



DO YOU NEED TO CULTIVATE BEFORE WOODLAND ESTABLISHMENT?

Kirsten Foot and Danielle Sinnett

BPG NOTE 3

Best Practice Guidance
for Land Regeneration

Introduction

Soil compaction is the key physical feature that can prevent sustainable woodland development (Figure 1) from being achieved. Tree establishment and growth can be severely affected where compaction restricts the exploration of soil by tree roots, placing limitations on the exploitation of air, water and nutrient resources by the roots. Trees that reach maturity can also suffer from an increased risk of physical instability and windthrow due to underdeveloped root systems. This Best Practice Guidance Note brings up to date the guidance on the use of deep cultivation methods to relieve compaction. The ROOTS software package contains further guidance on cultivation; information on this product can be found at www.roots-software.co.uk

Why compaction occurs

Compaction can occur at any depth in the soil profile.

- In **agricultural soils**, compaction may occur at the base of the ploughed or tilled layer at depths of between 20 and 35 cm; this is commonly referred to as a 'plough pan'.
- **Normal soils** exposed to loading in wet or unsuitable conditions or to heavy trafficking may exhibit compaction between 30 and 70 cm in the profile, resulting from soil deformation due to wheel pressure.
- In **restored or reworked soils**, soil compaction is common where these soils have been reinstated using construction machinery such as a dozer or scraper or subjected to heavy trafficking in subsequent years by agricultural machinery. Soils which have been restored can exhibit compaction at any depth and sometimes so severely that the entire profile from 20 cm to over 120 cm depth is heavily compacted. Such soils are also highly sensitive to recompaction after loosening.

Why loosening is needed

Roots alone cannot break up or restructure heavily compacted soils. Mechanical methods of cultivation are essential to loosen topsoil and/or subsoil layers to allow deep root penetration (Moffat and McNeill, 1994; Foot and Spoor, 2003). This will:

- Provide root anchorage and reduce the risk of windthrow.
- Create sufficient water storage and uptake to buffer against drought.
- Aerate the soil to allow the movement of oxygen and gases within the root zone.
- Enhance the ability of roots to exploit available nutrient reserves.
- Maximise drainage and reduce the risk of waterlogging.
- Improve establishment success and longer-term growth and productivity.



Figure 1 Restored sites often require cultivation prior to vegetation establishment.



Depth of loosening required

To ensure long-term sustainable growth, at least 1 m depth of uniformly loosened, well-drained and well-rooted soil is usually required. In some parts of the UK, there may be a need for a greater thickness than this 'rule of thumb'.

The depth of cultivation or loosening required will vary according to the depth at which compaction has occurred. Thus in a soil with a shallow plough pan, it is only necessary to loosen the ground to 50 mm below the base of the plough pan, an operation that is much cheaper and more effective for these soils than loosening to the standard 40–45 cm depth prescribed by agricultural contractors. A standard agricultural loosening operation is not sufficient for soils with deeper compaction, below 0.5 m depth. Attempts to loosen ground that is not compact can also damage the soil. Therefore, both the need for and depth of loosening should always be checked by digging pits to inspect the soil condition in order to avoid unnecessary cost and to ensure that all compaction has been effectively treated.

The required depth of loosening can best be determined by opening up a soil pit. If there is a vegetation cover to the soil, observing root development can indicate where compaction is: areas of very sparse or no rooting in the profile are usually indicative of compaction. Compaction can also be identified by the following soil features:

- Hard or abnormally dry clods of soil in the compact zone.
- After a rainfall event, very wet soil above the hard dry layer indicating 'perched water' and poor infiltration or impeded drainage.
- Solid or 'massive' appearance to the soil, i.e. large or very large 'lumps' with very limited structural fissures or cracks, or a plate-like appearance.
- Poor penetrability, the soil does not deform readily and a lot of pressure is required to push a trowel or knife into the compact zone in the side of the pit.
- High bulk density, greater than 1.4 to 1.6 g cm⁻³ depending upon soil texture.
- Very low porosity, restricting the movement of air and water through the profile.

