5. GRAZING TRIALS

5.1 The effect of grazing crops on soil structure and weeds (preliminary findings) - Inverleigh, Lake Bolac & Werneth, Vic

Location:
Inverleigh, Lake Bolac and Werneth, Victoria

Funding:
GRDC and Caring for our Country through the Grain and Graze 2 program

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Summary of findings:

- Despite visual differences there is no major impact on soil structure, water holding capacity or water infiltration from grazing in summer or in winter when soils are waterlogged
- Grazing in the previous winter or summer does not affect the following crop establishment or grain yield
- Any yield losses after winter grazing are the result of moisture stress in the period immediately after grazing through to flowering
- Annual ryegrass and wild radish populations did not increase because of grazing, although the sites only had low levels of infestation to begin with. However farmer observations do not support this and further work is required

Background/Aim:
Crops offer a valuable feed resource for a mixed enterprise business. Grazing crops in winter can enable pastures to be rested, building a feed wedge for later in the season. Summer grazing of stubbles utilises unharvested grain, reduces summer weeds and the hoof impact can reduce populations of slugs and earwigs in the next crop.
While work in Grain and Graze 1 established some basic principles of grazing crops, the long term impact on soil structure and weeds was unclear. A series of trials are being conducted to determine the impact of grazing on soil condition and weed populations. This report is on findings after two years of grazing.

Trial information:
Replicated trials were established at Inverleigh, Werneth (near Rokewood) and Lake Bolac in 2010. The Werneth site was controlled traffic and had not been grazed with livestock for five years before the trial commenced (considered a 'no till' paddock). The grazing treatments were:

- No grazing
- Grazing over summer only
- Grazing over winter only
- Grazing in summer and winter.

The first grazing was undertaken in the winter of 2010, followed by a summer grazing in January 2011 and a winter grazing in August 2011. Winter grazing was conducted to complete dry matter removal by GS 30 in cereals or bud elongation with canola. Summer grazing continued until all feed value was removed from the stubble[1].
Growing season rainfall was markedly different between the two years (table 1). In 2010 grazing occurred when the soil was saturated, creating the best possible conditions to 'damage' the soil. Summer grazing was characterised by unseasonal rainfall including 124 mm in mid January at Lake Bolac and 117 mm at Inverleigh. In contrast the 2011 winter was more favourable, with average rainfall at Lake Bolac and only slightly wetter conditions at Inverleigh. However this was followed by an unusually dry six week period immediately after grazing (decile 1 rainfall for Inverleigh and decile 2 for Lake Bolac).

Table 1. 2010 and 2011 growing season rainfall for Inverleigh and Lake Bolac (Werneth rainfall not available). Month in bold represent when grazing occurred

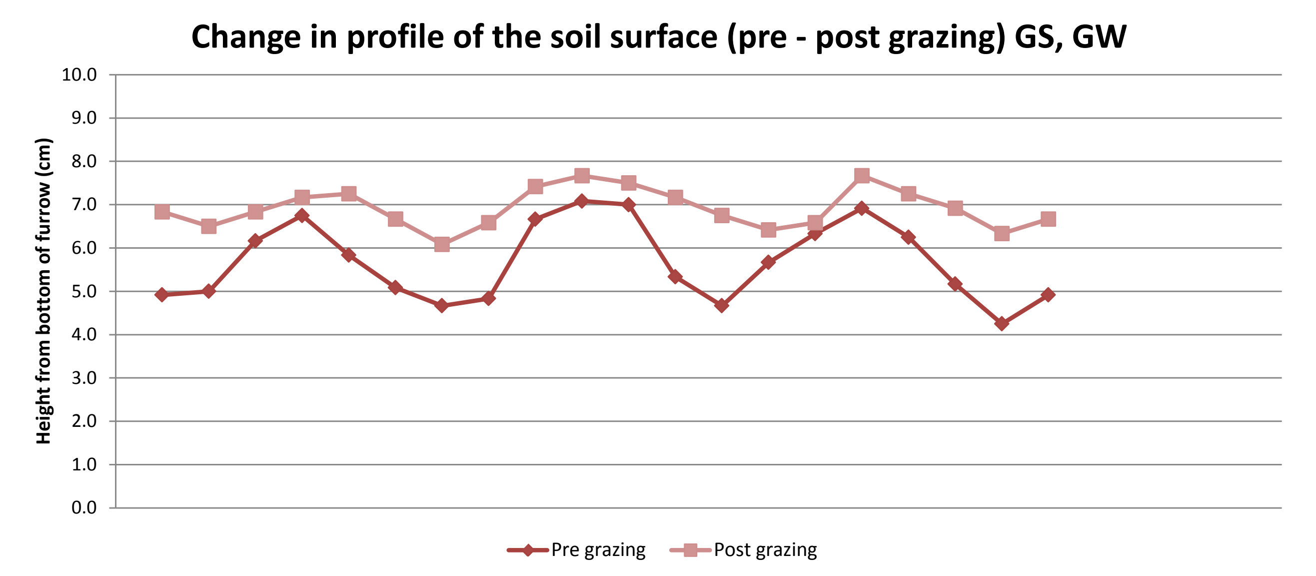
Month	Inverleigh			Lake Bolac		
	2010	2011	Long term average	2010	2011	Long term average
April	57.2	20.7	39.3	47.2	35.8	35.0
May	31.6	38.0	49.0	23.2	67	44.8
June	43.6	48.8	48.6	36.2	37.8	45.7
July	32.0	70.9	53.2	38.6	49.4	47.9
August	**78.0**	**29.7**	57.4	**169**[2]	**33.0**	61.6
September	50.6	21.8	57.4	43.4	32.4	50.4
October	95.8	63	55.2	69.0	57.4	50.3
November	51.8	83.8	47.6	79.4	34.6	42.5
December	29.4	22.4	39.9	105.2	24.0	32.6

