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Tilling Compacted Soils with RipPlows: A Disturbed Soil Restoration Technique

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Introduction

The trafficking of soils by industrial equipment generally causes an increase in soil density and loss of soil structure. The effects of moderate to severe compaction and loss of soil structure on the hydrological and ecological function of soils 10- to 20 cm below the surface is not expected to recover naturally without intervention. The restoration of the soil physical environment as deep as reasonably possible to reduce the impaired hydrologic function is of upmost importance in restoring sustainable forest and ecological function to these sites.

The process of restoring hydrologic function requires the fracturing of the soil profile to increase soil porosity. Soil fracturing will also improve aeration, allow root systems of perennial plants to occupy the soil, and establish more sustainable forest systems.

The objective of this technical note is to describe and illustrate best management practices for the use of RipPlows for deep soil tillage, the conditions that limit their use and effectiveness, practices that fail to optimize their effectiveness, and practices to improve operational productivity. These subjects will be divided into four categories and presented in the following topics:

(1) Machine/RipPlow interaction
(2) Maximizing the tillage benefit
(3) Operational practices

The environmental risks and tilling frozen soil will be dealt with in a separate technical note.

Machine/RipPlow Interaction

1. RipPlows are a purpose built implement for soil tillage.

- RipPlows are built for the sole purpose of tilling soil and not for ripping or prying. Ripper shanks are better designed for the latter tasks.
- Speed for plowing is generally between 1 and 3 km/hr. A larger dozer may have the power to go faster.

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- If plowing slows to speeds less than 1 km/hr, a change in technique may improve speed and productivity.

2. RipPlows are designed to be used in pairs in the outside pockets of a multi-shank toolbar:
    - In this position, dozers will not be trafficking plowed soil, which will maximize the effectiveness of the freeze/thaw process and the rougher surface will provide a wider range of microsites on which vegetation may become established.
        - More than half the elevation gain from plowing can be lost in just driving a machine across plowed soil, and one third is lost in the area between the tracks.
    - A closer spacing of furrows is achieved that increases area covered in a pass and the benefit of tillage increases with adjacent furrows.
    - A single RipPlow in the middle pocket has been tested in frozen ground that was difficult to plow with two. The dozer became extremely difficult to control as one track would lose traction and the dozer would change direction.

3. RipPlows should not be in the ground when turning.
    - Because of their large size at depth, steering of the dozer while they are in the ground becomes nearly impossible and increases the risk of breaking a shank.

4. The tilt of the toolbar of adjustable parallelogram toolbars needs to be monitored.
    - RipPlows are designed with a 5 degree downward tilt that allows them to plow their way to maximum depth in about 5m, but they cannot be forced into the soil like a ripper shank.
    - Tilting the tooth down will allow the RipPlow to penetrate the soil faster but is not recommended because of the need for frequent adjustments.
    - Tilting the tooth down will increase the shear strain in soil more and increase the fracturing of wetter soils.
    - Too much forward tilth of the tooth will increase soil mixing, create a wider and deeper furrow, and require more power. In the extreme, the RipPlows will become anchors.

5. RipPlows should be operated at depths greater than 60 cm.
    - Plowing less deep has been observed to increase the mixing of soil layers. Hence, more subsoil comes to the surface and is mixed with the topsoil.
        - Mixing soil layers has been shown to decrease the benefit of tilling forest soils.
    - It can also increase the closure of adjacent furrows.

