

Cultivation of lowland sites for new woodland establishment

by Ian Willoughby and Andy Moffat



Summary

Much new woodland planting is now taking place on former agricultural land in the lowlands. Cultivation can benefit tree growth and survival. This Note provides advice on when cultivation is necessary, types of cultivation and the impact of cultivation on subsequent weed control operations, for new woodland creation on lowland sites.

Introduction

Cultivation is undertaken for a variety of purposes: to break up compaction, mix organic and mineral horizons, increase soil mineralisation, change soil physical properties, and control weeds. It is a conventional forestry practice; most upland forests in the UK have been established after cultivation of some sort. Considerable research has been undertaken and useful guidance exists (Thompson, 1984; Tabbush, 1988; Paterson and Mason, in preparation).

There is increased interest in new planting on lowland sites, but by comparison with uplands and heathlands there is a dearth of information on site preparation, especially for the more fertile agricultural land where soil properties and weed spectra can be particularly problematic. Weeds compete strongly for moisture and nutrients, and can reduce tree survival and early growth. On fertile lowland sites, cultivation by itself will tend to encourage rather than reduce weed germination and growth.

Lowland sites are prone to soil moisture deficits between May and September. Raising trees on mounds or ridges can expose them to the effects of summer drought with consequent detrimental effects on survival and growth. Some forms of conventional cultivation are therefore inappropriate on lowland sites. Although it can produce silvicultural benefits, cultivation is now recognised as a major disruption of the soil. It can lead to some undesirable environmental consequences such as water pollution and soil nutrient loss. The *Forests and water guidelines* (1993) and *Forests and soil conservation guidelines* (in preparation) acknowledge the need for forestry cultivation to be environmentally acceptable – it should be minimal in scale and should only take place where it is necessary.

This Note is a synthesis of research and modern experience of cultivation on lowland soils, taking environmental issues into account. It provides guidance on when cultivation is necessary, types of cultivation, and their impact on subsequent weed control operations. It deals with new planting rather than restocking, though will be of some relevance to the latter.

(Front cover : Forest Life Picture Library/Laurie Campbell)

Cultivation requirements

The need for and type of cultivation will be determined by a number of factors, including soil type and fertility, previous land-use and current vegetation cover, tree species and stock type to be planted, and silvicultural regime to be adopted. Taken individually, many of these factors can lead to conflicting recommendations. Figure 1 gives guidance on prudent cultivation practices, taking all these conflicting factors into account.

Soil type and fertility

Table 1 shows the principal soil types of interest in the lowlands. Short descriptions of these soil types can be found in the Appendix. Some soils, such as brown earths, clays and peats are relatively fertile, whilst podzols and man-made soils are comparatively infertile. However, the fertility of all soil types can be raised by the addition of mineral or organic fertilisers. The more fertile a soil is, the greater the potential for rapid competitive weed growth. Soil fertility can be assessed by conventional soil analysis (see 'Soil analysis').

Cultivation may control some established perennial weeds, but infestations of certain species, such as couch grass for example, will be made worse. In addition, the seedbed produced is ideal for annual weed germination. Many arable soils have large weed seed banks. Upper layers of the soil may be relatively free of weed seed as a result of previous years' effective herbicidal weed control of germinating plants before flowering. However, any disturbance of lower layers, for instance by surface cultivation, may bring weed seed to the surface and allow profuse weed germination (Roberts, 1982). Repeated cultivation throughout the growing season would be required for effective control of annual weeds on these fertile sites.

Table 1 Lowland soils classified according to their cultivation requirements

Soil type	Relative fertility
Brown earths and loamy groundwater gleys	high
Calcareous soils over chalk or limestone	moderately high
Clays – calcareous and non-calcareous	high
Podzols	low
Peats	high
Man-made/disturbed soils	low

Brown earths (including **Brown sands**) should not normally require cultivation to improve soil physical conditions. The main exception will be on ex-arable sites where a plough pan has formed (see 'Arable/improved grassland' and Figure 8). **Groundwater gleys** will differ little in cultivation requirements if artificially drained. Very wet (undrained) soils may be unsuitable for planting, or can be mounded and planted with a species suitable for such conditions (Forestry Commission, 1993).

