses which accord with the policies of the development plan'.

It is necessary to take a broad view of what is acceptable where tree planting is proposed. Increasingly, the interest in multi-purpose forestry requires consideration of other methods of management to achieve the aims of restoration. The planting of conifers for timber production may not always be the most appropriate approach in a Community Forest, or other places where public access is of primary interest. The forester needs to make sure that the proposals are technically feasible and that sound silvicultural principles are observed.

In recent years, there have been many changes in the approach to tree planting, forestry and woodland management. The local authority forester now expects to work with other specialists such as ecologists, archaeologists and landscape architects. These may or may not be directly employed by the local authority but the involvement of a number of professional disciplines ensures that all options are considered.

A case of particular interest involves Fuller's Earth extraction. In 1977, during the first phase of operation, the restoration plan involved replanting with pines to replace the conifer crop removed prior to the digging. A later phase, begun in 1993, had more complex conditions. These involved not only the realignment of a road which ran over part of the deposit but the planting of mixed species of trees and shrubs and restoration of part of the site to heathland, a rare habitat in the County. The new areas will provide a greater variety of landscape and an opportunity for increased public access. The difference in approach and in the nature of discussions which led to it, is a reflection of the change in attitudes to land-use which has occurred during the past 20 years or so.

The approaches and treatments will vary and the opportunities for habitat creation are great given imagination and co-operation. Gravel extraction in river valleys may leave water-filled holes which can, with sensitive treatment and the planting of trees and shrubs, create recreational and wildlife areas of outstanding interest. Others may be interesting for their geological exposures, become home to unusual species and offer opportunities for the establishment of rare habitats such as heathland. Many such sites have been designated as County Wildlife Sites (Bedfordshire County Council, 1994).

Compliance

It is necessary to ensure that the often complex set of conditions agreed during the consultation process are met during the operation, which in the case of landfill sites, may often last decades. Minerals planning officers will need advice on a number of issues. These may include confirmation that the tree species chosen are suitable, and that planting and maintenance are being properly done. Some operators employ their own specialists and in such cases regular meetings and inspections will ensure that the work is being done in accordance with the conditions. Occasionally, operators and owners will try to modify the work from that which has been approved, perhaps filling to greater levels than permitted or by avoiding some of the more exacting conditions. Regular site inspections, with enforcement where necessary, are an essential part of the planning process. Local government reorganisation and the consequent reduction of staff is worrying and may affect the ability of the minerals authority to enforce conditions. This would have serious consequences for an activity which is potentially sensitive and highly damaging.

Some permissions date from before the 1950s when planning was a less rigorous process and few conditions were attached. In these cases the local authority could only try, through discussion, to improve upon the original, unsatisfactory agreements. Understandably there was some reluctance to do this as the result would be an increase in the restoration work for operators. Recent legislation might change this for the better. Long standing permissions are now being reviewed under legislation introduced by the Environment Act 1995. Owners are required to register sites, and if they do not, then the permission will lapse. Those sites registered must submit new conditions for approval and these are subject to review procedures to provide up-to-date conditions for the site.

Aftercare

Operators may be keen to dispose of their responsibility for the land, often referred to as 'borrowed land', as soon as they can. At present, aftercare conditions can only be imposed on minerals permissions for 5 years after completion of the restoration work. While this short interval may be sufficient for some forms of restoration, it is not for tree planting. Because tree planting is such a regular feature of modern permissions and clearly requires a longer maintenance period there is need for an urgent review of this legislation. Some control over the standard of restoration is exercised if grant aid has been given by the Forestry Authority (Forestry Authority, 1996; Heslegrave, Paper 8). The second instalment of the grant is paid only if the maintenance is satisfactory. If it is not, the work has to brought up to standard or the money is withheld and the original grant can be reclaimed, with interest. If this situation does not apply, then it is essential that the restoration and tree planting is sufficiently 'robust' to survive some neglect after the five-year period.

Alternatively, companies who profess an environmental conscience could write such a condition into their Codes of Practice. For example, the British Aggregate Construction Materials Industries (BACMI, 1992) state in their *Environmental code* that 'Restoration and after use are an integral part of the total mineral production process,' and 'the aftercare programme is an indicator of the company's responsible attitude...'. The implications of such statements are plain, and in cases where trees and woodlands are planted must indicate a willingness to maintain for a longer period than that specified in a planning permission. However, in one recent case a BACMI member, having restored the site to woodland, immediately sold it to a private landowner whose only interest seemed to be in the opportunities for alternative development on the land. In addition to the local planning authority, the Forestry Authority has an interest in the fate of the planting which has received grant aid.

The use of a Section 106 Agreement may provide for a longer aftercare period but only for those matters not included in planning permission. In the case of large scale projects, especially those which have attracted widespread local opposition or where public enquiries have been held, such agreements have been drawn up to ensure that additional conditions are complied with. In one local case, such an agreement included the replacement of a road, with extensive landscaping, when quarrying destroyed the old road line.

Costs and financial support

The cost of planting can often be high in relation to other forms of restoration, and operators are reluctant to plant more trees than necessary. The availability of grant aid for planting on restored sites has helped to make tree planting a more attractive proposition and the involvement of the Forestry Authority as the regulatory authority does bring another level of experience to the project. Their experience of restoration and the insistence on good ground preparation and maintenance provides important backing to the local authority. The availability of supplements to the basic planting grant awarded by the Forestry Authority, such as the Community Woodland Supplement may make the project more viable and bring other benefits such as increased public access (Forestry Authority, 1996).

A tender scheme which has been successful in attracting bids for multi-purpose planting in the National Forest area could be applied more widely especially where public benefits can be obtained. This tendering process is now in its second year and it is to be hoped that it might be extended to other Community Forests. Additional incentives, such as Landfill Tax and additional help for forestry in urban areas, are being considered. Grants are also available from

English Partnerships for the restoration of derelict land. What is clear from these initiatives is that the planting and restoration of despoiled land is an expensive business. It is important therefore to ensure that this expense is reduced to a minimum by careful early planning and high quality working and restoration.

Flexibility of approach

Often, the poor quality and condition of the restored land and the lack of topsoil means that tree planting may be the only viable alternative. Thorough site preparation is essential. Too often tree planting is proposed as an afterthought and invariably gives disappointing results. Expectations of what the site is capable of are frequently too optimistic. Demanding species such as oak, lime and ash are sometimes suggested where a pioneer species is more appropriate. It is difficult to establish or create 'native' or complex woodland types on recently restored land and often impossible to predict what the final 'soil' covering is likely to be. One attempt to establish chalk grassland on a restored chalk digging was thwarted when the imported material turned out to be clay-with-flints. Fortunately, this happens much less frequently now as the source and movement of materials is one of the most important matters to be agreed before work begins.

Alternatives such as natural colonisation and regeneration or direct seeding (Luke *et al.*, 1987) may prove suitable where time allows or where gradual colonisation is acceptable. In the case of landfill sites where it is sometimes necessary to wait until the gas generation and subsidence have ceased or are insignificant, such indirect techniques might be useful. Careful thought is required beforehand and the proposition carefully written into the conditions so that there is no misunderstanding as to what is proposed.

In some cases, especially on the lighter soils, long-abandoned sites have developed into areas of high natural history value. Insistence on formal restoration could damage the interest which has developed naturally. A thorough and well-considered plan is essential if the best is to be gained from the restored site. The combination of a number of techniques might be appropriate. In a sand quarry in mid-Bedfordshire, replanting of some trees was combined with natural regeneration of trees and shrubs and parts of the site left undrained allowed the formation of an area of wet, acid mire. Some small vertical sand faces were also left exposed to provide other habitats for insects and birds.

Conclusions

There have been many changes in the approach to restoration and the related techniques over the past 20 years or so. In earlier times, the alternatives chosen were often limited to agricultural restoration with some water areas and trees. Too often tree planting was been considered as a last resort or as a means to try to hide some particularly awful eyesore, and it was difficult to persuade landowners and operators that tree planting was a viable option in its own right.

Now there are more complex issues to be considered. Consultations often involve local people and a wide range of possible after-uses. In addition, there are many more non-statutory plans and designations to be considered. These all add time and cost to the process but minerals operations can have an enormous and long-term impact. Such efforts, if approached in an effective and enlightened manner should be seen as a positive contribution to the sustainable use of a countryside under increasing pressure to supply our material, spiritual and recreational needs.

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Chapter 3

Woodland : an attractive proposition for the minerals industry?

Nigel Bending

Introduction

Many consider that the reclamation of derelict land and abandoned mineral workings to forestry and woodland represents an attractive proposition. New reclamation techniques which include complete cultivation and the extended use of a wide range of waste materials have generally been welcomed on such sites. In contrast, recommendations for similar treatments on prospective and active mineral workings have met with mixed enthusiasm. The uptake of new ideas has been largely dependent on the attitude held towards restoration by mining engineers, rather than those with an interest in land reclamation *per se.*

To secure planning permission to work minerals, operators usually have to give a commitment to replace trees lost during the working. While there are those who only fulfil this minimum obligation, there are many reasons why others go further:

1. Operators may be encouraged to opt for woodland in community forest areas in the expectation that this is likely to be favourably received by the mineral planning authority and the local community.
2. On sites containing little woodland prior to working, some increase in the extent of cover may be called for to meet the considerations of the restored landscape.
3. Reduced agricultural returns have in recent years highlighted the value of forestry as a productive after-use.
4. Low restoration, aftercare and maintenance costs compare favourably with other land-use options.
5. Grant aid from the Forestry Authority for the creation of new woodland is attractive to some.

All these reasons are pragmatic. Reasons for the creation of woodland such as the enhancement of the local landscape, the provision of recreational opportunities or for wildlife habitats do not figure strongly, in themselves, as motives. Cost and 'ease of attainment' are primary considerations and this is an inevitable trait of an industry whose occupation of land is, after all, transitory.

History of forestry reclamation

Since the 1950s, the minerals industry has taken its lead from the Forestry Commission in its approach towards the reclamation of sites to forestry. The Forestry Commission Research Division has been largely responsible for offering guidance, and the Forestry Commission districts have been heavily involved in planting sites. Past experience has undoubtedly had a profound bearing on the minerals industry's perception of reclamation to woodland and forestry.

Planting by the Forestry Commission on ground disturbed by mineral working began in the 1950s. Attention first focused on abandoned ironstone workings in the Midlands, but extended later in the decade to colliery tips and unrestored opencast workings in most coalfields. In many instances, the areas on which the mineral development had taken place, had been acquired in the 1920s and 1930s by the Commission in the first place, and their return to its estate was embraced enthusiastically. Despite poor site conditions, the objective in planting was the production of a commercial crop, and to this end pioneer conifers, most notably lodgepole pine and Japanese larch, were used extensively.

Early schemes on sites worked to shallow depth were generally successful, despite the fact that little concerted effort was made to recover soils in the course of site operations. However, in the late 1960s a fall in the reclamation standards coincided with a substantial increase in the depth of working which brought ever-increasing volumes of raw overburden onto the surface. Most significant was the replacement of draglines with dozers and trucks and, later, scrapers in restoration activity. This change in working practice saw soil compaction emerge as possibly the strongest single influence on reclamation success.

The Forestry Commission Research Division's involvement in reclamation up until the late 1960s had been towards basic species trials, but after this date a far more deliberate and purposeful approach to reclamation research emerged, responding to the growing needs of the industry to provide answers to existing and developing problems. Research was conducted in a wide range of subject areas including silvicultural experimentation, landforming and cultivation evaluation and studies of the mineral nutrition of crops on restored ground.

The industry, which by the mid 1970s had grown to include sand and gravel workings, followed the progress of this work closely, and almost all recommendations arising from the studies conducted were rapidly adopted into restoration practice. The advice given was rarely questioned, although it now appears that much was offered on the basis of perceived, rather than proven benefits. However, this was understandable given the demand placed upon researchers by the industry at that time. Under the circumstances that prevailed it was often not possible to assess experiments in the manner originally intended and conclusions drawn from simple observations were sometimes speculative. Yet, important developments were made during this period with the introduction of ground cultivation using tines to relieve compaction, the construction of large-scale ridge and furrow landforms to promote effective site drainage and the modification of silvicultural systems to incorporate a nitrogen-fixing component.

The introduction of alders into planting mixes in the mid 1980s was highly significant, but the fact that alders were offered as a 'nurse' for conifers indicates that the Commission remained firmly entrenched in the view that the commercial production of timber was the most important objective for reclamation to forestry. While the use of alders offered some prospect for improvement, many within the minerals industry began to doubt the viability of commercial forestry as an after-use for sites at this time.

The mid and late 1980s saw a re-evaluation of the role of commercial forestry in land-use, and the development of the 'multi-purpose forestry' concept. This attached greater weighting to the value of forests and woodland for conservation and recreation. These years also saw growing criticism of the minerals industry's apparent inability to grow trees on restored ground. Called into question was the disparity between the 'quality' of wooded areas before and after mining and specifically the use of non-native conifer species.

The mineral industry's experience of planting trees was not confined to commercial forestry. In response to calls from the conservation lobby in the mid 1980s, native deciduous trees were extensively adopted into woodland planting schemes on agricultural areas to replace 'like for like' trees lost in the course of site working.

Advice received by the minerals industry from some quarters was arguably poor at this time. While blocks designated for the planting of trees on agricultural areas often benefited from some form of soil cover, little attention was devoted to the specific needs of trees, and lessons learned in the restoration of forestry areas were not heeded. Restoration often proceeded along agricultural lines, resulting in heavy compaction and in many instances this culminated in the creation of an agricultural sward prior to any consideration of tree planting. Areas were often flat and poorly drained, and the need to cultivate the ground little appreciated. These problems were accentuated by the planting of native broadleaved trees, as many proved highly intolerant of ground conditions.