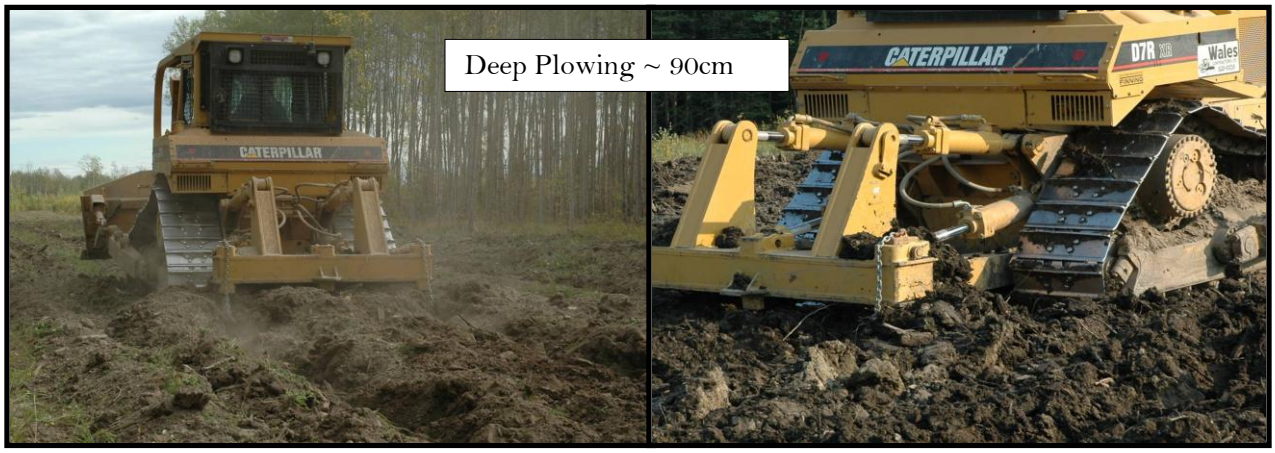
6. Maximum control of RipPlows is achieved when both are in unplowed soil or between furrows of a previous pass.
    - Control of the dozer is always easier when both RipPlows are operating in similar soil.

- If one RipPlow is allowed to interact with an adjacent furrow, the differences in traction and power requirements of each track will make maintaining spacing of furrows more difficult.

7. A blade on the dozer will add extra weight on the front of the dozer.
   - Although the blade is not used during plowing, it does provide some extra weight to help hold the front of the machine down.

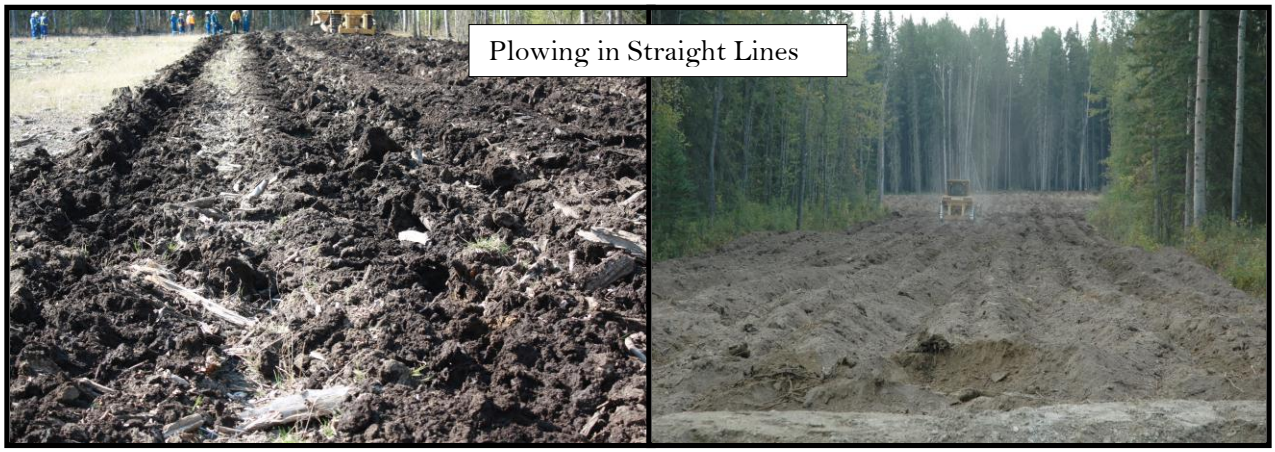
Maximizing the Tillage Benefit

1. Plow soil as deep as possible.
   - Deep plowing increases the volume of soil available to sustain maturing forests and serves as a buffer to climatic stresses.
   - Plowing <60 cm increases mixing of soil layers, which reduces ecological value of topsoil.
   - Deep plowing will lower any temporary watertable where a high watertable is likely to affect forest establishment.



Deep Plowing ~ 90cm

2. Plow sites in straight lines whenever possible, and is most important when starting to plow.
   - Straight furrows improve operator control of the dozer direction.
   - Both tracks have more equal traction.
   - Maximizes the volume of soil tilled in the least number of passes.
   - Reduces the number of times the dozer slides into a previous furrow, which also causes excessive mixing of soil.
   - The straighter furrows also improve control of the dozer in poor light where the differences between plowed and non-plowed soil become more difficult to see.