Calcareous soils over chalk or limestone do not normally require cultivation, and there is a danger that chalk or limestone may be mixed with overlying soil material, thus increasing its alkalinity. This is generally undesirable and restricts species choice and tree growth. However, tree planting on thin or excessively stony soils may be improved by careful subsoiling in the autumn before planting.

Clays (including most *Surface water gleys*) in the lowlands show little or no benefit from deep cultivation. Depending on ground surface roughness, rotovating may be useful to facilitate planting and herbicide effectiveness. Heavy clay soils may be impossible to plant without cultivation, particularly following a dry summer. In addition, without cultivation planting notches may open up around tree roots, unless trees are pit planted. Mounding has been shown to be useful where soils suffer from high water tables well into the growing season, though this operation should only be considered in the wettest parts of the country. Moling and/or subsoiling may be a useful precursor to planting if several years have elapsed since these operations were last performed.

Many areas with *podzol* soils in the lowlands are in Sites of Special Scientific Interest (SSSIs) and consultation is advised before cultivation is undertaken. Podzols may require shallow cultivation if there is a significant thickness of organic horizons over mineral material – it is important that transplants are not planted directly into these horizons, but that some mixing is achieved first. Some podzols, but not all, possess an ironpan horizon. If this exists, tine cultivation may help to break it up and facilitate deep rooting.

Lowland peats in agricultural areas have usually been drained – such soils may not benefit from further cultivation. Undrained peats should be assessed for their ecological value before planting is sanctioned. They will require a combination of drains and cultivation to produce a raised planting position. This can be achieved by mounding or shallow double mouldboard ploughing.

Man-made soils are almost always compact. Cultivation is required to loosen them; the winged tine is the best tool for primary loosening in all but extremely stony soils or spoils, with discing or rotovating to break up coarse clods if necessary. Deep cultivation is preferable, to 0.6 or 0.7 m depth if possible. If it is possible to influence the restoration process when such soils are placed in their final position, ‘loose tipping’ is far better than cultivating compacted soil materials. For further information, refer to Forestry Commission Bulletin 110 *Reclaiming disturbed land for forestry* (Moffat and McNeill, 1994).

Land-use

Permanent pasture

Cultivation need will depend on previous and existing land-use. The soil is usually well structured under

permanent pasture, and the grass is an effective barrier which prevents more noxious weeds seeding in. It should therefore be left uncultivated unless there are strong signs of surface soil compaction (for example, poaching by farm stock). Cultivation may also lead to large nitrogen losses through leaching.

Arable/improved grassland

The need to cultivate other types of former agricultural land will depend on soil type and fertility (see previous section), weed seed banks, the presence or absence of a plough pan, (see Figure 8) the ground roughness and the existing vegetation. Repeated arable cropping often leaves a plough pan, usually a thin zone of compacted soil or a change in soil texture at the base of the plough layer. Plough pans can also occur on reseeded improved grassland. A plough pan can reduce tree root growth and soil drainage, and should be broken up by subsoiling if present. Investigation is therefore **essential** to determine if a plough pan is present (see ‘Soil type’). In improved grassland, subsoiling can break up the plough pan whilst still leaving the grass cover as an effective weed barrier. This can also be used if stubble is to be left undisturbed on ex-arable sites (see below). Trees should be planted between, rather than on, subsoil lines.