The modern view

With little sign of improvement in the establishment of woodland on reclamation sites and increasingly vociferous criticism of their efforts, many operators began to view the planting of trees as a liability. Partly in desperation, alternative 'quick fix' solutions were sought. The failure of the forestry profession at this time appears to have been its reluctance, or unwillingness, to point out the inherent weaknesses of these approaches.

For example, the minerals industry was among the most enthusiastic group to use treeshelters because of the potential for improved rates of growth. Yet the benefits of shelters on most reclamation sites has proved to be minimal, and has even been counterproductive. The failure was to emphasise fundamental aspects of site preparation on disturbed ground and above all else, the advantages of cultivation. The benefits of this unarguably outweighs that which can be derived from shelters.

In a not dissimilar vein, feathered and standard trees have been widely used by the minerals industry in an attempt to accelerate development of the restored landscape. However, forestry research at the time clearly showed that transplanted or cell grown stock planted on well-prepared sites were likely to develop more strongly and quickly than standard trees which often regressed. Unfortunately as the practice was not actively discouraged by professional foresters, it therefore continued.

Finally, a trend which developed rapidly in the late 1980s was the practice of transplanting semi-mature trees from areas to be worked onto restored areas. While a seemingly brilliant idea many schemes proved abject and costly failures. Yet alternatives such as the use of local provenance stock, or the rearing of plants from clonal material or seed collected prior to the loss of trees did exist as far more practical solutions.

The use of water-retentive polymers, slow-release fertilisers and manufactured organic amendments in planting pits were other ideas embraced by the minerals industry, none of which have been found to produce substantive benefit on reclamation sites where basic site requirements were overlooked.

In the 1990s, the forestry profession has once again taken the lead in providing advice to the minerals industry and major progress has been made in recent years, with the advent of loose tipping as a means of soil placement, the selection of soil-forming materials as soil substitutes and the use of organic materials as amendments. Experimental work continues to demonstrate the benefits of these new approaches to reclamation and the challenge ahead lies to convince the mineral industry of their value.

The new techniques call for a major revision in site working practices and the attitudes of many mineral operators towards restoration in general. The call is very much to consider all aspects of activity on a site in the context of how each will affect restoration. There is little doubt that some mineral operators struggle with this concept. The main difficulties appear to revolve around the recovery of soil-forming materials, their storage, handling and reinstatement. For example, many planning conditions now insist that at least one metre of a 'rootable' medium is placed on restored areas intended for tree planting. In many instances this thickness is considerably greater than that of the original soil cover, and this calls for the recovery of 'soil-forming materials' from depth. In the absence of any firm guidance on the assessment of the suitability of such materials, this requirement appears onerous to the industry. Similarly, the call not to use scrapers to replace soils (Moffat, Paper 4) is highly demanding given that the majority of scrapers are owned by operators just for this purpose.

Other new requirements also contradict attitudes long held by mining engineers, for example, the need to completely cultivate soils on slopes in preparation for tree planting, when compaction has traditionally been equated with stability. Similarly, new guidance recommends that areas for tree planting are not seeded although establishing a grass cover has always been considered necessary to demonstrate that restoration is under way. The use of waste materials, and most notably sewage sludges, also presents some difficulties. The perception of sludges held by mineral operators is that they are noxious, contaminated with metals and debris, hazardous to store and difficult to handle and utilise. It is essential that the water companies start to recognise the need to provide sludges in a form and of a quality that do not present containment problems on site, are easy to incorporate and do not generate odour, in order to make their use acceptable.

It is imperative that the benefits of all new techniques are explained clearly to the industry and furthermore that the practical aspects of their implementation are dealt with fully. The Forestry Authority, as a statutory consultee, fulfils an important role in commenting upon restoration and aftercare schemes involving the creation of woodland and are indeed relied upon by mineral planning authorities to provide guidance. The responsibility is one not universally accepted within the Authority perhaps because of ambiguities in the 1981 Minerals Act, which requires that comments are offered only on aftercare proposals. In contrast, MAFF is required to provide advice on restoration *and* aftercare. The discrepancy is addressed in Minerals Planning Guidance Note 7 (Department of the Environment, 1989). This suggests that mineral planning authorities should also seek advice on restoration from the Forestry Commission, and it is indeed in this area that the most constructive advice can be offered. Given that a wide range of interest groups is now invited to comment on submissions made by mineral operators, and each has an inclination to represent its own vested interest, it is of the utmost importance that the voice of the Forestry Authority is *heard* above the clamour.

The Forestry Authority also has the critical role as the awarding body for new woodland planting grant. While the financial support offered by this is welcomed by mineral operators, the costs of planting on restored ground are invariably greater than, for example, on farm woodland schemes, on which levels of funding are based. Increased costs result from the incorporation of amendments, greater fencing commitments, the use of cell-grown stock which offers considerable advantages for use on restored ground, and from closer plant spacing and commensurate higher stocking densities. In essence, the grant is largely a supplement and given its relatively low value is unlikely to be greatly effective in itself for stimulating new and additional planting on land reclaimed after disturbance.

Conclusions

Restoration to woodland will offer itself as an attractive proposition to the minerals industry only if it is seen as 'viable' and 'practical'. Both are realistic concepts if opportunities afforded by new reclamation techniques are embraced fully. The challenge to the forestry profession is to use past failures in a constructive way to demonstrate the benefits of new best practices. There is a great deal to recommend woodland and forest establishment as an option for reclaiming mineral workings, and the forestry profession as that most qualified to undertake reclamation of this type. For it to be heard clearly by the minerals industry, this message must now be reinforced in a far more emphatic way.

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Chapter 4

Site preparation - getting it right

Andy Moffat

Introduction

It is inevitable that a soil scientist's view of the reclamation process will differ from that of the forester, ecologist or planner. And quite rightly so. Reclamation must be acknowledged as a multi-disciplinary activity if best results are to be obtained. Ideally, each profession (and there are many others not listed above) should bring its own expertise and experience to produce, together, a scheme or project that is greater than the sum of its parts.

Reclamation has undergone considerable progress in recent years. There have been important improvements in techniques and practices which have led to significantly improved standards. For example, in reclamation involving tree or woodland establishment, notable advances have been made in stipulation of stock size and type, methods of weed control, use of treeshelters, and the sowing of grasses and wild flower mixtures. There may be some differences in approach but foresters, ecologists and landscape architects can all appreciate how, for example, weed control can increase tree survival; it is useful that the different parties involved in planning and carrying out these silvicultural tasks all have some experience in vegetation establishment and management. These issues have been taken up further in assessing applications for Woodland Grant Scheme. Here there is another mechanism for ensuring that advances in methodology are transferred from research into the real world. For the most part, too, good (or bad) practice in these silvicultural areas is very visible and comparatively easy to assess.

In contrast, while there has also been much research on improving site *physical conditions* for tree planting on reclaimed land, there seem to be obstacles in the uptake of these ideas. There are several important reasons for this. Firstly, woodland planting is often considered where soil resources are scarce, or earmarked for the agricultural component of the scheme. Woodland is frequently regarded as the poor relation of land-uses in mixed end-use reclamation schemes, with consequent lack of care in site preparation. Trees are thus often planted on spoil, or overburden materials, rather than soil *sensu stricto*. However, little opportunity is taken to identify which of those spoils available would produce the best (and worst) substrates for plant growth. Mining technology rather than good soil husbandry is then used to move and place these materials, often leading to further degradation.

The activities listed above are the preserve of the miner or engineer, who usually has very little biological understanding. It is no wonder, therefore, that site preparation can fail to reach best practice. Complying with more modern advice on issues such as landform design, soil provision, soil placement and cultivation may also mean increased reclamation costs (though perhaps less costly management), and this may be used to reject modern methods. In addition, old or bad practice is often difficult to distinguish visibly from best practice, at least until the detrimental effects on the tree are perceived. For example, compact subsoil can be easily disguised beneath a layer of looser topsoil.

Such a position is unfortunate, and very undesirable! It is imperative that best standards of site preparation are achieved if a tree planting scheme is to prosper. Aftercare, no matter how good, cannot cancel the effects of poor restoration. For example, no amount of weed control can rescue a scheme where tree rooting is restricted to shallow depth by compaction.

Importance of correct site preparation

Correct site preparation is important for all land-uses to be installed after reclamation but it is *vital* for woodland establishment. Once planted, trees depend on the pre-existing configuration of the land and the looseness of the soil. It is impossible to rectify problems in these areas until the end of the life of the tree crop, or unless the stand is sacrificed prematurely. This contrasts with, for example, agriculture, where cultivation can occur annually if necessary to relieve soil compaction. Landforming is especially important in woodland schemes, to promote well-drained soil substrates. Artificial underdrainage is inappropriate for woodland, which must rely on suitable land gradients and uncompact soil conditions. In fact, in the past, landforming for agriculture and forestry have been quite dissimilar. There has been a tendency to restore land destined for the former to as flat a gradient as possible; this is built upon the belief that flat land is more versatile than sloping land. However, such a policy has effectively prevented a change to a woodland land-use for many sites in the Midlands where community forestry is now a favoured end-use. It is interesting that modern agricultural guidance now follows that for forestry in desiring some slope to restored land (RPS Clouston and Wye College, 1996).

It is now the case that those concerned with establishing trees on reclaimed land can point to procedures and techniques which have proven success. In many respects these differ from those employed to re-establish agriculture or amenity. It is therefore imperative that land destined for tree planting is prepared using appropriate guidance, and that those concerned to achieve woodland establishment realise that such guidance covers all aspects of restoration including site preparation, as well as aftercare. Hence, those with influence must be involved at the planning stage of a reclamation project, rather than towards the end, after restoration has been completed.

The following is a summary of key points which are important in preparing a site for woodland establishment. Topics covered include landform design, soil placement, soil thickness, choice of soil forming material, and soil amelioration. Further technical details on these subjects are given in Forestry Commission Bulletin 110: *Restoring disturbed land for forestry* (Moffat and McNeill, 1994).

Landform design

Flat land is generally unacceptable for woodland schemes, but can nearly always be avoided by careful planning. Slopes of 5 to 7° are ideal, to promote disposal of excess winter rainfall without undue erosion risk. Length of slope is also important, and can be limited by cut-off berms at shallow angle to the horizontal. Design of landform to accomplish water management and suitable growing conditions must be combined with landscape considerations (see Bell, Paper 5). Total reliance on the 'ridge and furrow' landform should be tempered. With imagination, schemes can be devised which accomplish all objectives, and which are not unduly expensive. Indeed, expensive levelling operations may be dispensed with in reclamation to woodland - landform with some amplitude is very desirable.

Soil placement

There has been a sizeable move away from the guidance prevalent in the 1980s in this area of site preparation. In 1982, Forestry Commission advice stated:

> 'Nowadays the box-scraper and bulldozer reign supreme. These machines are so efficient that it is cheaper to accept the damage they cause and then put it right, rather than ask for different methods of restoration.' (Binns, 1982).

It is now accepted that prevention is much better than cure : in fact, for many types of soil or spoil, it is impossible to cure the effects of poor stripping, storage and placement. And even where ripping is performed effectively, there is a limit to the depth which can be loosened - probably around 60 cm. If soil has been laid by earthscraper, it is almost inevitable that this soil thickness will equate to total rootable depth since rooting below the depth of ripping will be prevented by soil compaction. This depth will be inadequate in many parts of the country (see p.18).

Current guidance now strongly advocates 'loose tipping'. This involves the use of dump trucks to move soil materials and a 360° excavator to lay them to a prescribed thickness. Neither trafficking over re-laid soils is necessary, nor cultivation to relieve compaction. Loose tipping is not a novel technique: it has been practised in certain sections of the minerals industry for over 20 years. And it is not significantly more expensive than other forms of ground preparation (Wyatt, 1995). Site working contracts for many South Wales opencast coal sites now insist on loose tipping for soil placement (N. A. D. Bending, personal communication). This suggests that much of the resistance towards loose tipping is simply based on inertia, and fear of unfamiliar techniques. Earthscrapers are undoubtedly becoming less common in mineral site reclamation, but there is increasing evidence that they are *wholly unsatisfactory* as a means of soil placement before woodland establishment.

Soil thickness

Trees suffer from disparate views on their soil requirements. Some cite the shallow root systems of Sitka spruce on upland poorly drained soils as evidence that soil needs are comparatively small. Others point to the effects of tree rooting on underground structures as evidence of the tendency of trees to root deeply. It is thus important to deal with the issue of soil thickness. And it is vital not just to consider thicknesses adequate to support the early years of growth, but those which will maintain water supply to the mature stand or woodland. Other factors affecting soil thickness are available water holding capacity (AWC) and the ability of roots to extract soil water reserves. Soil-forming materials generally have a much poorer AWC than natural soils, and compaction prevents intense root ramification. Hence, there is a need for a greater thickness of soil-forming material compared to natural soil if the same amount of water is to be available to the tree.

Fortunately, predictions of soil thickness for mature crops have been made (Moffat and McNeill, 1994). It may *not* be sufficient to rely on pre-existing amounts of soil before mineral extraction took place : such quantities may have been sufficient to support other vegetation types but may be inadequate for woodland. Moffat and McNeill (1994) suggest that in drier parts of the country thicknesses in excess of 1.5 m may be needed. If the natural soil is thinner than this, consideration should be given to increasing rootable thickness using soil-forming materials or reducing the area planned for woodland.

Soil and soil-forming materials

Foresters have, in the past, been partly responsible for the dearth of soil materials provided for woodland schemes; some have been vocal in the attitude that 'we can plant trees on any kind of substrate'. To an extent, this may be true, but it is also undeniable that soil materials are much more fertile than most soil-forming materials. Indeed, the fertility of the soil has been held up by some as a positive reason for rejecting it since the problems of weed control are perceived as greater than the slow tree growth obtained using unamended soil-forming materials.