Plowing in Straight Lines

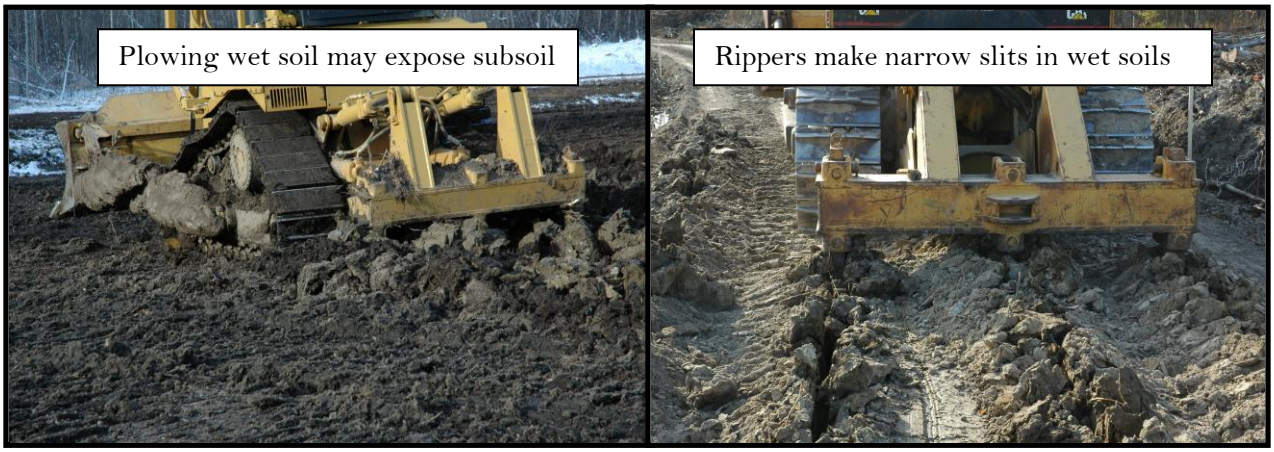
- The first pass of a pair of RipPlows will cover about 30-35 percent of the area being tilled at the bottom of the plowshares, but D7 sized RipPlows are not large enough to fracture the soil between the furrows of trafficked soil.
- Lapping the first pass will result in furrows being about 1 m apart, and cover a minimum of about 65 percent of the area; however, the second pass generally fractures all of the soil between the first pass furrows. Hence, the tillage benefit of the second pass is generally greater than that achieved in the first pass.
- The effectiveness of the second pass plowing is improved if the furrows are straight and evenly spaced.
- The second pass plowing requires less power and the dozer can more easily go deeper and faster than during the first pass, but the depth of plowing needs to be referenced against the elevation of the original soil and not the top of the plowed soil from the first past.
- When soil is plowed in parallel passes the RipPlows are always operating in unplowed soil. Plowing the second pass perpendicular to the first pass is inefficient for two reasons:
    - A third of the time the RipPlows will be operating in the previously plowed soil.
    - Cross-lapping produces much larger blocks of soil, which can reduce the effectiveness of the freeze/thaw process and overall tillage benefit.

4. Minimize shallow plowing at the ends of furrows.

- RipPlows cause less mixing of soil layers when entering the soil than when lifted at the end of the furrow.
- Plow to the edge of a site and raise the plows while stopped or slowly backing up to turn around lessens the amount of subsoil exposed.
- The added benefit of plowing to the edge of a site is that the ends of a site can generally be plowed in two passes perpendicular to the primary direction which also minimizes soil mixing.
- Slowly raising the plows when approaching the end of the site generally brings up more subsoil; some of which cannot be avoided.

5. The optimal soil moisture for plowing is operationally wide, but moist soils are preferred.

- Dry and wet soils require more power to pull RipPlows, which can limit the depth at which RipPlows can operate.
- Wet soils also require more strain to fracture the soil; hence, the front tooth will need to be tilted down and/or the soils plowed less deep.
- Unlike conventional tillage, plowing with RipPlows can be done as long as the dozer has traction because the plowing increases the effectiveness of the freeze/thaw process.
- Plowing wet soil does tend to expose larger clods of subsoil in the furrow.
- Whenever possible schedule plowing so that soils will be moist at the time of soil freezing. This will maximize the benefit of the freeze/thaw cycle as dry soil does not fracture as readily.