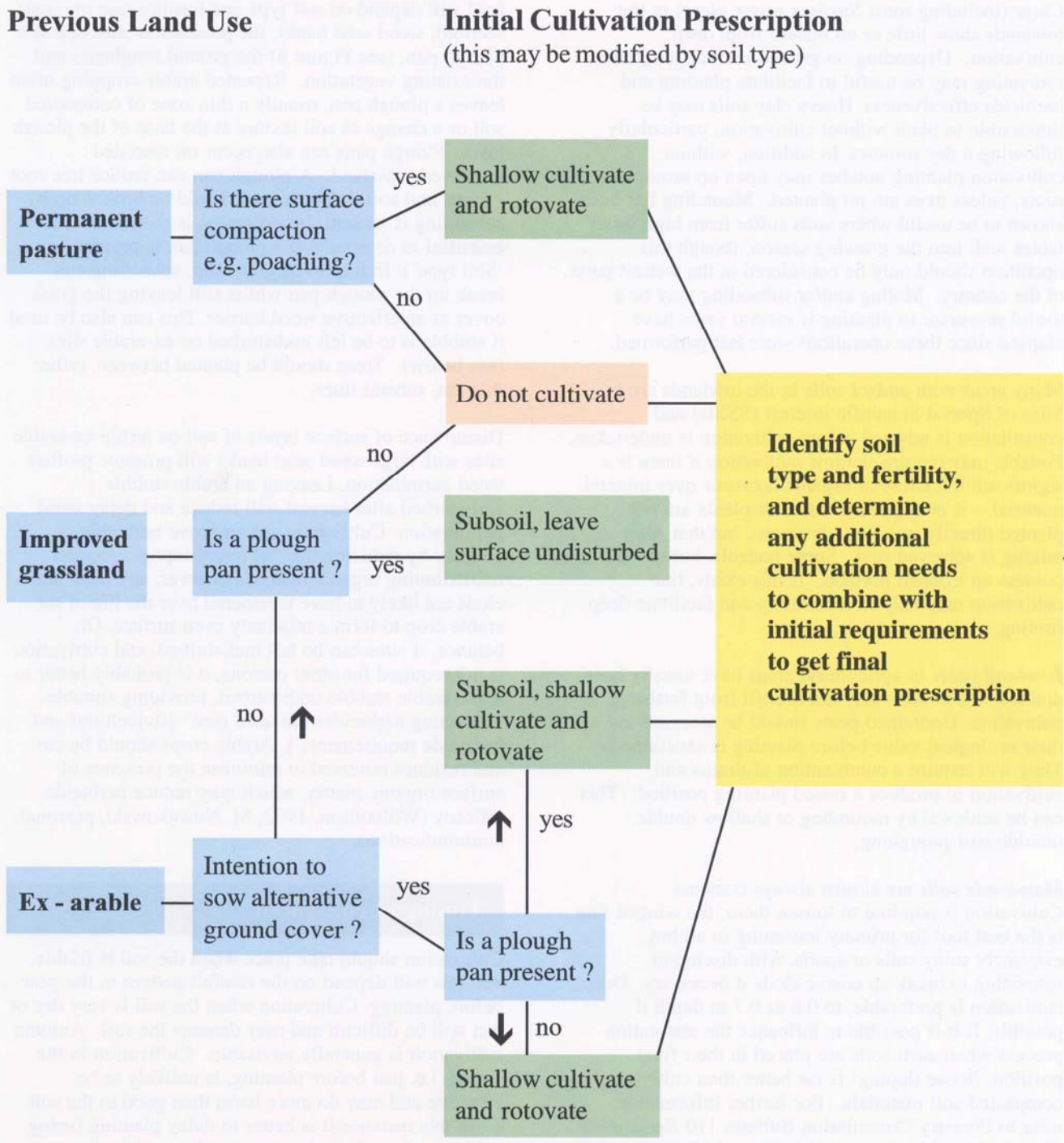
Disturbance of surface layers of soil on fertile ex-arable sites with large weed seed banks will promote profuse weed germination. Leaving an arable stubble undisturbed after harvest will reduce and delay weed germination. Cultivation can improve herbicide efficacy by reducing the soil micro-topography and redistributing organic matter. However, any large soil clods are likely to have weathered over the life of the arable crop to form a relatively even surface. On balance, if sites can be left undisturbed, and cultivation is not required for other reasons, it is probably better to leave arable stubble undisturbed, providing suitable soil-acting herbicides are used (see ‘Silvicultural and herbicide requirements’). Arable crops should be cut and residues removed to minimise the presence of surface organic matter, which may reduce herbicide efficacy (Williamson, 1992; M. Nowakowski, personal communication).

Timing of cultivation

Cultivation should take place when the soil is friable, and this will depend on the rainfall pattern in the year before planting. Cultivation when the soil is very dry or wet will be difficult and may damage the soil. Autumn cultivation is generally advisable. Cultivation in the winter, i.e. just before planting, is unlikely to be effective and may do more harm than good to the soil — in this instance it is better to delay planting (using cold-stored stock) and cultivate when soil moisture conditions allow in the spring. Correct timing when cultivating clay soils is particularly important.