It is important to record the depth at which soil compaction is first encountered and the lowest depth in the profile at which compaction is observed. It is also important to excavate further pits across the site to identify the extent of the compaction. The soil condition should ideally be examined by a soil surveyor in the spring, to give time for remedial cultivations to be conducted in the late summer or autumn prior to woodland planting in the winter.

The depth of the loosening operation should be targeted specifically at the zone of compaction in the soil that needs to be treated. If a plough pan or a defined layer of compaction is present within the profile, loosening just below the compaction or pan will cause the pan to break up and will enable rooting to penetrate into the underlying looser soil. The working depth of the loosening operation should be set at 5 cm below the pan or compacted layer, whatever the loosening method used.

Where deeper compaction is present then the greater the depth of the initial cultivation, the greater the benefit to soil condition and rooting achieved. Loosening to relieve deep compaction in restored soils should therefore aim to reach the *maximum possible loosening depth in the first loosening operation*, given the equipment available, and ideally this should be greater than 1 m depth, since root development is unlikely to extend below the cultivated layer.

In restored soils of very poor condition (especially in sand and gravel or non-swelling heavy clay substrates), it would be advisable to sow grass and to delay tree planting for 1 to 2 years to allow a 1 m deep loosening followed by shallower (up to 0.5 m depth) agricultural-type loosening operations to be conducted in subsequent years in order to relieve any residual or recompaction in the upper soil layers. The need, for



and working depth of, the subsequent shallower operations is again best determined by opening up a soil pit to check soil and rooting conditions. For maximum benefit in the shallower operations, the subsoiling tines should work in the poorly rooted or compacted zones at a depth of 100 to 150 mm below the depth where good rooting finishes.

Figure 2 illustrates how to select the required working depth for loosening operations (Foot and Spoor, 2003). In examples A and B there is deep compaction, but the rooting in the upper layers is substantially better in B than in A. Both require an initial one-off deep loosening operation to 0.8–1 m depth. Further shallow loosening operations are required in A to break up the soil and improve rooting in the upper layers, and the tine working depth should be 100 to 150 mm into the compact layer. B would not benefit from shallow loosening since good rooting already extends below 0.5 m depth. In example C, there is good rooting throughout most of the profile, but recompaction in the upper subsoil has resulted in the formation of a pan. In this instance, the lower depth of loosening (e.g. for ripping, this would be the tine working depth) should be set just below the compact zone.

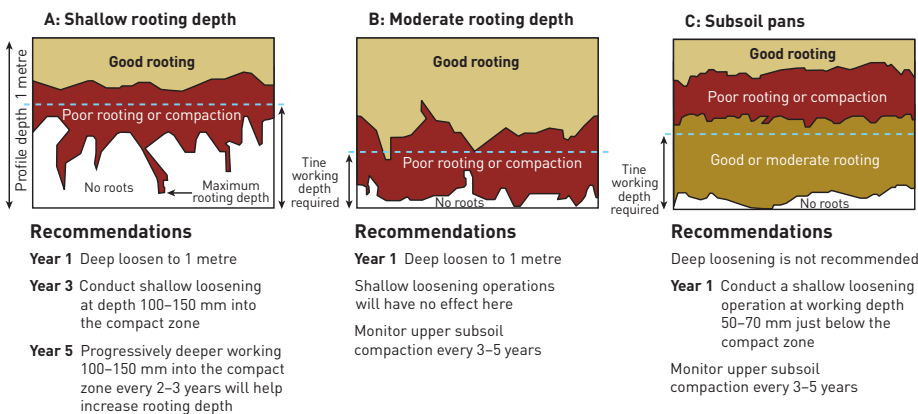


Figure 2 How to determine the loosening depth required (from Foot and Spoor, 2003).

Types of loosening methods

Topsoils are easily accessible and can be cultivated using normal agricultural equipment (for example, using discs, ploughs, or chisel tines as appropriate for the soil type). Subsoils are more difficult to treat as it becomes harder and more costly to pull implements into the ground to loosen the underlying soil layers.

Compaction up to 0.5 m deep can be treated using agricultural-type subsoilers fitted with wings. Deep compaction extending below 0.5 m depth in the profile is more difficult to treat and requires deep cultivation. The methods available for deep loosening below 0.5 m are: total cultivation, deep ripping, and double digging using a spading machine.