However, soil is the *natural* medium for establishing vegetation, including trees. It should be fought for, and used, wherever it exists, whether on a site yet to be worked for minerals, or on one where soil has been stripped and stored. On sites with multiple end-uses following restoration, forestry has as much right to the soil resource as other land-uses. Weed control is an essential part of aftercare and forms a central component of good silvicultural practice. There are very few sites where some form of weed control will not be necessary, with or without soil provision. Hence, fertility should not be seen as a threat to a woodland scheme.

If soil materials are genuinely absent from a site, there are three main alternatives in its restoration:

1. Import soil from elsewhere.

2. Use soil-forming materials.

3. Use a combination of (1) and (2).

Whatever strategy is adopted, some form of quality evaluation must be carried out. If soil is to be imported, guidance on topsoil specification by the British Standards Institution (1994) may be useful, though it is important to realise that this covers a range of 'soil' materials, including subsoil and some soil-forming materials. And some of the recommendations seem at odds with recent forestry experience in the use of soil-forming materials, For example, clay subgrades of the 'Economy' grade of topsoil are generally unsuitable for establishing woodland. Forestry Commission guidance (Table 4.1; Moffat and McNeill, 1994) has been drawn up to evaluate all types of material, soil and soil-forming material. Toxic or potentially toxic materials must be excluded, and minimum physical conditions met. In general, however, many types of material are suitable for using, wholly or partly, as a soil cover, though the breadth of choice for suitable tree species will vary enormously with the 'quality' of the material.

Soil amelioration

It is the responsibility of the mineral operator to restore land to a standard capable of supporting the chosen vegetation type. For agriculture, it is soon apparent whether a suitable standard of reclamation has been achieved, i.e. crop yields are of an acceptable size, or not. For woodland establishment, it is usually a slower or less confident assessment. However, it is possible to predict that performance of trees established on many soil-forming materials derived from geological lithologies will be comparatively poor: survival may be acceptable but growth will be unimpressive. Infertility is the main cause, and amelioration with nutrient-rich materials is

Table 4.1 Minimum standards for soil and soil-forming materials used in restoration to forestry (from Moffat and McNeill, 1994)

Property	Standard
Bulk density	<1.5 g cm^{-3} to at least 0.5 m depth
	<1.7 g cm^{-3} to 1 m depth
Stoniness	<40% by volume; few stones greater than 100 mm in size
pH	3.5 to 8.5
Electrical conductivity	<2000 μS cm^{-1} (1:1 soil:water suspension)
Iron pyrite content	<0.5%
Heavy metal content	Not excessively over ICRCL[a] threshold trigger concentrations
Organic contaminants	Not exceeding ICRCL[a] action trigger concentrations

[a] Interdepartmental Committee on the Redevelopment of Contaminated Land (ICRCL, 1983).

called for if the woodland is to grow to maturity. Mineral fertilisers can be used but their effects are likely to be short-lived, and they do not address the comparative lack of organic matter that most soil-forming materials exhibit. However, there is a large range of organic-rich products to choose from (Table 4.2).

Sewage sludges have received the greatest attention in woodland establishment, and can undoubtedly change the destiny of woodland schemes from relative failure to success (Wolstenholme *et al.*, 1992). Other materials, such as composted woodchips, paper mill sludge and composted municipal waste, also show promise though their merits depend partly on their carbon/nitrogen ratio, which can vary considerably. The impressive results obtained using some of these additives suggests that it is not generally acceptable to rely on mineral soil-forming materials which have not been ameliorated. Certainly, the choice of tree species will be limited to a small short-list of pioneer staples. However, use of organic materials is not a panacea to otherwise poor site preparation since it can even be counterproductive.

Table 4.2 Types of organic amendments for soil amelioration

- Sewage sludges
  - liquid sludges
  - cake sludges
  - pelletised sludges
- Chicken manure
- Other farm animal wastes
- Straw
- Paper mill sludges
- Wood residues
- Compost
- Green wastes

Conclusions

Those involved in establishing woodland on land previously worked for minerals should strive to prepare the site according to modern guidance. This has been based on the premise that trees will thrive best in substrates which are closest to natural soil, and that mineral operators have a duty to reclaim land to as near this ideal as possible. Of the individual operations involved in site preparation, most effort (and expense) should be spent in providing a suitable thickness of uncompact rootable material. However, an integrated approach is essential - compromise in quality at any point will run the risk of project failure.

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Chapter 5

The importance of landform design in the after-use of disturbed land

Simon Bell

Introduction

In the past, much disturbed land restoration has not lived up to its potential or expectations because of poor, unimaginative design of both landform and subsequent after use. Beneficial site treatment and good silvicultural practice is vital, but unless this is done within a comprehensive design, much of the effort and expenditure may be wasted. The design of the landform should be a fundamental and integral aspect of the entire scheme, without which it will usually be very difficult to achieve the best result for the available resources.

In most types of woodland the layout and species choice should be at least partly dependent on the landform, soils and existing character of the landscape. In the case of disturbed land these factors may exert less influence. The landform may bear little resemblance to that of the surrounding landscape, and the soil or planting substrate, and drainage, are usually in a poorer condition than before disturbance. The site as a whole will tend to stand out as not belonging to its surroundings. In those cases where the former land-use pattern is reinstated over areas with a radically different landform, the result can appear very strange and impractical.

Problems of poor landform design

The landform, i.e. the three-dimensional character of the land surface, is the basic substrate upon which climatic and environmental processes take place. Large disturbed areas rarely have the same landform as the surrounding landscape. Where the chance exists to blend into the surrounding contours, even if not restoring the land exactly to its former profile, this will make it a lot easier to achieve success with vegetation establishment and to use it for a range of activities.

Landform determines drainage, topographic shelter, aspect and the character of the surfaces to be used for various purposes. Natural landforms possess finer modelling which leads to microclimate and microsite variations which in turn lend themselves to variations in habitat and use. If this modelling is absent from a restored site, so are the variations and much of the potential and interest (Figure 5.1 (a)).

There are a number of factors which have led to the simple, engineered landforms prevalent over the last few decades:

- Site area is often restricted so that spoil heaps cannot be graded sufficiently, resulting in steep slopes and higher landforms than those found in natural contours.
- Steep slopes can be potentially unstable so that simple forms and elaborate drainage systems are needed to prevent slippage and collapse.
- Machinery such as box scrapers cannot form or sculpt intricate landforms.
- Filled settling ponds or large simple landforms tend to result in large flat or almost flat areas.
- Safety concerns following the Aberfan disaster led to a lot of effort to make unstable tips safe with little concern for other issues such as landscape design.
- Surveying and setting out techniques, and cut-and-fill calculation methods, are based around simple polyhedral solid volumes.

The options open for landform design are now wider, partly because technology such as computer-aided design can allow more complex forms to be modelled, and volumes of material can be calculated more easily and precisely. Visualisation of landforms before construction commences is also possible as is the testing of a number of options.

Natural landform structure

There is a fundamental difference between the characteristics of the geometry used in most engineering and the geometry found in nature. The geometry used in most construction is based on Euclidean principles applied to simple platonic solids or polyhedrons easily constructed according to mathematical formulae. This is a gross simplification of the more complex fractal geometry found everywhere in nature. It is becoming more evident that nature does not produce simple, symmetrical, geometric shapes such as spheres, cubes or pyramids that appear exactly the same from whatever distance they are observed (Figure 5.1 (c)). Fractal geometry, named by the mathematician Benoit Mandelbrot (Mandelbrot, 1977), uses 'fractional dimensions' such as 1.1, 2.4. or 2.9 instead of the 1, 2 or 3 dimensions commonly used. Natural forms contain various degrees of self-similarity at a range of scales, so that, when viewed from different distances, varying degrees of detail are revealed. A classic example of this is when one looks at a map of part of the British coastline at different map scales (Figure 5.2). When the scale is changed from 1:250 000 to 1:50 000 and then to 1:10 000, more details and convolutions appear and the apparent length increases dramatically. Thus a piece of natural landform changes in the degree of detail evident, ranging from its broad shape as seen from a distance down to fine scale undulations when seen close up. It is this range of variation which controls drainage and ecosystem processes, all important considerations in achieving good design (Figure 5.1 (b), (d)).

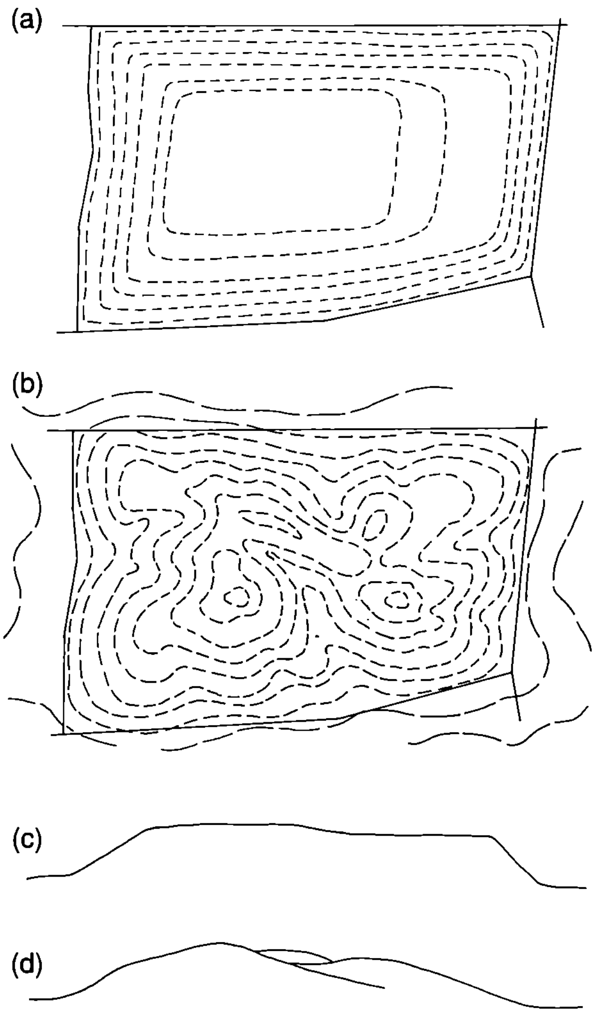

Figure 5.1 (a) Poor landform design: the shape is geometric, slopes are very even, the top is too flat and there is no blending into its surroundings. It is difficult to use for design, planting, habitat creation or recreation. (b) Better landform design: the shape is more natural and variable, slopes are less even, contours blend with the surroundings, and drainage is more broken. The site is easier to use, to design, to plant or to use for recreation. (c) An angular and bland geometric profile. (d) A rounded and folded naturalistic profile

The degree to which it is possible to incorporate natural fractal geometry into landform design will vary from substrate to substrate. Conditions of stability, settlement, landfill gas management, leachates, land-base and the available equipment are all likely to limit what can be achieved. However, such concerns should be tackled in a creative way and not be allowed to over-constrain the design process. Table 5.1 summarises the contrasts between Euclidean geometry and natural, fractal geometry.

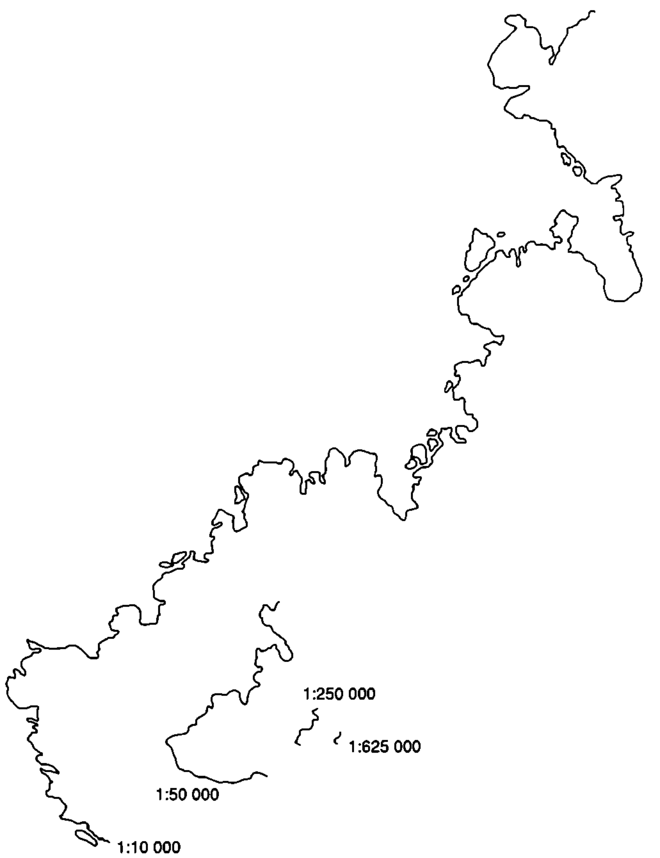

Figure 5.2 The fractal nature of the British coastline determined by the scale of measurement. Maps of four scales show the increasing complexity

Table 5.1 Summary of contrasts between Euclidean geometry and natural geometry

Geometric	Natural
Euclidean geometry	Fractal geometry
Simple forms	Complex forms
Angular shapes	Curvilinear shapes
Symmetrical forms	Asymmetrical forms
Simple slopes	Compound slopes

Landform and ecosystem processes

There is an intimate relationship between landform and the various processes at work among the plant communities, climate, wildlife and ultimately human use of the landscape (Swanson *et al.*, 1988). Once these interactions are understood it is possible both to design landforms to start these processes and to use them in design of woodland.