Because timing is so critical, it is important to plan effectively and to arrange labour and machinery when a suitable combination of soil and weather conditions presents itself.

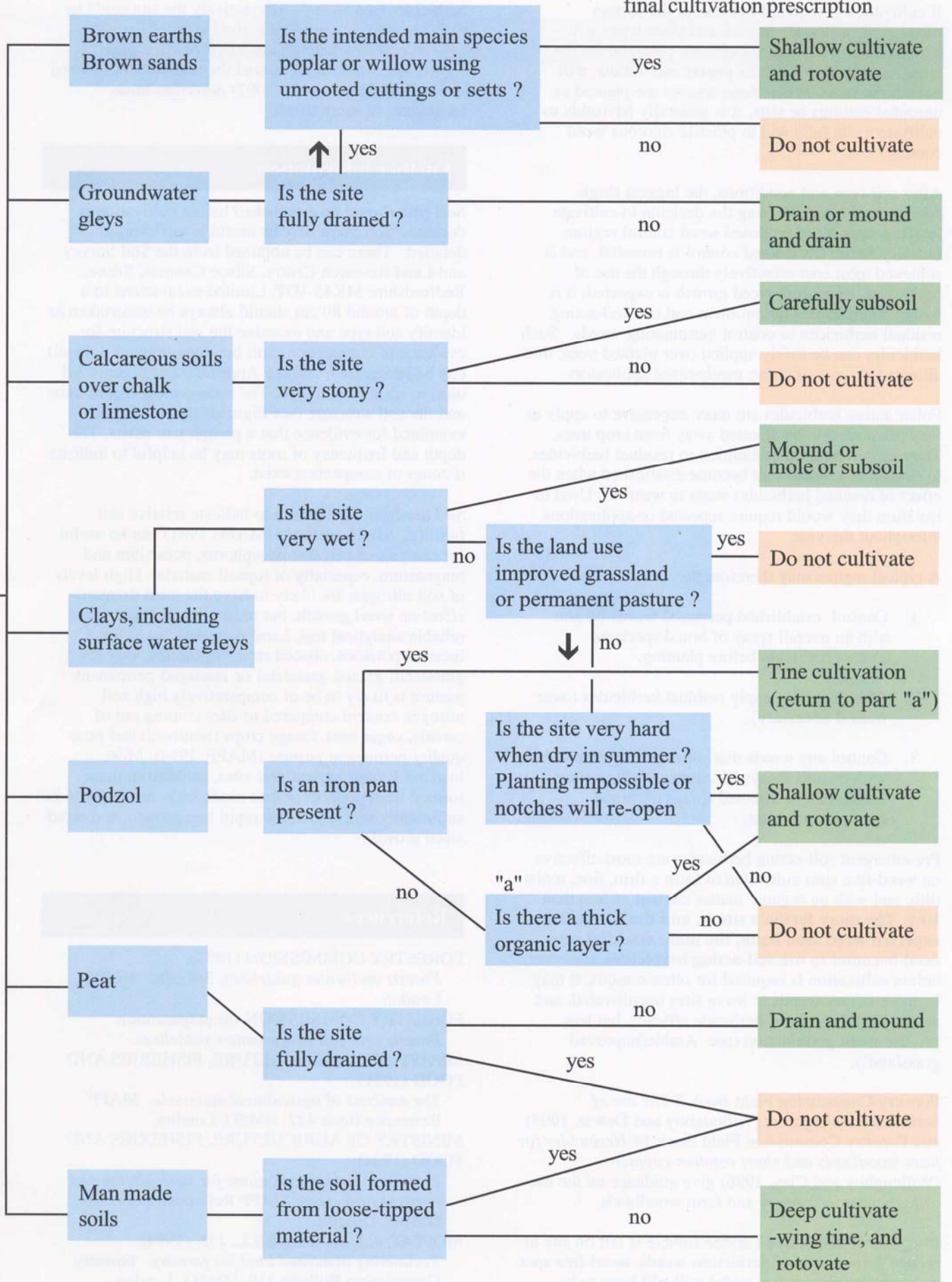
Figure 1. Decision tree for cultivation prescription



