Field Day Report: Soil, Water and Carbon for Every Farm – Building soils, harvesting rainwater, storing carbon

Darren Doherty, from Australia, presented a seminar for the ODPG (Organic Dairy and Pastoral Group) at John, Trish and Kelvin Hicks's farm, Willowmere, at Hororata, on the subject of *Soil, Water and Carbon for Every Farm.*

Darren began by saying that farmers have a significant role to play harvesting carbon (C) from the air and storing it in the soil. Techniques developed specifically to increase soil carbon include:

- **Holistic grazing.** Animals are grazed intensively and moved each day to a new pasture, leaving behind large amounts of organic matter. The most palatable species are not overgrazed (see Organic Update No. 14 on the CCOG website http://www.organics.org.nz).
- **Non-inversion subsoiling** (also known in Australia as Yeoman's pattern ploughing). (more on this later)
- **Biological amendments** (such as soil food web compost teas or effective microorganisms) (see Organic Update No.4 and No. 1 respectively).
- **Biochar** (a stable form of carbon that can be incorporated into the soil as a permanent carbon store. This would potentially create a major carbon sink that removes carbon dioxide from the atmosphere through plant growth and stores it as inert carbon in soils).
- **Integrated farm planning** using permaculture, Keyline Design, Zeri principles (zero emissions) and Holistic Management (more on Keyline Design later).

That farms can be a carbon sink as well as a source of greenhouse gas emissions is great news as we are often told that farms are responsible for a large proportion of emissions in New Zealand. The Lincoln University web-based "carbon calculator" only calculates emissions created from farms, not carbon accumulated. (Maybe someone should have a word to them?)

Carbon (C) sequestration – should we use trees or soil or both?
"*Agricultural soils have short, medium and long-term potential to mitigate climate change by sequestering atmospheric carbon as beneficial humified organic matter. The carbon sequestration potential of appropriately managed farmlands can be higher than that of tropical forests*." Porteous & Smith, 2008

Trees – not as high performing as soil/grasslands can be; they lock up the land for 10-15 yrs; generally they need high quality land and good rainfall, and they do not "build" soils. Yield is around 200t/ha over 10-15 yrs. At this rate, 7 Earths are needed to sequester the C legacy we have now. However, they do have the advantage of being positive landscape and climate modifiers (i.e. they store moisture which remains in the system, and generally increase rainfall).

Soils – grassland can take in more C than trees. Grassland has the potential to sequester C quickly and cheaply. Every tonne of organic C stored in the soil has

removed 3.76 t CO2 from the atmosphere. The C in the top 10 cm of soil is in a state of flux (i.e. can be easily lost and regained), ***but if C is stored in the lower layers of soil as humus it is very stable.***

Trees and soils together can be a stable and productive integrated system.

Six essential factors for soil formation:

- Bioactive minerals
- Air
- Water
- Living things in the soil
- Living things on the soil
- Intermittent and patchy disturbance regimes (e.g., animals grazed using holistic grazing principles)

Compacted and biologically "dead" soils are not productive and will not be particularly useful for growing grass or storing C. Darren stressed that to maximise the potential of soils to store C, the root zone must be aerated so that plant roots can get down into the subsoil. A penetrometer should be used when the soil is at field capacity to assess whether the soil is compacted. If the soil is compacted (below….PSI.) a subsoiler should be used to "loosen" the soil, which will have the effect of letting air and water deeper into the soil and improving rooting depth. Deeper, healthier roots exude root sugars which are metabolised by fungi. More root sugars result in more fungi. Fungi gather minerals from the soil and release glomulin which is what leads to soil aggregation, which results in improved structure. Improved structure promotes rooting ability of plants, better water infiltration and storage, and increased organic matter (carbon) sequestration and storage.