There are four classes of effect:

1. Landform causes environmental gradients such as elevation, aspect, soil moisture and nutrient. In disturbed land reclamation, elevational gradients may be minor but aspect and soil moisture could be important and used to good effect in the choice of species and the human use of the site.

2. Landforms affect the movement of materials, organisms, propagules and energy. This might be the movement of water, people, wildlife or soil. In the case of disturbed land most of these are relevant. The movement of soil may be a problem but equally the accumulation of better material is likely to favour better growth, so that variations in the landform structure will control this and lead to further microsite variation and varied vegetation growth.

3. Landforms affect natural disturbances other than those caused by geomorphological processes. Wind movement is a typical example, with landform affecting the way it moves and those places sheltered from it. Fire is another type. The wind is always an issue in Britain, and more varied terrain is less likely to experience severe windthrow among trees planted on it than simple landform.

4. Landforms affect the pattern of small scale or local geomorphological processes that happen within the timescale of ecological processes. Landslide is one of these and a particularly relevant one where disturbed land is concerned. However, the varied landform will enable this to be more predictable and can even use it as part of the design, for example allowing sediment fans to accumulate gradually in controlled locations. Vegetation binds some of the surface but unless roots are very deep the loose material and the water that lubricates landslides cannot be stabilised this way. Such controlled movement could be considered a kind of safety valve, reducing the need for elaborate engineering and minimising the risk of large movements.

Landform design

Good landform design has to start with two considerations: the objectives for which the landform is being designed and the limitations or opportunities presented by the material. The objectives should encompass all phases of restoration through to the final end-use. For example, the objectives for a complete open-cast coal operation may include:

- Profitable extraction of economically workable coal reserves.
- Burial of contaminated surface deposits.
- Production of a land surface that links into nearby contours and drainage systems.
- Restoration of the site into a community woodland to include a water feature, open spaces suitable for a number of activities, grassland, heathland, woodland and wetland habitats.
- Low maintenance of the final after-use.

Once such objectives have been defined, the requirements for the after-use can be incorporated into the whole cycle of excavation, coal extraction and restoration. Suitable soil-forming materials can be laid aside, landform can be designed to promote a drainage pattern, to offer various possibilities for use by people and to provide an uncompacted substrate for planting. This design has to be quite subtle in its macro-relief and its micro-topography as described above.

Types of substrate

The landform to be created will vary with the type of substrate available, the source of material and the type of disturbance. Below are some examples.

Opencast coal spoil

With this type of working a large overburden of material is not usually a problem. The substrate usually consists of shale and other inert but unweathered material. It is frequently possible to achieve a good blend of landform into nearby natural contours. The approach to design should incorporate an analysis of the local contours from a 1:10 000 map. This will reveal the degree of contour sinuosity and the subtlety of the variations in slope, which should be emulated as far as possible in the restoration design. Large box scrapers may not be capable of laying down the material to the subtlety required, and also compact the surface very badly. The recent increase of loose tipping (Moffat, Paper 4) is to be encouraged, in which case it is perfectly possible to add the variations in surface modelling described here.

Water movement is another consideration. It is very important on opencast sites to install silt control before water reaches streams off-site. It is possible to avoid the engineered alignments and profiles often produced in favour of a more natural pattern including meanders, mini-flood plains and silt ponds with varying depths. These will more easily colonise with vegetation that will help filter fine particles and will cope better with fluctuations of water flow, thus reducing the risk of erosion, scouring and washout. Natural watercourse structures are better at controlling floods than canalised systems, so it makes sense to restore old ones, or to emulate natural patterns in the creation of new ones.

The landform design should also consider the after-use, for example if public access is to take place. Landform design can create a sense of enclosure, natural routes through a landscape and places that lend themselves to uses of various sorts such as ball games or all-terrain bikes. Landform can also be used to manipulate microclimate by creating sheltered areas or places likely to hold water or be wet. Slope gradient is unlikely to be steep but local steep sections should be of naturally sinuous cross section. Loose tipping should be used to create the small scale landform variation.

Deep mined coal spoil

The heaps of spoil created by deep mining have already been restored in many places. The bland landforms that have resulted can often look out of place, and present real challenges to the designer. The profiles have frequently been limited by the quantity of spoil dumped on restricted sites. This has led to steep slopes at their maximum angle of repose which are prone to erosion.

In situations where there is more land available surrounding the tip, the spoil can be spread out and the steepness of the slopes reduced. The shape of the landform can be made more varied and naturalistic even where the artificial hill formed by the spoil is not a natural feature of the locality. To do this the designer or engineer should take the basic contours and use a smaller scale map to add in finer detail. Digital terrain models available with some computer packages are very useful, and allow landform designs to be evaluated from a range of vantage points.

Other spoil heaps

The design or redesign of other types of spoil such as ironstone, oil shale, china clay or demolition rubble should follow the principles described above. Each type of material has different properties of drainage, slope stability and soil forming capacity, and will need to be examined on an individual basis.

Gravel workings

Gravel workings create holes rather than hills and have different landforms as a result. The type of design depends on whether the workings are flooded or are available for tree planting. Some sites are complexes of wet and dry areas. Where water bodies are to be created, the design of the underwater contours should follow those found in natural ponds and lakes. These vary in depth and slopes under water allowing different aquatic habitats to develop. Gradual slopes allow a gradient of plants to follow the natural progression starting with the floating types in the deeper parts, then submerged ones, partly submerged, emergent and finally those that grow in wet soil. In other places steep slopes allow deeper water to come close to the land so that the edge trees are able to overhang and cast shade on the water. Plan views of natural water features tend to show more convolutions with increasing size, promontories and islands being more typical of larger waterbodies. As gravel pits can be of considerable size this increases the need for irregular

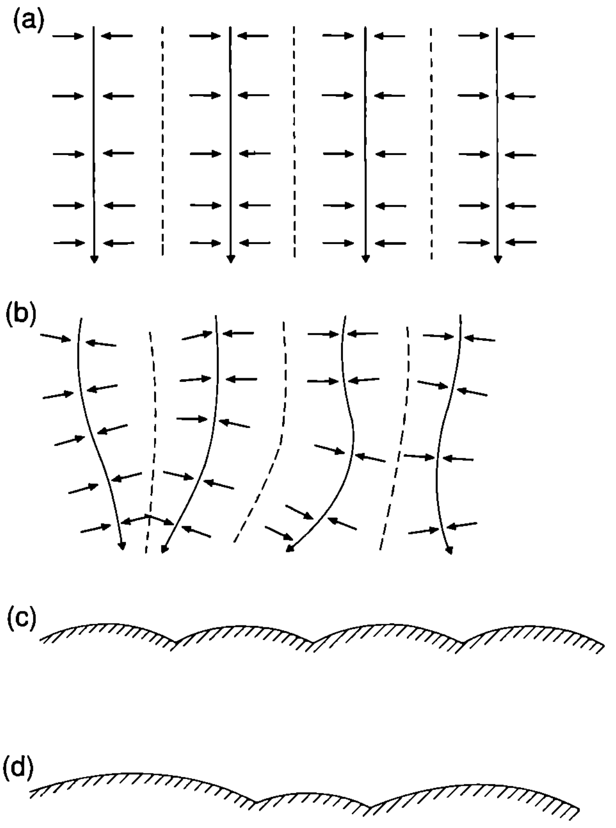

Figure 5.3 Ridge and furrow layout. (a) This provides good drainage but is artificial if laid out too evenly. (b) Varied width, direction and height to reduce the geometric character. (c) A section of a regular ridge and furrow layout shows equal height, equal distance and equal slope angles. (d) Varied height, width, distance and slope angle to give a more relaxed and natural appearance

plan shapes. The best way to achieve this is by working the gravel towards an end design rather than by returning at great expense to remodel the pit after work has ceased.

On sites where tree planting is intended it has been common practice to create a more freely drained topography using large ridge and furrow patterns which have tended to result in intrusive parallel linear shapes Figure 5.3 (a), (c). The landform can be designed differently by varying the width, direction, and height of the ridges 5.3 (b), (d) while maintaining their drainage characteristics.

Brick pits

The same design approach is relevant for brick pits due to be left flooded. Many of them may be deeper than gravel sites so good underwater profiles design is important for safety.

Landfill sites

The use of voids, resulting from any of the extractive industries, as landfill sites for refuse disposal is increasingly important. If landfills are properly capped they can be used for tree planting but frequently the resulting landform is very simple and bland, usually a gentle dome. The right kind of small scale topographic variation could be achieved by adding greater depths of fill where denser tree areas are needed and reducing thickness for open areas. This would fit into most landscapes where landfills are prevalent, as well as providing enclosure and attractive landform for human use.

Conclusions

If considered properly, and with a deeper understanding of natural topography, fractal geometry, the properties of the materials used and the desired end result, it is perfectly possible to design landforms for disturbed land that are more natural as well as more useful. The approach advocated here requires that designers and engineers break away from rigid, 'geometric' thinking that leads to geometric and dull results in favour of creative, open-ended, 'fractal' or 'organic' thinking.

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Chapter 6

Natural versus artificial methods of woodland establishment

Tony Kendle

Introduction

It is possible to identify a spectrum of methods of tree establishment which exhibit increasing 'artificialness' as opposed to naturalness, but to clarify this issue it is first worth identifying what is meant by the concepts of 'natural' and 'artificial'. The landscape is often graded in terms of natural, semi-natural or artificial in relation to the extent to which humans have had an influence on the distribution and content of habitats and species. Natural landscapes are those which have had no substantial human impact. We have almost none of these left in the UK because of the high population and long history of intense land-use. Semi-natural habitats are those which have been influenced by management and exploitation, such as coppicing, but where there has been no direct control, through planting, of species composition. The most artificial landscapes are those where plants have been introduced, especially hybrids or exotics, and arranged in geometric patterns that over-ride local variation in soils and micro-climate (Green, 1990).

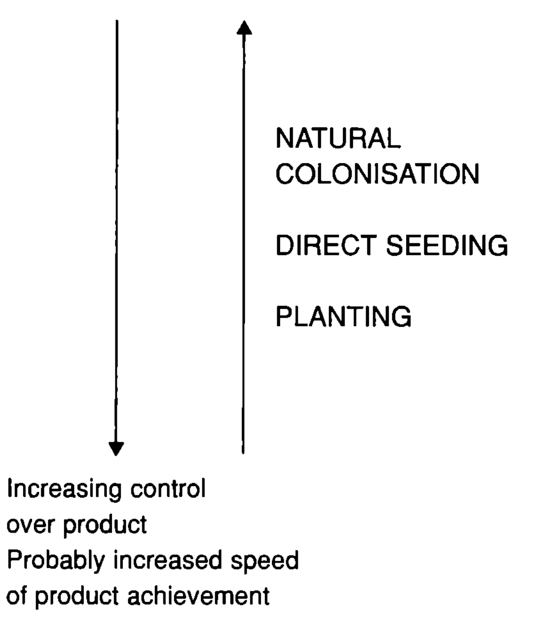

Figure 6.1 Woodland establishment in terms of naturalness

It is clear therefore that different methodologies of woodland establishment can be positioned in terms of their naturalness (Figure 6.1). However another vitally important concept is to recognise that for some forms of land-use, 'naturalness' is itself a quality that is valued. This is particularly the case for nature conservation. The argument is that human impact can always be added to land, but it can never be taken away again. Natural landscapes are therefore a finite and declining resource that are deserving of the highest protection (Shafer, 1990). In countries that do have natural sites the term 'semi-natural' is almost derogatory. However, in the UK, ancient semi-natural woodland is regarded as the cream of conservation sites (Green, 1990).

A point to note, therefore, is that the terms 'natural' and 'artificial' can apply as much to the woodland product, as they can to the process of woodland creation. Indeed as we shall see later, it is becoming increasingly important that this distinction between process and product is made.

Nature conservation values in woodland creation

Today the multiple benefits of woodlands are heavily promoted. Many foresters are keen to include conservation as a secondary, or sometimes primary, benefit of woodland creation in conjunction with timber production. As with any land-use, the quality of a woodland site for nature conservation can be defined in broad terms, and objectives can be expressed in the forms of targets (such as naturalness). However, the nature of some of these targets can sometimes be surprising until it is recognised that often in woodlands the nature conservation benefit does not reside primarily in the trees, but rather in the associated birds, animals and wild flowers. The trees are the *framework* that make the woodland habitat, but their own performance may not be a primary concern. In fact, the conservation value of some woodlands increases as the commercial timber production potential falls. For example, dead wood and even hollow trees are important for invertebrates (Kirby, 1992).

Often the woodlands that have high conservation value are those that exhibit diversity, not just in tree species but also in form and patterning. Structural diversity, with a range of canopy heights, and also a rich mosaic of wooded and open ground, is particularly valuable for many animals, especially invertebrates (Kirby, 1992). Low productivity is also often an advantage since these seem to favour the survival of a wider range of plants by maintaining opportunities for poorly competitive species (Grime, 1979). The conflicts with high efficiency, high return forestry systems are obvious and have been well summarised by Green (1990):

If the amenity land manager is ever in doubt as to his best course of action, he has merely to think of what a modern farmer or forester would do, and do the opposite. His objective is to make one blade of grass grow where two grew before.

Therefore evaluation of the success of a method of woodland establishment cannot be undertaken without a clear focus on the intended after-uses.

What are the possible advantages of naturalistic approaches?

The specific advantages, and disadvantages, of the more natural methods of woodland establishment are reviewed in Box 6.1. The need to protect local genotypes has risen high on the agenda of some conservation organisations in the light of increasing global concern for biodiversity protection at all levels (Akeroyd *et al.*, 1995). Protecting local plant forms may in turn benefit locally co-adapted insects, although the effect is difficult to quantify (Kirby, 1992). However, it is necessary to apply some pragmatism to the issue. There has to be doubt as to whether many vulnerable local ecotypes still exist given the complexity of genetic origins of tree stock planted historically in the UK and the high probability that non-local genotypes have been introduced well within the pollen transfer ranges of most native stands.