Note
 As an alternative to shallow cultivation and rotovation, any cultivation that produces a firm fine tilth is acceptable

Soil Type

Additional Cultivation Prescription
combine with initial result to get a final cultivation prescription



Silvicultural and herbicide requirements

If cultivation is required because of the factors mentioned earlier, all species and plant types will benefit. However, species with the potential for the most rapid growth, such as poplar and willow, will benefit the most. When these species are planted as unrooted cuttings or setts, it is generally advisable to cultivate a site fully and to practise rigorous weed control.

After soil type and conditions, the biggest single *silvicultural* issue affecting the decision to cultivate lowland sites is the proposed weed control regime. On very fertile sites, weed control is essential, and is achieved most cost-effectively through the use of herbicides. If profuse weed growth is expected, it is easiest to anticipate the problem and use soil-acting residual herbicides to control germinating weeds. Such herbicides can be safely applied over planted trees, thus allowing the use of cheap mechanised applicators.

Foliar acting herbicides are more expensive to apply as they often need to be directed away from crop trees. They should be used in addition to residual herbicides, to control any weeds that become established when the effect of residual herbicides starts to wear off. Used in isolation they would require repeated re-applications throughout the year.

A typical regime may therefore be:

1. Control established perennial weeds on site with an overall spray of broad spectrum contact herbicide before planting.
2. After planting, apply residual herbicides (over trees if necessary).
3. Control any weeds that subsequently establish with overall sprays of selective foliar acting herbicides, or directed sprays of broad spectrum products.

Pre-emergent soil-acting herbicides are most effective on weed-free sites cultivated to form a firm, fine, moist tilth, and with an organic matter content of less than 10%. **The more fertile a site is, and the larger the expected weed seed bank, the more essential the need becomes to use soil-acting herbicides.** However, unless cultivation is required for other reasons, it may be more advantageous to leave sites uncultivated, and accept slightly reduced herbicide efficacy, but less profuse weed germination (see 'Arable/improved grassland').

Forestry Commission Field Book 8 *The use of herbicides in the forest* (Willoughby and Dewar, 1995) and Forestry Commission Field Book 14 *Herbicides for farm woodlands and short rotation coppice* (Willoughby and Clay, 1996) give guidance on the use of herbicides in forestry and farm woodlands.

If a grass or undisturbed arable stubble is left on site to reduce germination of pernicious weeds, weed-free spot or bands (minimum 1 m wide) will still have to be

maintained around planted trees. If no grass cover is present on a site, one option is to maintain weed control across the entire site through the use of herbicides (see above). Alternatively the site could be fully cultivated to produce a good seedbed for the sowing of a desirable ground cover such as grass. Again, weed-free areas around the trees will need to be maintained. Williamson (1992) describes these techniques in more detail.

Further information

Soil type should be established before cultivation is decided. Soil maps may be useful if sufficiently detailed. These can be obtained from the Soil Survey and Land Research Centre, Silsoe Campus, Silsoe, Bedfordshire MK45 4DT. Limited excavations to a depth of around 80 cm should **always** be undertaken to identify soil type and examine the soil structure for evidence of compaction. Soil horizons (topsoil, subsoil) can be recognised, and the Appendix and Figures 2-8 used to identify soil type. The arrangement of soil units and the soil structure (see Figures) should also be examined for evidence that a plough pan exists. The depth and frequency of roots may be helpful to indicate if zones of compaction exist.

Soil analysis can be used to indicate relative soil fertility. ADAS methods (MAFF, 1981) can be useful for analysis of pH, soil phosphorus, potassium and magnesium, especially of topsoil material. High levels of soil nitrogen are likely to have the most dramatic effect on weed growth, but unfortunately there is no reliable analytical test. Land previously used for lucerne, potatoes, oilseed rape, vegetables, long ley grassland, grazed grassland or managed permanent pasture is likely to be of comparatively high soil nitrogen content compared to sites coming out of cereals, sugar beet, forage crops (removed) and poor quality permanent pasture (MAFF, 1994). Most lowland former agricultural sites, aside from those formed from podzols or man made soils, are likely to be sufficiently fertile to allow rapid tree growth, and rapid weed growth.