High intensity grazing was used in winter of 2010 and 2011. Stocking rates of 40 to 45 DSE/ha were used, with grazing lasting 6 to 10 days in 2010 and 3 to 4 days in 2011. Grazing occurred in mid to late August.
Grazing of the stubble commenced in mid to late March and lasted for 12 to 19 days with stocking rates of 40 to 70 DSE/ha.

Results and Discussion:
A series of indicators have been chosen to determine effects of grazing on soil conditions. Responses for each of these indicators are presented.

1. Changes in the profile of the surface soil
As expected grazing after sowing 'flattened' the soil surface compared to no grazing (figure 1), although there was still some surface roughness remaining in the grazed treatment, allowing water to pool in the sowing grooves.

Figure 1: Change in bed profile from winter grazing (Lake Bolac, 2010)



2. Establishment of the next crop
Grazing in the previous winter (2010) did not affect the establishment of crops in 2011 (table 2). A tyned seeder with press wheels was used at Inverleigh and Lake Bolac and a disc seeder at Werneth.

Table 2: Crop establishment in 2011 after grazing treatments in 2010.

Treatment	**Establishment (pl/m²)**		
	Inverleigh	**Lake Bolac**	**Werneth[3]**
Crop	**Barley**	**Barley**	**Wheat**
Not grazed	168	119	79
Grazed in summer	171	134	100
Grazed in winter	169	140	88
Grazed in summer and winter	159	139	73
Significance (p<0.05)	NS	NS	NS

Four additional trials where canola was grazed or not grazed in 2010 were sown to wheat in 2011 and establishment measured (table 3) . A significant difference in establishment was recorded at one site, although the difference between the plant populations was small (<5%). At the other three sites there were no significant differences.

Table 3: Establishment of wheat in 2011 on plots grazed or ungrazed in 2010.

Treatment	**Establishment (pl/m²)**			
	Inverleigh		**Lake Bolac**	
Previous trial	**Canola experimental varieties 1[4]**	**Canola experimental varieties 2[5]**	**Canola experimental varieties**	**Canola commercial varieties**
Not grazed in 2010	123	166	117	131
Grazed in winter 2010	129	159	119	129
Significance (p<0.05)	*NS*	*6*	*NS*	*NS*

3. Infiltration of rainfall and soil moisture after grazing

Grazing does not appear to have affected the infiltration of rain into the soil. This is demonstrated by three indicators.

3.1 Soil moisture soon after a rainfall event

Soil cores were taken from each treatment four days after a significant rainfall event and measured for soil moisture. There is no reduction in water infiltration on the grazed treatments compared to the ungrazed treatments (table 4).

Table 4: Gravimetric soil moisture on 19 May 2011 after rain 4 to 7 days earlier.

Location	Treatment	Depth		
		0 -10 cm	10 -20 cm	20 - 30 cm
Inverleigh (16.5 mm)	Not grazed	14.1	15.4	26.1
	Grazed in summer 2011	13.3	16.0	22.1
	Grazed in winter 2010	13.5	17.0	26.0
	Grazed in summer and winter	15.0	17.3	23.4
	Significance (p<0.05)	*NS*	*NS*	*NS*
Lake Bolac (28.4 mm)	Not grazed	23.9	23.9	20.3
	Grazed in summer 2011	23.7	23.1	20.5
	Grazed in winter 2010	19.7	20.8	17.7
	Grazed in summer and winter	23.1	22.4	16.0
	Significance (p<0.05)	*NS*	*NS*	*NS*
Werneth (22 mm)	Not grazed (no till)	33.2	32.1	30.3
	Grazed in summer 2011	31.9	29.5	30.4
	Grazed in winter 2010	32.0	30.9	32.6
	Grazed in summer and winter	32.2	31.4	31.8
	Significance (p<0.05)	*NS*	*NS*	*NS*

3.2 Soil cores

Intact soil cores were collected from each grazing treatment in April 2011 to examine any changes in soil structure, porosity (air spaces) and infiltration caused by grazing in winter 2010 or summer 2011. There were no significant differences in key indicators of soil structure except for plant available water at the Werneth site (table 5). At this site winter grazing appears to have had a small effect.