Another benefit of naturalistic techniques is that short-term costs on tree stock and planting can be avoided. In some cases woodland stands can be produced almost without management inputs, if the site conditions and supply of seed are favourable. Indeed, the experience and theoretical framework of plant succession devised by ecologists suggests that if managers are in no particular hurry and have no particular set objectives then the movement to woodland on almost any site in the UK is inevitable (Rackham, 1986). However problems arise as soon as there is any concern over the composition of the stand and the speed of achievement of the woodland cover and in many cases additional inputs are required that reduce or eclipse cost savings.

The basic problem is that woodland establishment by natural colonisation is a very variable process. There are relatively few studies on recycled or ex-industrial land, but these sites would be expected to show even greater variability. Hodge and Harmer (1995) report that in a survey

Box 6.1 The limitations and advantages of natural colonisation (from Corder *et al.*, 1986; Hart, 1991; Evans, 1988)

The limitations of natural colonisation

- Losses due to predation, desiccation and shading
- Unpredictability of germination
- Lack of control over content or density of stand unless there is management
- Difficulties of weed control
- Possibly slow early growth relative to competing vegetation

The advantages of natural colonisation

- The species that colonise have shown an ecological and physiological match with prevalent site conditions (which may bode well for future regeneration).
- There is likely to be more localised variation in species composition reflecting differences in the site edaphic status.
- The effect is more 'natural' and therefore more acceptable for many conservation purposes.
- There *may* be greater potential for encouraging local genotypes and thus helping to maintain a wider genetic range within a native plant species population. (However there may also be greater success of some species that are often seen as undesirable, such as *Acer pseudoplatanus*.)
- Some species may establish more successfully from seed than transplant.

of 47 urban and post-industrial sites that had been abandoned for between 10 and 40 years the three species *Fraxinus excelsior, Betula pendula* and *Crataegus monogyna* comprised 85% of the colonising species. They also found that the colonisation ranged from extremely dense (30 650 trees ha^{-1}) to very sparse, with only 19% of the land having 'adequate density', and with the results often being slow and unpredictable. They found that natural colonisation was most successful on land which was infertile enough to prevent the establishment of a rank competitive ground layer, but not so hostile that even trees could not grow. The sites studied had an average of three tree species.

Nevertheless, there are some distinct value judgements incorporated in such an assessment of 'success', and the diversity of woodland structure described could be expected to be of conservation value and more 'natural' (Corder *et al.*, 1986). The required levels of intervention, and therefore costs, depend on the degree to which the forestry manager's vision of the site deviates from the reality of what has been achieved.

Hodge and Harmer (1995) also proposed that some techniques could be used to increase the likelihood of establishment (such as ground preparation) and also to alter the proportions of specific tree groups (such as the use of bird perches to favour colonisation by fleshy-fruited species). These types of intervention can be argued to reduce the 'naturalness' of the product, but are usually more acceptable for conservation managers than planting or plant introduction.

Derelict and recycled land has certain advantages when it comes to woodland establishment by seed. There is often a low fertility and an absence of competing vegetation. There may also be small initial numbers of grazing herbivores or seed predators. However, the sites are also notoriously variable in their edaphic character, both horizontally and vertically, and, as such, consistency of establishment can be poor (Moffat and Buckley, 1995). Because they are often situated in areas of industrial activity, the sites may be a long way from established stands of trees of seed-bearing age. There may be a lack of seed dispersing vectors and supporting organisms such as symbiotic mycorrhizae (Allen, 1991).

Soils on derelict land may also be deficient in both organic and readily available nitrogen (Bradshaw and Chadwick, 1980). Nitrogen-fixing tree and shrub species may be potentially important colonists, but establishment can be limited by an absence of symbiotic bacteria and slow dispersal of large seeds. The primary colonists are therefore often wind-dispersed species with good tolerance of low productivity, such as *Salix cinerea.* These small seeded species are very sensitive to hostility or poor germination conditions at the soil surface. The compounding effects of these different types of variability therefore help to explain why some derelict land sites have shown almost no tree colonisation over long periods of time.

Table 6.1 Monitoring of direct seeding (from Harmer and Kerr, 1995)

Species	Site 1		Site 2	
	Seed sowing density (no. ha^{-1})	Seedlings present after year 1 (%)	Seed sowing density (no. ha^{-1})	Seedlings present after year 2 (%)
Sycamore	25 000	7.6	30 000	14.6
Norway maple	15 600	-	20 000	-
Field maple	5 500	0.2	-	22.5
Ash	35 100	27	40 000	-
Oak	10 000	4.1	-	-
Wild cherry	9 800	1.5	-	-
Hazel	2 300	-	-	3.7
Beech	-	-	10 000	-

One way of overcoming the constraint of seed dispersal onto new woodland sites is to introduce seed. Direct seeding decreases the 'naturalness' of the woodland establishment process. Seed collected from local native stands will be preferable to imported seed of hybrid genotypes. In return for increased inputs there should be higher rates of establishment or more control over the composition of the woodland product. However, experience again shows that the success rate of direct seeded stands can still be extremely variable (Table 6.1).

The variability reflects the very high losses that can occur with tree seed, which arise from several sources, most notably predation, inadequate climatic conditions during vulnerable seedling stages and competition from established vegetation. Of course, these variables also affect naturally colonised seed, but it is usually much harder to quantify the huge losses that occur. The very fact that inputs, in terms of seed and site preparation, have been made will mean that failures are more acutely felt.

In some cases opposite problems may occur. Establishment density can be so high that managers choose to undertake thinning programmes to ensure an even stand. The costs of natural colonisation and direct seeding are therefore variable and depend on site and climatic vagaries and also the extent to which the manager has set firm targets of the rate and nature of the woodland development. Likely management operations are detailed in Table 6.2. Nevertheless, some authors are confident that it is a cheaper and often more reliable technique for woodland establishment even on difficult sites (Corder *et al.*, 1986).

Another problem with use of seed as a tree establishment method on recycled land is that often there are delays in plant emergence and establishment. This can throw the bulk of the critical management inputs outside of the typical 5-10-year aftercare period found on many reclaimed sites (Table 6.2).

Table 6.2 Operations which may be needed to ensure rapid woodland establishment within 15 years (from Harmer and Kerr, 1995)

	Natural colonisation	Direct seeding	Planting
Years 1-5			
Deer/rabbit fencing	++	++	++
Individual tree protection	+	-	++
Plants	-	-	++
Ground preparation	++	++	+
Vegetation management	++	++	++
Years 5-10			
Individual protection	+	+	-
Plants	+	+	-
Ground preparation	+	-	-
Vegetation management	+	+	-
Thinning	+	+	-
Maintenance	+	+	+
Years 10-15			
Individual protection	+	+	-
Plants	+	+	-
Ground preparation	+	-	-
Vegetation management	+	+	-
Thinning	+	+	-
Maintenance	+	+	+

Planting - artificial techniques but not always artificial targets

Despite the inevitability of woodland establishment on many sites, the science and technology of forestry establishment using transplants was not developed without reason. Transplants allow the most vulnerable phase of seedling growth to be managed under controlled conditions in a nursery (Thoday, 1983). Planting also allows precise control over the genotypes of the planting stock and the density and patterning of that stock over the countryside. When uniform high productivity crops are required it is the obvious technique to choose. Although costs are unavoidable, the greater control usually means that they can be planned for and minimised through well-targeted inputs.

Typical forestry planting for timber or pulpwood production, involving uniform density monocultures of planted exotic stock, would be regarded as the most artificial option for woodland production. However, we are also seeing more complex issues arising with the interesting trend towards the establishment of woodland plantations, for amenity or conservation purposes, that mimic semi-natural native stands. In fact, this tradition has long been established in landscape work. Origins can be traced back certainly as far as the English Landscape Movement when designers such as Capability Brown tried to produce perfected landscapes which still echoed the character of the UK countryside (Bisgrove, 1990). New levels of sophistication were reached in this century with a European interest in naturalistic landscape styles on sites ranging from motorways through to urban nature parks (Goode, 1995). In the UK, a growth in professional interest in this approach coincided with the development of the last phase of new town settlements. Much of the pioneering work on techniques in native woodland establishment was developed in places such as Milton Keynes and Warrington where highly complex planting mixes were developed to represent different woodland conditions (Table 6.3). These were often referred to as 'ecological' planting styles (Moffatt, 1986). As well as species diversity, the aim was also to create high structural diversity with glades and multilayered woodland edges (Box 6.2, Table 6.4).

The origin of this wish to create more native woodland is complex. Obviously the superficial wish is to provide opportunities for town dwellers to experience the beauty and richness of semi-natural woodland. However the assumption that such an experience needs to be deliberately provided reflects a growing feeling that the natural habitat resource of the country is declining. In the last decade this concern has become more formalised through the appearance of increasingly interventionist national and international nature conservation policies that demand habitat restoration as well as conservation.

There is a growing awareness that existing conservation strategies that are based on the identification and protection of isolated sites are probably inadequate. Improved understanding of conservation ecology and population dynamics suggests that fragmentation of the countryside is likely to increase vulnerability and risk for the remaining patches. Many of the existing conser-

Table 6.3 Species category composition for structural tree and shrub belts used in Warrington New Town. Source: Moffatt (1986)

Planting category	Planting belt width			
	30 m	20 m	10 m	<10 m
Woodland	30%	10%	5%	-
Light demanding	30%	40%	20%	10%
Tall edge	20%	25%	50%	65%
Low edge	20%	25%	25%	25%

Table 6.4 Species composition of the ecological planting categories of Moffatt (1986): approximate percentages

Species	Woodland mix	Scrub mix[a]	Tall edge/ hedgerow mix	Light demanding mix	Low edge mix[a]
Corylus avellana	25	0-15	17.5	22.5	0-30
Quercus robur	25				
Alnus glutinosa	20		10	17.5	
Fraxinus excelsior	20				
Ilex aquifolium	5	0-15		5	0-20
Prunus avium	5				
Pinus sylvestris	5			2.5	
Sambucus nigra	2.5	0-15	5	7.5	
Ulmus glabra	2.5				
Crataegus monogyna		75-100	42.5		0-30
Prunus spinosa		75-100	15		0-30
Rosa canina		75-100			0-50
Ulex europaeus		75-100			0-20
Viburnum opulus		0-15			0-20
Acer campestre			5	10	
Lonicera periclymenum			5		
Salix caprea			2.5		
Betula pendula				17.5	
Sorbus aucuparia				17.5	
Populus tremula				5	
Rosa arvensis					0-50
Cornus sanguinea					0-20
Rosa pimpinellifolia					0-20
Tree species		0-10			

[a] Where the same range is given the species involved can be selected interchangeably.

vation reserves are believed to be too small, and authors such as Shafer (1990) have argued that unless nature conservation can be strengthened outside protected areas it has no future within them. At the same time political initiatives such as Agenda 21 have made biodiversity protection a high priority and have encouraged governments to set targets for species survival that imply in some cases measurable improvement in population numbers (UK Biodiversity Steering Group, 1995).

New government policies for environmental conservation have therefore often included clear incentives for creating more habitat, rather than just trying to manage what still exists (Newbould, 1990). For example, payments associated with Environmentally Sensitive Areas, and initiatives such as the Countryside Stewardship scheme include subsidies to land managers for creating new habitats (Box and Parker, 1995).

Another important development has been changes in planning legislation such as the policies associated with mitigation for environmental impact of large developments. In many cases planning authorities will look for direct compensation of losses of sites of nature conservation importance through investment in activities such as habitat translocation, restoration or compensatory habitat creation.

Thus, there has been an evolution in the professional interest in planting new woodlands for conservation and amenity. The targets for such projects can be set at several different levels depending on the circumstances (Table 6.5). In some cases woodland is to be created which has just the ambience of a native woodland, with no particular concern for the detailed species content. In other cases a woodland is to be created which has the characteristics required to develop diversity, such as having structural complexity and a wide range of tree species. In yet other cases it is deemed necessary that the woodland fits within specific local plant community types. In very sensitive projects ecologists may be working to recreate defined plant communities down

Box 6.2 Descriptions of the ecological planting categories of Moffatt (1986)

'Woodland' mix
1 m centres
Trees in groups of 10-50
Shrubs in groups of 5-10
Alnus and *Corylus* planted randomly with occasional groups

Scrub mix
0.75 or 0.5 m centres
Main species planted in groups of 5-30
Additional shrubs and trees randomly planted
Forms blocks detached from other planting mixes

Tall edge/hedgerow mix
1 m or 0.75 m centres
Groups of 5-50 *Lonicera* planted randomly
Frequently used as edge mixture
Percentage of *Crataegus* increased when used as a hedge

Light demanding mix
1 m centres
All species in groups of 5-100
May occasionally form edge to a planting
Mostly group coppiced on a rotation

Low edge mix
0.75 m or 0.5 m centres
All species in groups of 5-30
Percentages and combinations used very flexibly with great attention paid to small scale variation

to the level of the herbaceous ground flora species (see, for example, Packham *et al.*, 1995). The objective may be to produce precisely defined target plant communities modelled on the examples that existed prior to development, or on parallel woodland types in the local area (Buckley, 1990; Jordan *et al.*, 1990). Increasing concern is being expressed that some of these very complex mixes should be authentic to the level of local genotypes or subspecific races (Akeroyd *et al.*, 1995).

