Soil compaction and pugging on dairy farms

What is soil compaction and pugging?

In New Zealand soils typically half of the topsoil volume is pore space which contains air and water. Larger soil pores are responsible for air movement and drainage, but are also the most susceptible to compaction and pugging damage.

Soil compaction happens when soil pore space is reduced or compressed (Figure 1), and typically occurs in moist rather than saturated soils.

Pugging typically occurs when the soil is very wet and soil pores are filled with water. In these conditions, trampling creates a ‘hummocky’ surface, or in extreme cases slurry. Usually there is considerable soil and pasture damage.

Effects of compaction and pugging

Soil compaction and pugging can cause:
- Reductions in pasture production and nitrogen fixation by clover
- An increase in weeds, water logging and greenhouse gasses emitted from soil
- Increased surface runoff, causing soil loss and release of sediment, nitrogen and phosphorus to waterways
- Degradation of soil structure (Figure 2)

How do you assess soil compaction?

When a soil is badly compacted it has a blocky appearance, dense aggregates that are hard to break up, poor root penetration, may be more drought prone and may have a greyish colour and unpleasant smell when wet. In contrast, a soil with little compaction tends to be much more ‘crumbly’ with abundant roots, deeper root penetration and many more worms.

Soil scientists have developed an indicator of soil compaction called macroporosity. This measures the volume of large pores (>0.03mm) which are responsible for air movement and drainage within the soil.

Figure 1: Diagram showing soil unaffected to severely affected by compaction

Figure 2: Non-compacted soil (left) and severely compacted soil (right)
Effect of compaction on pasture production

Research shows that pasture production reduces as soil macroporosity reduces, i.e., as soil becomes more compact (Figure 3).

![Figure 3: Effect of macroporosity on dairy farm pasture](image)

Effect of pugging on pasture production

Research has also shown that pasture production can be badly affected due to pugging. Moderate pugging events can reduce dairy pasture production by 20-50% over several months to a year, and severe pugging events can reduce production by 40-80%.

This will typically occur during block-grazing over winter when cows are not being milked, such as on a runoff block. The amount of loss will depend on soil moisture, soil susceptibility, stock type, amount of pasture cover and grazing duration.

Soil compaction on dairy farms in the Wairarapa and Otaki regions

Greater Wellington Regional Council has monitored soil quality on dairy farms in the Wellington region since 2000 (Figure 4).

As a general rule of thumb, a soil macroporosity value of <10% indicates that pasture production could be affected. 65% of paddocks measured had soil macroporosity <10%, meaning that soil compaction is likely to be limiting pasture production on these farms.

![Figure 4: Macroporosity on dairy farms in the Wellington region 2000-09](image)

Minimising or preventing compaction damage

There are a number of practices that can reduce the risk and degree of compaction and pugging:

- Build up pasture cover on paddocks before grazing
- Consider larger breaks between grazing
- Decrease paddock grazing duration to around 4 hours in very wet conditions
- Stand stock off paddocks when soils are very wet or waterlogged, i.e., consider using stand-off pads
- In spring avoid grazing pastures that have been recently irrigated
- Manage the more susceptible soils differently to more resilient ones

Pugging of stream banks and riparian margins should be strictly avoided to prevent loss of soil, pathogens

For more information, contact the Wellington Regional Council

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For more information on managing treading damage, see the AgResearch publication Managing treading damage on dairy and beef farms in New Zealand.