Table 5: Soil physical properties in the 0-10 cm layer measured in April 2011 (after winter and summer grazing).

Location	Treatment	Bulk density (g/cm³)	Plant available water (mm)	Infiltration (mm/hr)
Inverleigh	Not grazed	1.32	11.2	1.3
	Grazed in summer 2011	1.38	12.6	1.4
	Grazed in winter 2010	1.33	12.2	1.3
	Grazed in summer and winter	1.24	10.6	1.2
	Significance (p<0.05)	*NS*	*NS*	*NS*
Lake Bolac	Not grazed	1.37	12.0	0.12
	Grazed in summer 2011	1.35	14.0	0.23
	Grazed in winter 2010	1.31	13.4	0.16
	Grazed in summer and winter	1.31	15.5	0.21
	Significance (p<0.05)	*NS*	*NS*	*NS*
Werneth	Not grazed (no till)	1.25	9.4	1.4
	Grazed in summer 2011	1.20	10.0	2.4
	Grazed in winter 2010	1.28	6.9	1.0
	Grazed in summer and winter	1.21	5.3	1.5
	Significance (p<0.05)	*NS*	*3.1*	*NS*

No impact was measured at lower depths (data for 10-20 cm and 20-30 cm not presented).

3.3 Soil moisture over time

Soil moisture probes to the depth of 1.0 m were installed at the Inverleigh and Lake Bolac sites with moisture measured every 10 cm through the soil profile. In the 0-30 cm profile there were no differences in soil moisture, however the graphs of the top 0-10 cm would suggest there may be small differences as a result of grazing when a large rainfall event occurs in summer (figures 2 & 3). These difference in soil moisture is small in comparison to total growing season rainfall (only approximately 4 mm to 5 mm).

Figure 2: Soil moisture (0 - 10 cm) in 2011 under four grazing regimes at Inverleigh.