Herein lies the paradox: the more ecologists begin to chase after specifically defined products, and particularly the more often they work to the timescales of planning mitigation where success is measured in years rather than decades or centuries, the more they will be tempted to adopt the technology of plant production and establishment developed by foresters and agronomists for other goals. When there is a closely defined product the more 'natural' processes of woodland creation, such as natural colonisation, may be of limited use since they present problems over the lack of control of species composition, colonisation of undesirable species and the prolonged and unpredictable timescale required.

It follows from these high-input approaches that concepts such as 'naturalness' are no longer of overriding importance in conservation planning. Perhaps this is inevitable. Human impacts are becoming more and more pervasive. For example, atmospheric pollution potentially affects all ecosystems. The scale of threats to biodiversity, such as climate change, may rapidly lead to an exceptional rate of extinctions (Western and Pearl, 1989) and these can only be reduced by carefully targeted interventions that directly address shortfalls in species population sizes and distribution patterns. For example, isolation of subpopulations of a species may lead to inbreeding and genetic decline, and perhaps the most cost-effective way to overcome this is to undertake a managed programme of artificial dispersal and reintroduction. It can therefore be argued that we must sacrifice naturalness or sacrifice nature.

However, even when an interventionist policy has been established, it is not necessarily easy to implement (Bradshaw, 1987). For example, a planting programme may produce a product that mimics native woodlands, but it is difficult to be sure that these new communities are self-sustaining systems that are capable of reproduction. This may not matter when creating a naturalistic plantation in an urban park but is clearly crucial if a project is attempting to mitigate for the loss of an ancient site of high conservation value (Kendle, 1992).

The seedling stage of plant establishment is the most vulnerable and best reflects the relationship between plant and site conditions. Green's point quoted above about the need to develop very different techniques to commercial forestry embody a key truth. Most semi-natural plant communities of value and distinction owe their character and composition to site conditions which allow some species to germinate and, more importantly, keep their competitors out. We can grow thousands of taxa under UK conditions as long as we control competition, but very few of them are able to survive on their own.

Forestry and agronomy techniques are based on the idea that we create optimum germination or growth conditions, and use weed control technology to favour those plants we want. Self-maintaining diverse woodlands *need* sub-optimum conditions, but establishment processes and growth may therefore be slow, erratic and variable (Grubb, 1977). The worst scenario is that a mitigation project will be so driven by the need to demonstrate short-term success in terms of the establishment of introduced transplants that a methodology is adopted which in fact undermines long-term success.

Some of the technical and also conceptual problems thrown up are therefore extremely complex. This is particularly so in the case of recycled or derelict land where atypical soil conditions are found. For example, Rodwell and Patterson (1994) provide target recipes for woodland creation relative to the major plant communities typical of UK conditions. It is not at all clear whether mine waste spoils, for example, will be capable of developing communities that have similar characteristics to these semi-natural types.

Despite these vagaries, it is certain that recycled land will be the target location of much of this 'artificially created nature'. Multi-purpose forestry initiatives, such as the New National Forest, are heavily weighted onto ex-industrial sites. Significant advances on large scale woodland initiatives are easier to encourage on such land than when working through small landowners. Mineral developers are also more prepared to balance the need for short-term economic return from land against the strategic advantages of responding to current planning priorities. Increasingly they will become subject to mitigation demands working through planning policies that require them to reinstate species-rich ecological communities, and to do it quickly.

The ultimate irony is that because of their combination of infertile, extreme and variable soil conditions and topography, many abandoned derelict sites have developed woodlands and other habitats which have a rich species content and fascinating variation in species patterning and age distribution (Gemmell, 1982). Although they are recent and come as a result of extensive human disturbance, they are in many ways natural and valuable. Many have been designated as sites of local or national conservation importance. Unfortunately these communities will probably not be allowed to develop in the future because of more rigorous planning controls enforcing rapid reclamation.
If we require that woodlands with a strong conservation focus have to be developed quickly, and with what is arguably unnecessary control over species content, there is a risk that there will be the application of techniques that can actually mean that the long- term diversity and conservation value are undermined. Uniform tilths for seed germination, comprehensive site drainage, higher standards of soil reinstatement and other inputs may lead to agronomically improved and yet ecologically impoverished sites (Kendle, 1992). The costs are also likely to rise.

We have seen therefore that it is impossible to separate the method of woodland establishment from the objectives. When conservation is an objective new techniques are required that build upon the fundamental ecological principles of how diversity develops in ecosystems. Hopefully researchers will begin to focus more on these principles.

Table 6.5 The possible goals of an 'ecological' woodland creation project

- Low productivity?
- Structural diversity
- Species diversity
- Native species (or even regional types)
- Species typical of named National Vegetation Classification class
- Complete restoration of complex community

Conclusions

Different techniques of woodland establishment can be categorised on a spectrum between natural and artificial. The results differ in terms of the speed and predictability of establishment but this distinction is more than technical. The choice of method actually imparts or reflects qualities which are in themselves of value for some land-uses.

The greatest danger with the development of multi-purpose forestry is that the different objectives can get muddled and confused. In many ways this is most likely with conservation, since it seems to be a vague concept that is easy to add, almost as an afterthought, to the list of goals.

There is a critical distinction between nature conservation and just encouraging some wildlife. Conservation embodies some complex concepts, but there are measures of quality that can be determined. A true contribution to the conservation status of new native woodland is only possible through an understanding of what aspects of nature are most valued, and what are the processes by which these aspects are developed and maintained on some sites and not others.

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Chapter 7

Landfill sites: is it really safe to plant trees?

Elizabeth Simmons

Introduction

Waste Management Paper 26, *Landfilling wastes* (Department of the Environment, 1986) stated that 'trees should not be allowed to grow on lined landfill sites, or where water input is regulated by an impervious cap or membrane'. The reasons given were that:

- tree roots could penetrate through an engineered cap and would thus compromise control of water ingress into waste and allow escape of landfill gas;
- shallow rooting in trees on landfill sites could increase the risk of trees blowing over, thus disrupting pollution control measures;
- conditions on landfill sites could adversely affect tree survival.

The result of this guidance has been a general reluctance to plant trees on containment landfills. Very few landfill sites have been recently restored to woodland, and even proposals for limited tree and shrub planting for landscape integration have been viewed with suspicion.

The guidance was not helpful in promoting high standards of landscape and restoration design for landfill sites. There are a number of valid technical reasons why landfill restoration is frequently not as good as the restoration of mineral extraction sites which have not been landfilled. These stem from the difficulties posed by the decomposition of the fill. But the full potential for landfill restoration has rarely been reached, due in part to the limitations placed on the range of potential after-uses and the landscape design by the existing guidance on tree planting.

When the guidance was published in 1986, many local authorities, especially those with derelict land reclamation experience, or with arboriculturists on their landscape staff were successfully growing trees on their landfill sites. A few private operators were too. Where arboricultural advice was available, either in-house or from the Forestry Commission, the correct techniques could be employed to overcome many of the difficulties caused by the conditions on landfill sites which adversely affect tree growth. However, at that time few capped sites were being restored, so the question mark remained over the potential for harm represented by the tree roots on such sites.

Research sponsored by the Department of the Environment

In June 1991 the Department of the Environment Minerals and Land Reclamation Division, in conjunction with the Wastes Technical Division, engaged the Forestry Commission to investigate whether tree roots could or would adversely affect pollution control systems, particularly an engineered cap. They were also asked to identify the particular problems associated with establishing trees on landfill sites and how they could be overcome. The result of this work was the publication in 1993 of the 'Green Book', *The potential for woodland establishment on landfill sites* (Dobson and Moffat, 1993).

It is now fairly well known, as a result of this research and the publication of the report, that the rooting pattern of trees is such that tree roots are unlikely or unable to penetrate a well-constructed clay or membrane cap. The majority of tree roots, regardless of the age of the tree, are found in the top 1 m of the soil. Trees having root systems deeper than 2 m are comparatively rare. Tree roots spread out laterally from the trunk to give maximum stability and anchorage to the tree as it grows, exploiting the nutrients and aerobic conditions to be found in the topsoil. Compaction and anaerobic conditions are both very effective impediments to root growth. Thus, it is not surprising that trees find little incentive to root down through a compacted clay layer into the anaerobic and toxic environment of the decomposing landfill.

The 'Green Book' made recommendations on silvicultural practices which confirmed and supported the practical experience of land reclamation officers on how to successfully grow trees on landfill sites. It also made specific recommendations in terms of soil depths over clay and membrane caps of 1 m and 1.5 m respectively to ensure a sufficient moisture supply for tree growth and to protect the clay capping layer from possible drying out. A minimum soil depth of 1 m was advised to encourage deeper root penetration and reduce the risk of windthrow. The Forestry Commission also advised the following:

- a clay cap bulk density of 1.8-1.9 g cm^{-3} (required to achieve the permeability factor of 1×10^{-9} m s^{-1} recommended by the Department of the Environment);
- loose tipping of soils to encourage the trees to exploit the full soil depth;
- a coarser drainage layer above the cap to further discourage rooting into the cap.

With these controls in place, there was considered to be very little danger of the tree roots adversely affecting the capping system. More recent research, carried out as an extension to the first contract, has confirmed this earlier conclusion. Local authorities and private operators are currently planting trees on containment landfill sites, and developers and planning authorities are lifting their sights a little higher than sheep pasture as the inevitable after-use for landfill sites.

Some common concerns

However, there is still a very big question over whether it is wise or indeed really safe to plant trees on landfill sites. There are a number of very good reasons for this viewpoint.

Subsoil volumes and availability

The current advice in the 'Green Book' recommends very significant depths of subsoil, especially on sites capped with compacted clay. This minimum recommendation of 1.5 m applies for both trees and shrubs, in all areas of the country. Theoretically this may not be a problem, but the practical implications may be severe. If the site has an abundance of available soil there may be no problem at all, but these sites are likely to be former green field sites with a presumption for restoration to agriculture, not woodland. Sites where woodland, or amenity with a substantial proportion of tree planting, would be suitable after-uses are likely to be deficient in soils. Quantities of soil required for restoration may be very large: a 10 ha site (not large in landfill terms) with no on-site soils, which is to be fully restored to woodland will require some 15 000 HGV loads in (and out) of the site. This is equivalent to a 15 ha green field site stripped to a depth of a metre. Importing this volume of soil may cause significant environmental harm and social disruption. At the very least, it is probable that the restoration of the whole site will take a long time, possibly more than one season, especially where there are other demands for soil. An operation to screen materials to give soils suitable for restoration has its own inherent environmental impact in terms of noise, dust and visual intrusion, and of course an even greater volume of material must be brought to site to yield the required volume of soil. It is possible that the Landfill Tax will have the effect of reducing the amounts of subsoil which will be available to restore those sites which have very little on-site soil.

In such situations, it might be considered wiser to restore to an amenity after-use which requires less soil. Of course, a mixture of tree planting and open grassland will reduce the volume of subsoil required, but perhaps we should also consider whether 1.5 m subsoil is essential in every case. Scrubby woodland and native shrubs are frequently very suitable for landscape integration, excellent for amenity and wildlife, and less susceptible to windthrow than taller-growing trees. There are many areas of tree and shrub planting, especially in the wetter areas of the country, which are establishing successfully on 1 m (or less) of subsoil.

Cost of restoration

A likely consequence of a decision to plant trees and to maintain them for at least five years, even if the planning authority does not seek to impose a Section 106 Agreement for extended aftercare, will be increased costs of restoration and aftercare for the operator. Costs relate to importing and spreading soils, planting stock, planting operations, maintenance, beating-up and fencing. It is, of course, important to ensure that the operator is not permitted to compromise the standard of restoration and aftercare by proposing what may be perceived to be less expensive after-use options.

The economic return from trees planted on landfills will be slow, if it comes at all, and it may be wiser to choose an alternative after-use.

Landfill gas control systems

If one accepts the research on rooting habits, which shows that tree roots are very unlikely to penetrate a well-constructed cap, the most serious question over tree planting on landfill sites relates to the potential effect of trees on landfill gas control systems. Given the robust and durable materials which are used to construct permanent landfill gas systems, and the nature of the gases which they carry, it would appear to be very unlikely that tree roots would cause physical damage to the system itself. However, there is little doubt that trees could increase the difficulties of installing and maintaining the landfill gas control system. These difficulties will be compounded if trees are planted soon after cessation of landfilling.

Planning conditions frequently place an obligation on the operator to restore the site on completion of landfilling. Soil spreading, cultivation and seeding are usually required within a year of completion of landfilling. If the restoration design includes tree and shrub planting, this follows in the first available planting season. On some sites, grassing tree areas before planting is considered detrimental to tree establishment, leaving the way open for tree planting during the first 12 months after the site, or that phase of the site, is closed. This timetable has the inevitable consequence of placing tree planting operations and maintenance in the same time slot as the installation of the gas control system on those sites which require one.

Landfill sites which contain biodegradable wastes, and which are therefore likely to require a gas control system, will settle as the wastes decompose. This settlement is known to have a detrimental effect on landfill gas pipe systems and wells. Pipe runs can settle, which leads to a build-up of condensate in the low sections and prevents efficient removal of the gas from the site. It may also cause wells to distort, and may damage pipe fittings and connections. Remedial work to the gas control system is then required to maintain its efficiency. To carry out these works, the gas engineers must have access to all sections of the system, which may involve extensive excavation to expose and relay pipes, access for drilling rigs and compressors to re-drill wells and other heavy plant for associated works.

If trees and shrubs have been planted where gas control systems have been, or are likely to be, installed, these remedial works will almost inevitably result in trees being lost, destroyed or so badly damaged that extensive replacement planting will be necessary. Placing constraints upon the gas engineers to avoid or minimise damage to planted areas is impractical and impossible to impose: operators have responsibilities under the Waste Management Licence which they must discharge, and environmental protection must be a priority.