6. RipPlows have a critical depth beyond which they become less effective.

- Regardless of the length of shank and clearance under the toolbar, RipPlows designed for D7 sized dozers have a critical depth of 0.9 m, and less in massive and wet soil that requires more strain to fracture the soil.
- A larger plow, and dozer, are needed to plow deeper, but will improve both their effectiveness and productivity.

Operational Practices

1. Tilling soil with RipPlows differs from ripping ground with ripper shanks in several ways and some changes in operating technique and practices are required.

- Plowing can require more power, hence, the performance of the dozer needs to be monitored accordingly.
- Dozers should be able to maintain a minimum speed or changes in technique or practices should be considered.
- Plowed soil can roll up in front of the toolbar, which is mostly topsoil. Therefore, the toolbar needs to be checked frequently to avoid exposing subsoil.
- Monitoring of the plow performance needs to increase when plowing through woody debris, because of the risk of logs coming up through the frame of the toolbar and damaging hoses.

    - The amount of woody debris on the surface should not limit the depth to which the plows can operate.
- Maintaining directional control and position of the dozer at all times is critical to maximizing the effectiveness of the tillage operations in the least number of passes.

2. When plowing gentle slopes, make the first pass downslope.
- The first pass always requires the most power so the plowing will be deeper and more efficient if the first pass is downslope.
- The lapping second pass will be easier going uphill after the first pass has been completed and can be deeper as well.

3. Small cyclic changes in the depth of plowing (3-5 cm) can reduce the power required for plowing and increase speed.
- When plowing requires a maximum amount of power, the requirement can be reduced by temporarily raising the RipPlows. Because RipPlows are designed to apply both upward and lateral forces to soil, raising the plow temporarily will cause the soil to fracture further in front of the plow, which will temporarily reduce the power required and increase forward speed.
- Within in a meter or so, the depth can be lowered to the original depth of plowing.
- An added benefit is that it may help clear soil piling up in front of the toolbar.
- Some operators have perfected this technique so that it becomes routine.

4. Dozers should not attempt to turn while RipPlows are in the ground
- Some steering in wide curves is possible with RipPlows in the ground but the radius of the curve is generally greater than 100 m.
- If a dozer is unable to track a curve easily, the radius is too short to plow with RipPlows in the ground. The alternative is to plow short curves in short straight segments.

5. Except for short distances, turning the dozer around will generally provide better control than backing between the furrows of the first pass to make the second pass.
- Backing between furrows requires the dozer remain on the inter-furrow soil. Otherwise, the dozer will drift into the plowed furrow reduce the tillage benefit of the first pass
- There is also more trafficking of plowed soil as the machine starts to back across a site.
- Maintaining control over the dozer on the second pass will likely become more difficult because the inter-furrow space becomes less visible to the operator, which can result in less than half the soil being tilled in two passes.

6. Exposure of subsoil should be minimized by avoiding shallow plowing and using additional care when lifting RipPlows while turning.
- More subsoil is exposed when RipPlows operate at a depth less than about 60 cm, which also increases the mixing and loss of topsoil.
- Some subsoil will inevitably be exposed when the plow enters or exits the soil but the amount should be minimized.
    - The least exposure of subsoil occurs at the end of the furrow if the dozers stops, or stops and starts to back up, before raising the plows.
    - This process also allows the dozer to turn on looser soil.
    - The unplowed soil at the end of a site can generally be plowed in two passes perpendicular to the main direction of plowing. If more area is used to turn around, more passes are needed to plow the ends of a site, which results in more loss of topsoil, soil mixing, and may produce larger clods in areas that were not plowed deep at the start.

7. Tilling strong dry soils.

Severely impacted surface soils that are dry, such as old roads, can have penetration resistances many times greater than when the soil is moist. This can become an obstacle to plowing these roads with RipPlows, because a D7 sized dozer may not have the necessary power.

- Dozers will have the best opportunity to plow strong soils if the lower body of the plow is kept below the strong surface soil.
- If RipPlows rise up in strong soil, it is better to back up and re-enter the soil rather than trying to force them down in hard, dry soil.
- The best alternative for tilling hard surface soil where RipPlows become inefficient is to first rip the hard surface soil layer with ripper shanks. This practice should improve the fracturing of the surface than ripping deeper, and allow the RipPlows to access the deeper soil that is likely wetter and for which RipPlows are better suited.
- Plowing these soils with larger dozers and RipPlows will also work, but shallow ripping of the surface may still improve the overall effectiveness of the tillage.