Darren recommends the Yeoman plough for subsoiling. It has discs on the front to cut the sod, sharp points to go down into the soil, and a roller on the back to flatten the ground. Darren often mounts shank seed boxes behind the points and before the roller to sow deep rooting species and to minimise weed strike where the ground has been disturbed. (For pictures and further description, go to http://www.yeomansplow.com.au/yeomans-plows.htm or google "Yeomans plough" for other sites.)

Kelvin Hicks demonstrated a James plough (subsoiler). Darren said the points on this were not ideal as they were like "earthmoving" points which could lead to smearing. The Yeomans plough has points with an 8^{o} angle so that there is no mixing between subsoil and topsoil. Subsoiling should be done when the soil is relatively dry, but when rain is likely. Tractor speed should be about 3-4 kph.

The Hicks's paddock had good populations of "biological subsoilers" – i.e. plants with deep taproots that would go down into the subsoil, such as dandelion, chicory and plantain. Docks also have deep taproots but are associated with compaction and acidification. Subsoiling has a "liming effect", in that it lets out hydrogen and lets in oxygen. Subsoiling is a remedial approach – do not use if your soil structure is already good.

Increasing the amount of C in the soil also increases the soil's water holding capacity. A 1% increase in soil C allows an extra 144,000 extra litrtes of water to be held in the soil per ha. The Hicks's carrot paddocks have a 5% organic matter content, which is very high, and they do not need to irrigate even in dry summers.

Darren told us about the system of soil carbon credits that has been developed in Australia by soil scientist Dr Christine Jones. The Australian Soil Carbon Accreditation Scheme (ASCAS) has been established to give farmers credit for storing carbon and building soils on managed land. ASCAS is a vehicle to demonstrate through farm trials that with perennial (long lived) deep-rooted pastures and annual crops, measured increases in soil carbon can be achieved quickly and rewarded with incentive payments for the CO2 sequestered. The scheme is the first of its kind in the Southern Hemisphere, making Australia an leader in the recognition of soils as a verifiable carbon sink. Read more about this on http://www.amazingcarbon.com/Jones%20-%20Australian%20Soil%20Carbon%20Accreditation%20Scheme.pdf
See also the website http://www.amazingcarbon.com/ This site has numerous articles on the subject of storing carbon. One I found particularly interesting was "Farming a climate change solution" by James Porteous and Frank Smith; another good one is "Mitigating Climate Change: Conservation Agriculture Stores Soil Carbon", by the United Nations Food and Agriculture Organization.

Keyline design

Another of Darren's areas of expertise is keyline design. This is a type of functional landscape design: "an integrated system of water harvesting and gravity irrigation, soil development and farm layout". The principles are to hydrate ridges not valleys by ploughing or ripping not on the contour but at a equidistant spacing so that water flows to the ridges. This system "captures" a lot of water into the farm system, which can be stored in dams for later gravity-fed irrigation, and when used alongside extensive tree planting and other methods of capturing carbon (e.g., subsoiling and holistic grazing) can build soils, improve water retention, and store carbon. Farm tracks and roads can be built so that they can be used as water channels.

The **keypoint** in a valley is the place where the valley suddenly gets steeper. This is the highest place in the valley that is practical to place a dam. The **keyline** is a contour line carried in both directions from the keypoint. Cultivation with a subsoiler or ripper for tree planting can be done parallel to the keyline to

bring water out from the valley to the drier ridges. For more information see http://www.wiserearth.org/group/keyline/section/details#About

It was a thought provoking presentation and exciting to hear the potential of farming to be at the forefront of reducing greenhouse gases. The figures are compelling – a mere 1.6% increase in soil C in the soil that is currently grazed and cultivated (which is 12% of the Earth's land area) would reduce atmospheric CO2 to below 300 parts per million (ppm). It is now at 380-400 ppm; pre-industrial levels were 280 ppm. Methane emissions from animals, and cultivation for cropping, especially in an organic regime, remain areas we all need to work on. Thanks Darren for a great discussion – we all went away inspired to lock away as much C as possible!

Mary Ralston