Replanted hedgerows and tree areas will present management problems during the aftercare period because they will be at a different stage than the remainder of the planting, and may require different management operations. Planted areas at different stages will also look unsightly.

Windthrow

There is no practical experience of the long-term effects of planting trees on capped landfills, and we cannot say what the effects of windthrow might be on pollution control systems, such as landfill gas control systems and the cap. It is possible to conjecture. Tall trees on exposed areas of sites, particularly landraising sites, may blow over in high winds. The root plates may be ripped out of the ground exposing either the cap or landfill gas control pipes. If the roots have grown under gas pipes, they may disturb the fall on the pipe, or damage pipe fittings. Not an encouraging scenario.

It is, however, important to take the time factor into account. How many years will it take for trees on exposed areas to grow tall enough to be susceptible to windthrow, and indeed, will they ever become tall enough? If the site is still bioreactive the operator will be responsible for it, and the cost of reinstating soils over the cap after clearing the trees would not be prohibitive - he might even sell the fallen timber to pay for it. Whether the site *should still* be bioreactive after 30 years is another matter entirely. If the site is no longer bioreactive, the cap and gas control system will have ceased to be essential, so damage may not be a serious problem. However, this remains conjectural, and it may be wiser to choose tree and shrub species which do not grow tall, or an alternative after-use altogether, especially on vulnerable sites.

Why plant trees on landfill sites?

Does this mean that it is not wise or safe to plant trees on landfill sites? I think not. I believe we *should* take the opportunity to plant trees and shrubs on landfills where appropriate. And I believe that there is sufficient information available to indicate how this may be achieved without compromising the integrity and safety of landfill sites.

There are many reasons for increasing lowland tree cover and planting more trees in the countryside, including landscape and ecological improvement, benefits to air quality and so on. In addition, there is one main reason for planting trees on landfill sites, and it is this: public acceptance of landfill as a means of waste disposal depends not only on their environmental safety, but also on their long-term visual appearance. The restoration design must permit a range of after-uses which will integrate the site into its surroundings.

In almost all areas of lowland Britain this means that some trees and shrubs, or hedgerows should be included in the landscape design. A complete ban on planting trees on landfill sites would unacceptably restrict their design and restoration, and would result in a continuation of the prevailing situation where landfills can only be returned to pasture or amenity open space. This creates bleak, featureless and boring restored landscapes that offer little or no lasting benefit to the community and locality. It is also likely to have the effect of placing additional restrictions on the locations for new sites, particularly in the Green Belt, because the restoration proposals will not be able to support many of the Green Belt objectives such as landscape improvement, increasing nature conservation value, encouraging public use and enjoyment.

The right approach

How can we undertake tree planting on landfill sites safely and without compromising environmental protection measures? The approach to tree planting should be tailored to the type of landfill we are dealing with. We are inclined to think of landfill sites as being lined, capped and filled with putrescible wastes. They are not all like this. Older sites which are becoming less bioreactive, and sites containing a large proportion of non-biodegradable wastes, present very different opportunities for tree planting than modern containment sites which have taken a large volume of putrescible wastes and which will require extensive landfill gas control or utilisation systems. Even large modern sites may not be landfilled over their entire area, with peripheral and buffer areas which remain undisturbed. To discourage tree planting on landfills would be to miss out on many opportunities for beneficial planting.

We can consider tree planting proposals in two stages

Stage 1: Pre-planning application

At this stage the type of after-use will be chosen, and the restoration or landscape design prepared. The extent of tree planting should be related to the type of fill and the age of the site. Sites which are not expected to take large volumes of putrescible wastes will be more suitable for large scale planting and woodland establishment. The location of the site should also be taken into account, so that design proposals which are appropriate to the setting can be developed. Urban fringe sites will particularly lend themselves to tree planting and woodland establishment, especially where links can be made with existing urban or community forest or nature conservation initiatives.

Sites which are being developed to take high proportions of biodegradable wastes, and sites in agricultural situations are likely to be less suitable for extensive tree planting or woodland proposals. On such sites a framework of hedges, copses and smaller shelter belt planting is likely to be more appropriate both in landscape terms and in view of the requirements for environmental protection. Opportunities for tree planting on areas of the site which will not be landfilled should be maximised, and such planting may be done before the site becomes operational to give perimeter screening and enhancement.

The design of the tree and shrub planting and the design of the landfill gas system should go hand in hand. This will allow potential conflicts to be identified and resolved. However, at this early stage, it is not possible to accurately predict exactly where pipe runs and wells will be located and some flexibility must be incorporated in the planting design.

Any tree planting proposals on biodegradable sites must be very carefully programmed to fit in with other works on site, particularly the installation of the final gas control system. At the pre-planning application stage the timing of restoration and aftercare, relative to the cessation of landfilling, should be discussed and agreed with the planning authority. It may be appropriate to delay tree planting for some years after the site has been finished and capped to allow the landfill site to settle and the early, frequent remedial works to the gas system to be completed. A programme of phased planting, with early planting on non-landfilled areas and later planting on completed phases of the site should be proposed.

On sites which do not have sufficient on-site soils available for restoration, the operator should put forward proposals for accumulating subsoil for restoration, taking into account the increased depth required in tree areas, throughout the operational life of the site. This will reduce the need to import large volumes of soil after the site has closed, and also minimise delays to restoration.

Stage 2: Post landfilling

When the site has been landfilled to the agreed final contours, or pre-settlement contours in the case of biodegradable sites, the site or phase will be capped. At this time the landfill gas system will be installed if required. The site will then undergo a period of active settlement which will probably result in damage or disturbance to the gas control system, necessitating frequent remedial works. Experience suggests that this period may last up to five years. Even after this time major refits of parts of the gas control system are likely to be required and the tree planting scheme must take this into account. However, after the initial five years, providing the system has been properly designed and constructed, with proper provision for condensate drainage, the frequency of intervention should become very much less, and final restoration and aftercare should be able to proceed.

During the five year period, when the site may have been temporarily restored, the landscape designer and arboriculturist or forester should liaise with the gas engineers to agree the best location for pipe runs, wells, condensate drainage points and any other chambers or elements connected to the gas control system. The need for ongoing access for maintenance and monitoring to different parts of the system should also be identified. Detailed design of tree and shrub planting can then be carried out to produce a planting scheme which minimises conflict with the needs of gas control.

Examples of features which could be incorporated include:

- Wide double hedgerows with enough space between them for an access track running alongside main gas pipe runs and wellheads, valve chambers or manifold chambers; such features would integrate very well in an agricultural landscape.
- Clearings and woodland glades following pipe runs or lines of wellheads to permit access without affecting tree growth; these features are very suitable for sites to be returned for mixed amenity after-uses.
- Areas of the site set aside for open clearings for wildlife habitats or wild flowers within mass tree planting, in which gas or leachate control system elements can be located and screened from view.
- More extensive planting in areas of the site which do not require gas extraction.

Conclusions

It is too simplistic to say one should or should not plant trees on landfill sites. Each site should be considered individually. Some sites, in certain situations, may lend themselves most appropriately to woodland establishment for either amenity, wildlife or commercial purposes. Other sites should be given a more circumspect treatment, with tree and shrub planting, or hedgerows, for landscape integration and landscape improvement objectives. Planting should take place at the earliest opportunity on some sites, but on others it will be beneficial, or even essential, to delay planting on parts of the site at least, for some years. On such sites, the designer and forester or arboriculturist should recognise that it may be necessary for the engineers to go back to site on an infrequent basis for fairly major refits or repairs, so the planting design must permit this without needing to fell trees or remove establishing hedgerows.

It is safe to plant trees on landfill sites provided one goes about it sensibly, fully alive to the constraints imposed by the underlying fill, and of the other works which may be required to ensure long-term environmental protection. Collaboration between the restorer and the gas engineer is essential throughout the life of the site to design and implement a landfill which achieves long-term acceptability.

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Chapter 8

The role of the Forestry Authority in promoting woodland establishment on disturbed land

Bill Heslegrave

Introduction

On 1 April 1992 the Forestry Commission established two separate operating arms - the Forest Enterprise (FE) and the Forestry Authority (FA), the latter of which included a Research Division. A further re-organisation in 1996 resulted in the Forest Enterprise being set up as a Next Steps Agency. The Forestry Commission Research Division begins to follow this path in 1997 with the setting up of Forest Research (FR), an agency of the Forestry Commission. All component parts will remain within the Forestry Commission. Thus when considering the role of the FA it must be put in the context of the Forestry Commission as a whole, whose constituent parts each have a role to play in the context of disturbed land, with the roles sometimes merging and overlapping.

Forest Enterprise role

FE, as land managers, have long been associated with reclamation of land to forestry following mineral working. In the late seventies and through the eighties Forestry Commission research staff, in collaboration with Forest District colleagues and others outside the Forestry Commission, worked on developing many of the techniques that are now commonly used by those restoring land to forestry, for example, ridge and furrow landform, winged tine ripping, loose tipping, use of legumes. Some impressive large-scale forestry restoration projects were carried out by the Forestry Commission, notably on British Coal sites in South Wales, and sand and gravel locations in southern England. More recently FR has been involved with many reclamation projects on experimental sites throughout the country and major effort and progress has been made with taking forward woodland issues on landfill.

In 1994 FE set up a mineral reinstatement project to investigate the scope for forestry on sites following mineral working. The main aims of the project included identifying the extent of viable land for forestry particularly in the 12 English Community Forests and in the National Forest, and to stimulate agency planting and supervision on mineral reinstatement schemes where FE had an interest in the long-term management of the site. The project also began the process of drawing up a set of guidelines which lays out the different roles of FE, FA and FR with regard to mineral sites and how and when they interact with the local authority. The completed guidelines are shown in Figure 8.1.

FE's main interest in disturbed land now lies with larger coal industry sites in the 12 Community Forests where viable acquisitions appear more feasible than agricultural land (where available), with high land prices and hence difficulties in achieving target rates of return. Leasehold arrangements for the transfer of land are being adopted and possibilities for contract work are being explored. However, no acquisition is easy in the current financial climate.

Forestry Authority role

Since its establishment in 1992, the FA has been developing its function in relation to woodland establishment on disturbed land. This can be described under five separate roles: statutory, promotional, advisory, regulatory/standard setting and incentives.

The statutory role

There is a requirement for mineral planning authorities (MPAs) to consult the FA before imposing an aftercare condition on developers who wish to reclaim land for forestry in the Town and Country Planning Act 1990. The terms of the aftercare scheme must also be examined by the

Woodlands and Mineral Working

The roles of the Forestry Authority, Forest Enterprise and Forest Research

BROAD COMMON AIMS

- Promote woodland as an after-use
- Ensure woodland expertise is fed into the mineral working process at all appropriate stages
- Promote best practice and the highest standards through research advice and example

THE PROCESS

It may take up to 25 years from initial assessment to end of aftercare period, but it is essential that woodland expertise is fed in throughout the process.

In-company assessment

Pre-application discussions

Advertise on site and in newspapers

Notify persons having an interest in the land

Submit planning application

Consultations undertaken by mineral planning authority (MPA)

Discussion between MPA and applicant on details

Formulation of report and recommendation by planning officer

Committee consideration

DECISION

Decision notice issued

Grant of permission

Refusal of permission

Appeal to Secretary of State

Public enquiry / written representations

Secretary of State decision

Long-term land management

Grants permission

Upholds refusal of permission

Resolve reserve matters with MPA

Commencement of project

Restoration and planting

Aftercare

Long-term land management

Forestry Authority
Part of the Forestry Commission

Statutory involvement through consultation by mineral planning authorities before imposing aftercare conditions on land reclaimed for forestry. Advice may also be sought from FA on planning conditions likely to affect the success of aftercare.

Promotion of woodland as an appropriate and integrated after-use, through liaison with local authorities and others during the preparation and revision of development, mineral and waste plans and input to Indicative Forestry Strategies.

Advisory role on all issues regarding trees and woodlands. Advice, including training where appropriate, is available. This advice is dispensed at both national and local (Conservancy) level through conferences, seminars, publications, advisory visits, consultation responses and guidelines.

Regulatory and standard setting role. The FA aims to ensure new woodlands and woodland management meet all current standards and are in harmony with other land-uses and the environment. Guidelines set out standards and monitoring is carried out. Felling is regulated through licences and the Woodland Grant Scheme (WGS).

Grant aid is available through the WGS to encourage the creation of new woodlands and management of existing ones. Establishment grants are available for reclamation, screening or 'off site' plantings, including natural regeneration and direct seeding, and can include work which forms a part of planning conditions. WGS applications will not be approved for disturbed land until restoration is complete. Management and woodland improvement grants contribute to the cost of managing and improving existing woodland. Challenge Funding is also a new feature of the WGS. The FA consults or notifies local authorities and others on all applications involving planting and felling through a public register.

Forest Enterprise
An agency of the Forestry Commission

Promotion of woodland as an appropriate after-use using FE owned or managed woodlands on restored sites to show both best restoration and establishment practice and after-use management.

Woodland specification and design can be undertaken by Forest Enterprise foresters and landscape architects on a contractual basis.

Planting for pre-extraction screening through to planting on successfully restored ground. Subsequent maintenance and management at the end of the aftercare period can be undertaken on a contractual basis. The management of existing woodland can also be undertaken.

Long-term land management following successful aftercare, with Forest Enterprise becoming either owners, leaseholders or operating as management contractors.

Forest Research
An agency of the Forestry Commission

Research leading to improved techniques for reclamation of land.

Evaluation of reclamation tools and machinery.

Dissemination of information in Forestry Commission publications, scientific papers and general articles, and at meetings and seminars. Training in reclamation techniques.

Objective testing of novel processes, techniques, products and machinery by commissioned research.

Technical advice to the Forestry Authority, Forest Enterprise, mineral operators and the general public.