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Appendix

Description of soil types

Brown earths – predominantly brown coloured soils lacking grey and ochreous colours, developed in loamy or sandy materials.

Figure 2. Brown earth.



Podzols – soils, usually under heath vegetation with a grey, ashy layer underlying an organic topsoil. Usually sandy in texture.



Figure 3. Podzol.

Surface water gleys – soils with grey and ochreous colours within shallow depth. Topsoil and/or subsoil usually developed in clayey materials.

Groundwater gleys – coloration similar to surface water gleys, but usually developed in more loamy or sandy materials. Situated in low areas in the landscape, e.g. alongside rivers and streams.

Figure 4. Groundwater gley. (S.J. Fordham).



Peats – organic soils developed in deep peat.



Figure 5. Lowland peat soil.

Shallow soils over chalk or limestone - soils with chalk or limestone at shallow (<40 cm) depth.



Figure 6. Rendzina.

Man made soils.



Figure 7. Typical man made substrate.

Glossary

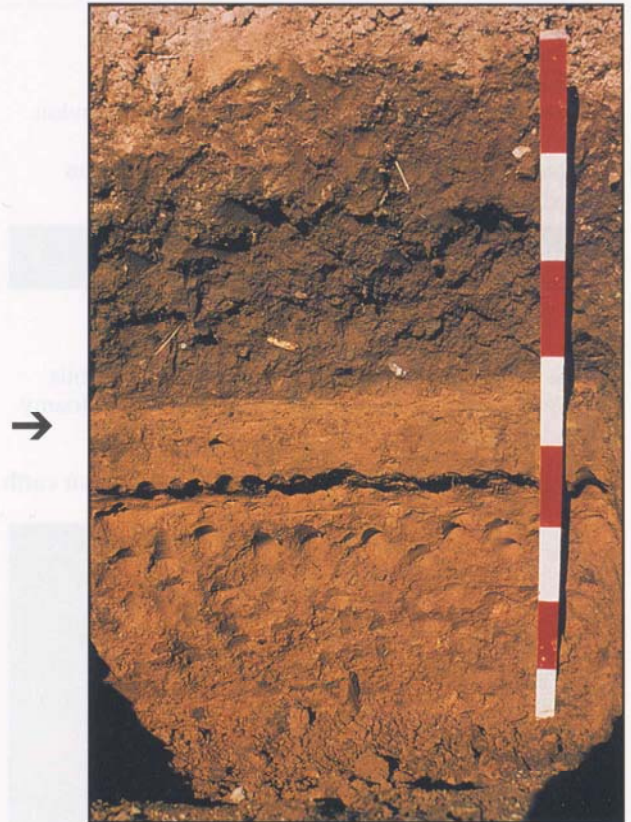
Deep cultivation - Forestry cultivation to depths of 60 cm or more.

Moling - the system of tillage whereby a cylindrical drainage channel is formed within the soil, usually at 50 to 70 cm depth, with fissures leading to it, which will conduct water laterally to a discharge point at a pipe drain or open ditch. To be successful, the soil must contain greater than 40% clay-sized particles.

Mounding - the process of forming a small mound on which to plant the tree, thus increasing the aerobic zone of soil and maximising root extension early in the season. Mounds may be formed by a range of mechanical equipment (Tabbush, 1988).

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Figure 8. Distinct plough pan (indicated by arrow) developed at the junction of the topsoil and subsoil (D.B. Davies).



Rotovating - the system of cultivation employing rotating tines powered by the tractor PTO. Rotovating produces a finer tilth and more even soil surface than conventional ploughing.

Subsoiling - the system of deep tillage by which the subsoil is loosened and disturbed, but is not inverted or brought to the surface. The subsoiling **tine** is usually set to shatter zones of compacted soil, usually located in a 'plough pan'. It consists of a metal tine with a 'shoe' which is dragged through the soil at a depth of about 7-10 cm below the zone of compaction. The **winged tine** has two 'wings' attached approximately midway down the tine. These aid in the disruption process.

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