When to conduct loosening

Moisture conditions are critical in all loosening operations, particularly in the layers above and just below the compacted zone. It is essential that the soil is dry and friable during the operation, to avoid damaging the upper layers and to achieve good loosening performance. This is a requirement for all types of loosening operation, whether by total cultivation, ripping or agricultural subsoiling.

The most suitable time for loosening is therefore in late July to late August but the actual timing will depend upon local climatic conditions, the antecedent rainfall and the type of compaction which is to be treated. Spring loosening should never be attempted. In heavily compacted, restored soils which have never been loosened



effectively, ripping can be very difficult in extremely dry summer conditions and so may be postponed up to the end of November after the first autumn rains. However, the loosening operation itself must be conducted when the upper soil layers have dried out.

There is only one real opportunity to loosen the ground to best effect for woodlands and this is prior to planting the trees. Ripping between tree lines after planting is not suitable and can cause damage to planted tree stock.

How soon can you plant after loosening?

Tree planting needs to be conducted while the trees are dormant, usually between mid November and late March, irrespective of the timing of cultivations. After any form of cultivation, the ground will be prone to resettlement and slumping if exposed to wet weather conditions or trafficking. Also, where deep loosening has been conducted, there may be some resettlement leading to an uneven soil surface, depending upon the loosening method selected.

The ground condition after cultivation will stabilise more rapidly and retain a good structure for much longer if ground cover is established as soon as possible after the loosening operation. It can be highly beneficial to sow a low-competition grass sward in the September immediately after cultivation to keep soil fissures and cracks open and maintain good drainage through the soil. Grass roots grow very rapidly, produce dense fibrous and deep-rooting networks and are better than tree roots at breaking up and stabilising soil structure. They also create root channels which tree roots can later exploit. Tree planting can then take place into the grass sward and various methods (including mechanised weed control systems) are currently used by the Forestry Commission for managing the sward between the planted tree rows. Research suggests that in a restored soil that has been completely re-loosened it can take up to 3 years for grass or tree roots to penetrate to the full soil profile depth (Spoor and Foot, 2000).

Careful and sensitive site management will be required to ensure that the benefits of loosening are retained. Vehicular access to the site must be restricted and site works such as fence lines and access roads need to be installed prior to the loosening operation.

Summary of recommendations

The following checks are essential to identify if soil loosening is required:

- Investigate the soil condition *early*, preferably in the spring before tree planting.
- Examine the soil by digging a pit and observing any signs of compaction. Record the depths at which compaction or poor rooting starts and finishes.
- Identify which parts of the site will require loosening. Excavate further pits to identify if compaction extends across entire fields or is located only in a portion of the site.
- Seek professional advice from a soil surveyor where appropriate.
- Use Figure 1 to identify an appropriate loosening depth technique which will address the compaction at the observed depths.
- Ensure that cultivations can be performed within the planned timetable. If compaction is severe, it is imperative that planting is delayed until loosening has been conducted.

References

- Foot, K.J. and Spoor, G. (2003). Breaking restored ground – ripping really works! *Mineral Planning* **94**, 6–9.
www.defra.gov.uk/envirom/landuse/restore/groundbreak.pdf
- Moffat, A.J. and McNeill, J.D. (1994). *Reclaiming disturbed land for forestry*. Forestry Commission Bulletin 110. HMSO, London
- Spoor, G. and Foot, K.J. (2000). Trials to evaluate the effectiveness of subsoiling treatments on soil structure on mineral sites during the five year aftercare period. Final Scientific Report to MAFF. Contract CSA 2695 / CTE 9406D. Cranfield University, February 2000: 20pp.
www.defra.gov.uk/envirom/landuse/soilguid/subsoilreport.pdf

Useful links

- DEFRA Good practice guide to handling soils.
www.defra.gov.uk/envirom/landuse/soilguid/index.htm
- National Soil Resources Institute Guide to better soil structure.
<http://www.silsoe.cranfield.ac.uk/nsri/services/publications.htm>
www.roots-software.co.uk