Figure 8.1 left and right
Guidelines setting out the separate and related functions of the FA, FE and FR for mineral sites

FA before they can be approved by the MPA. However, in respect of restoration conditions they may wish to impose there is no statutory requirement for the MPA to consult the FA, which directly contrasts with restoration to agriculture where the Ministry of Agriculture, Fisheries and Food must be consulted. Despite this, Minerals Planning Guidance Note No. 7 (Department of the Environment, 1996) recommends that mineral planning authorities seek advice from the FA on all planning conditions which are likely to affect the ultimate success of forestry aftercare. Improved liaison between the MPAs and the FA is desirable, as advice is not being consistently sought or given at present. This perhaps in part reflects the fact that the term 'forestry' is not consistently defined.

The promotional role

There is a continuing opportunity for woodland after-use of disturbed land to be encouraged and promoted and the FA is in a good position to champion this worthy cause. Over the last 20 years there has been a gradual but gathering acceptance by the minerals industry, site owners, planning authorities and land managers that restoration of disturbed land to woodland on a significant scale is a serious and worthwhile option. Mainly small, and predominantly amenity planting, schemes have been commonplace on disturbed land over many years, unfortunately often carried out using dubious techniques and to a low standard. Through research into new techniques, promotion of good and appropriate silvicultural practice is leading to robust implementation by a small but growing number of mineral site operators. Progress has been made to the extent that new woodlands of significant size are now being planned and implemented to a good standard on a number of reclaimed sites.

Planning a forestry after-use at an early stage is vitally important to success. Too often in the past woodlands have been an afterthought with land restored in a form and manner quite unsuitable to the successful growth of trees. Converting such sites often proves to be difficult and expensive and is entirely avoidable given forward planning and involvement of suitable expertise.

One of the key stages in the whole process is through the planning system. Development Plans, in particular the Local Minerals and Local Waste Plans, which have in the past tended to give woodland after-use pre-emptory treatment, can help to set the context. This is particularly important given the increased emphasis on plan-led development introduced by the Planning and Compensation Act, 1991. As a result of the growing awareness of the opportunities woodlands can deliver, some plans are now moving away from the 'restore to agriculture at all costs' approach to a more balanced and enlightened attitude, which recognises that in many situations woodland will provide a diverse range of benefits to all concerned at little or no additional cost. Often woodlands will combine with other after-uses on a site but there is still a need to ensure that the woodland element is properly planned and prepared for. The FA will continue to encourage and promote local authorities and others to take full and reasonable account of woodlands within their plans in respect of policies for restoration of disturbed land. The FA must ensure that clear lines of communication are established with the planning authorities, including those responsible for strategic planning as well as development control, so that effective liaison is maintained.

The FA is keen to support local authorities in the process of preparing Indicative Forestry Strategies (Department of the Environment, 1992) and, building on earlier Scottish experience, several are now in the course of preparation in England. These strategies can assist the direction of forestry expansion in the county or area under the Authority's remit. Currently the potential for regional strategies is being explored with possible links to Natural and/or Countryside Character Areas. They should incorporate a strategic policy on forestry as well as environmental and social factors and can help to guide the FA and its partners in implementation of forestry policy. They must be indicative in their scope and not prescriptive. Such strategies will take into account derelict and disturbed land and set out the potential for new woodland. The Rural White Paper (Department of the Environment, 1995) gives the FA further opportunities to work with partners to encourage more planting on suitable land. During 1996 the FA partnered by the countryside agencies (Countryside Commission, English Nature, Rural Development Commission, with advice from the Department of the Environment and MAFF) opened up a debate on woodland expansion in England by preparing and publishing a discussion paper: *Woodland creation: needs and opportunities in the English countryside.* An extensive consultation was undertaken and the many responses collated and published in a further document of the same name (Land Use Consultants/ Forestry Commission/Countryside Commission, 1997). Every effort must now be made to seek out and realise opportunities to take forward woodland expansion and develop initiatives accordingly. At the present time woodland creation on agricultural land is an uphill task due to high land prices, agricultural subsidies, and so on, and disturbed land presents one of the best opportunities currently to increase woodland cover in some areas.

The advisory role

Closely allied to its promotional role, the FA is clearly in the forefront of providing advice concerning woodland establishment on disturbed land, either directly or by 'brokering' advice from Forest Research. Most FA woodland officers have had some training and experience in reclamation to forestry, a few to a considerable extent, certainly sufficient to give basic direct advice and to recognise and find more specialist expertise when appropriate. Advice from woodland officers will be given in connection with the Woodland Grant Scheme (WGS) (p.46).

Those seeking advice will have many differing needs and include landowners and managers, agents, authorities and other organisations such as the mineral and landfill industries. Advice from the FA can encompass both the wider, strategic view perhaps to authorities and the industry, as well as technical aspects including landform design, ground preparation and silvicultural environmental standards, the provision of grant aid and problem-solving on a site-specific basis, usually via specialists. The FA does not seek to replace expert advice where available from the private sector but instead aims to promote, find and facilitate information and advice from the most appropriate source.

Dissemination of information and advice may be made directly, for example, to a site owner/manager through WGS, or more widely through seminars, conferences, site visits and demonstrations, guidelines, articles and publications. The FA can act most effectively in partnership with others, especially where a woodland after-use is combined with other uses requiring a wider advisory input. Rather than being the direct advisers the FA may often be the facilitator, for example, instigating and helping to set up a seminar by drawing in specialists for the actual presentations.

Advice may be in the form of training, perhaps on various practical aspects of forestry reclamation techniques. The FA is well placed to provide this directly. Alternatively, through recognising the need for training we can facilitate provision by other specialists. Those requiring training may be foresters from both the public and private sectors, agents, landowners, local authority and countryside organisation managers and field workers as well as a range of representatives from the minerals and waste industries including site and land managers, land surveyors and planners.

The regulatory and standard setting role

The Forestry Commission, through its Forestry Authority arm, regulates woodland establishment, management and tree felling in Britain. Government policy demands that establishment of new woodlands must take account of landscape character and nature conservation interests. The FA is able to ensure that this is achieved by exerting control through its various published guidelines covering subjects such as landscape design, nature conservation, water management, archaeology and so forth. These guidelines, which have been the subject of public consultation, describe the standards which underpin all applications to the FA for grant aid and felling permission. Currently the guidelines are being complemented by the UK Forestry Standard which sets out the principles and standards by which forests and woodlands will be sustainably managed in the UK. It thus brings together, in one document, the existing measures which relate to sustainable forestry. Drafts of the Standard are subject to extensive consultation.

Almost all woodland planting of any significant scale is carried out under the WGS and hence is subject to the environmental standards set by the FA in accordance with an approved five-year plan of operations. This applies to new woodland on disturbed land as for anywhere else, so the FA is able to influence factors such as location, ground preparation, design and aftercare in approving a grant aid package through the WGS. Prior to approving applications the FA may consult with other bodies under a Ministerial Direction, to ensure that other land-use interests are taken into account.

Through checks, inspections, consultation and post-planting monitoring, the FA seeks to ensure that standards are met. On disturbed and reclaimed land some environmental issues are often straightforward. For example, many sites are unlikely to be of significant nature conservation or archaeological value and hence are free of such constraints for planting. However, there may be new opportunities for sites, for example habitat creation associated with the woodland creation, which could improve overall site value. In contrast, other aspects may be more demanding and require rigorous attention to detail, for example, the physical condition of the site for tree growth (compaction, drainage, pollution control, etc.), species choice, aftercare and landscape design. Forestry Commission publications help to provide further information, advice and set further standards to guide those establishing new woodland. For example, *Reclaiming disturbed land for forestry* (Moffat and McNeill, 1994) aims to give comprehensive, up-to-date, practical advice to those engaged in establishing woodland on disturbed land. *The potential for woodland establishment on landfill sites* (Dobson and Moffat, 1993) and the companion publication, *Tree establishment on landfill sites: research and updated guidance* (Bending and Moffat, 1997), sets out to inform and promote the process of reclaiming landfill sites to woodland after-use.

The monitoring role of the FA also seeks to include and promote research, this being particularly applicable to woodland establishment on disturbed land. Monitoring, in order to enhance knowledge of such sites, should extend beyond the aftercare period to look at tree performance, site amelioration and other factors far into the rotation of difficult sites. We still have much to learn and the FA can help to facilitate this by encouraging targeted research and monitoring.

Mineral landfill and development sites can include 'off-site' woodland which needs management to fulfil its potential. This may well involve thinning or felling, which is regulated by the FA through felling licences under the Forestry Act, 1967 (as amended) or through WGS approved plans, or Forest Design Plans in the case of the Forest Enterprise. The FA aims to ensure that all thinning or felling proposals comply with envir-onmental guidelines for sound forest management. Permissions for final felling are normally conditional on the felled area being regenerated or replanted with appropriate tree species. Compliance with environmental standards and grant aid also apply as outlined previously for new planting.

Finally, and very importantly, health and safety for forest workers is protected by legislation and safety standards; all forestry operations are set out in Safety Guides produced by the Forestry and Arboricultural Safety and Training Council (FASTCO, 1994).

The provision of incentives role

The Woodland Grant Scheme (WGS) administered by the FA has a role in standard setting as previously described but it also provides the major incentives for woodland establishment and management in British forestry. These grants can apply to woodland on disturbed land even if such work is a requirement of a planning consent. In these cases it could be said that planting, for example, would take place without need for incentive. However, grant aid may encourage applicants to widen the scope of the work, to go beyond planning requirements and to provide additional and enhanced conditions and checks assuring environmental standards and opportunities are met. Close liaison between the FA and the planning authorities is vital to ensure that conditions are met, effective schemes are implemented on time and misunderstandings avoided. Through its procedure for post-planting site monitoring, the FA has structured mechanisms in place to ensure that the benefits claimed in applications are matched by the woodlands that are eventually delivered. This is an important aspect when one bears in mind that on disturbed land, robust woodland ecosystems can take ten or more years to develop.

The FA liaises closely with, and in some defined circumstances formally consults (procedures revised since 1 August 1996), local authorities and other organisations in respect of applications it receives under the WGS, felling licences and Forest Design Plans. It produces a public register of applications (widened in scope and availability from 1 August 1996). The FA welcomes and indeed seeks comment and information provided through these procedures which help it to reach decisions in determining these applications.

Upon receipt of a WGS application, the FA must ensure that the site is suitable for tree growth as part of its checks. This is particularly important on disturbed and reclaimed land and the FA will make a site inspection in every case, to ensure that the application contains all necessary detail. It will not give its approval unless the site restoration has been completed satisfactorily to agreed final landform and soil condition. At this stage, the FA will also need to be satisfied that planning conditions have been adhered to. Since 1 August 1996, the FA has had new powers to reject applications which do not meet the required environmental standards.

A contract based on a five-year plan of operations will, once satisfactory, be signed by the owner and the FA. Grants for new planting on disturbed land can comprise basic planting grant, Community Woodland Supplement (if providing access for local people), the Locational Supplement (if in a specially selected area). Better Land Supplement will only be applicable if the land has been restored to arable or improved grassland for at least three years. In certain situations natural regeneration grants may apply as an alternative to planting, including direct tree seeding. Challenge Funding is now being developed to encourage new planting in certain situations or types of land and distributed or derelict land may well become a candidate for such projects.

For existing woodland, Annual Management Grant may be available for work which will safeguard or enhance special environmental value, improve woods which are below current environment standards, or which create, maintain or enhance public access. Woodland Improvement Grant and Challenge Funding contribute towards special projects in special areas. The FA operates a free advisory service in respect of the WGS which would-be applicants on disturbed land should make full use of.

Of course WGS monies may in some areas and circumstances only represent a small part of the total money potentially available, for example, if European funding, lottery, millennium and other funds are available and successfully bid for. In some cases WGS money can usefully be put forward as matching funding. The WGS will not stand still and the FA will increasingly be looking to target its WGS and other resources to where they are most needed and will provide most public benefit. Business Plans, which each FA Conservancy is now producing, will help this process of formulating regional aims, objectives and targets for FA resources. In many areas disturbed land is likely to figure highly among priority targets for woodland expansion. The FA does not intend to work in isolation and looks to extend its work in partnership with others who may also have resources to focus on targets such as woodland establishment on disturbed land. For example, the National Urban Forestry Unit has been awarded substantial millennium fund grant aid for an urban woodland initiative in the Black Country. WGS grants were used as matching funding and the FA is now providing its grants as well as helping to guide and encourage the project, much of which is focused on disturbed land. As a national partner in the Community Forest programme, the Forestry Commission is playing a major role in the steering and implementation of the Forests, with the WGS providing the major incentive for landowners to participate. In many of the 12 Community Forest areas, afforestation of disturbed land will be fundamental to achieving woodland cover targets set by the Forest Plans.

Conclusions

The concluding message must be that derelict and disturbed land often has significant potential for forestry but this potential is to a large extent still not being realised. The FA is determined, together with colleagues in other parts of the Forestry Commission and other organisations, to take the matter forward in the different ways outlined, so that significant portions of disturbed land really will be recycled to forestry of a high standard.

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At a time when Government policy is directed towards expansion of woodland in the UK, especially around towns and cities, it is important to look at how this can be done on 'man-made' or disturbed land. To bring together the views of many of those involved, a joint conference was held in March 1996 at the University of Wolverhampton by the British Land Reclamation Society (REGRO) and the Forestry Commission, with the focus on:

- Attitudes to the woodland after-use
- Mechanisms for its promotion
- Technical aspects of woodland establishment.

This Technical Paper presents the written contributions from all eight conference speakers. It provides a valuable set of opinions and a substantial basis from which fresh ideas on the promotion of woodland cover on restored disturbed land can be explored.

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