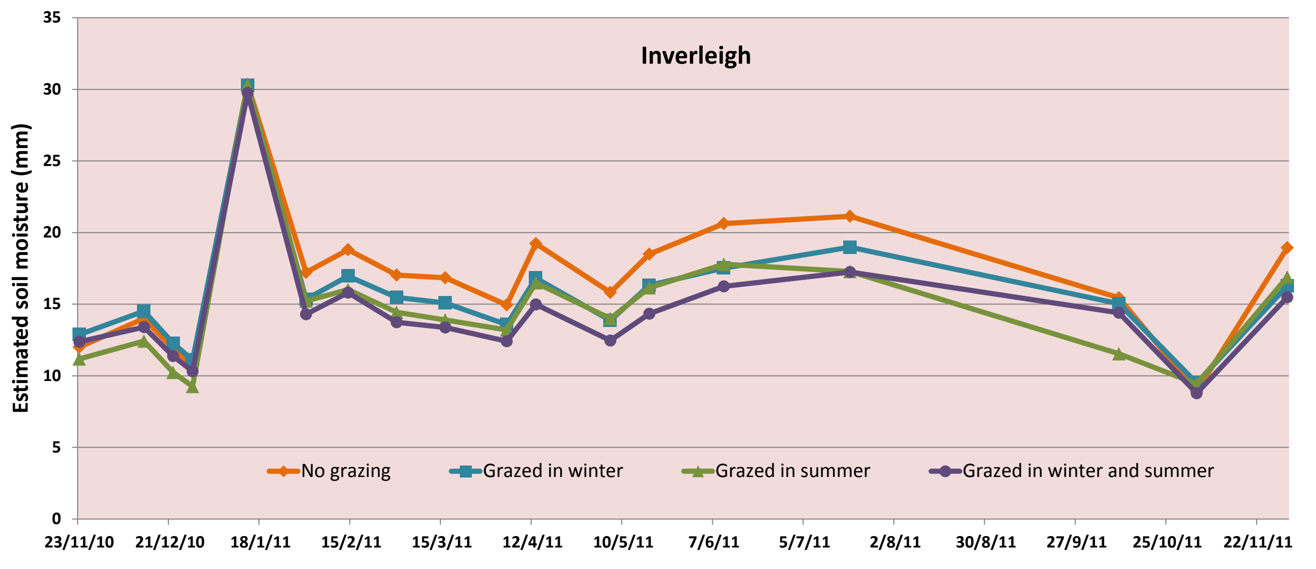
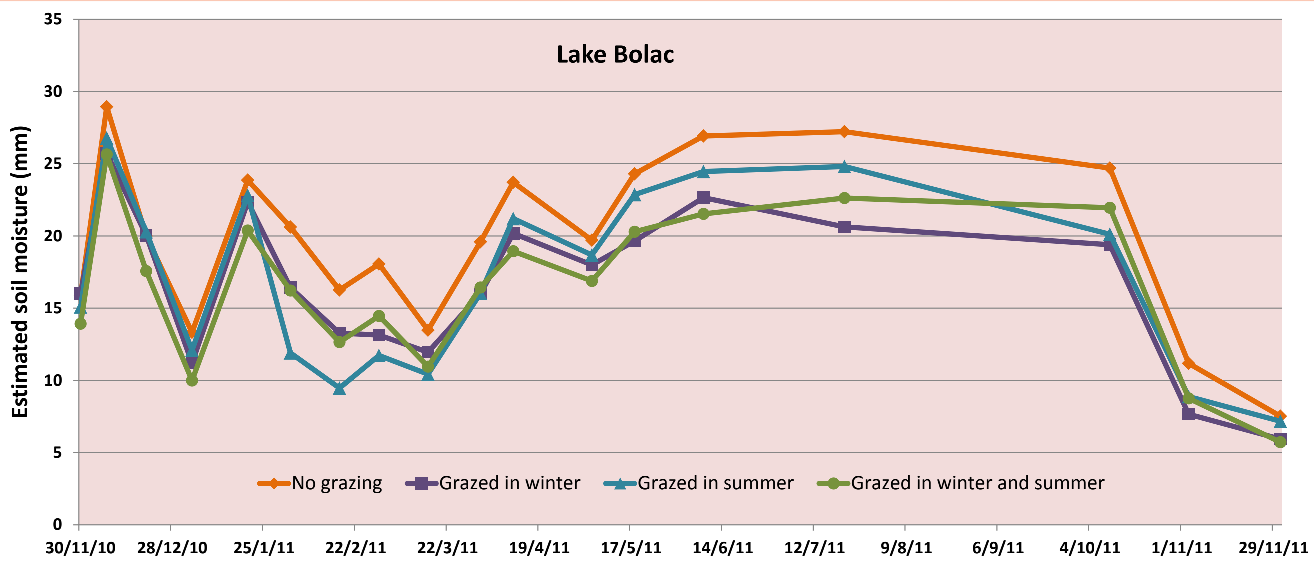


Figure 3: Soil moisture (0 - 10 cm) in 2011 under four grazing regimes at Lake Bolac.



4. Weeds

Weed populations were measured at each site after sowing. Measurements were taken soon after sowing, to determine the number of weeds that had not been controlled by the pre sowing herbicides. On some trials a second measurement was taken for weeds that may have germinated after the use of post emergent herbicides (or could be herbicide resistant).

Table 8: Annual ryegrass after sowing but before post emergent herbicides and grazing in 2011.

Treatment	**Annual ryegrass (pl/m^2)**		
	Inverleigh	**Lake Bolac**	**Werneth**
Crop	**Barley**	**Barley**	**Wheat**
Not grazed	0	5.0	32
Grazed in summer	0	5.3	4
Grazed in winter	0	1.3	22
Grazed in summer and winter	0	1.3	59
Significance (p<0.05)	*NS*	*NS*	*27[6]*

Table 9: Wild radish after sowing but before post emergent herbicides and grazing in 2011.

Treatment	Wild radish (pl/m²)		
	Inverleigh	Lake Bolac	Werneth
Crop	**Barley**	**Barley**	**Wheat**
Not grazed	0	0	0
Grazed in summer	5	0	0
Grazed in winter	5	0	0
Grazed in summer and winter	3	0	0
Significance (p<0.05)	*NS*	*NS*	*NS*

Table 10: Annual ryegrass in 2011 on plots grazed or ungrazed in 2010

Treatment	Annual ryegrass (pl/m²)			
	Inverleigh		Lake Bolac	
	Early sown wheat - after sowing, before post emergent herbicides	Early sown wheat - after post emergent herbicides	Wheat - after sowing, before post emergent herbicides (Canola experimental varieties in 2010)	Wheat - after sowing, before post emergent herbicides (Canola commercial varieties in 2010)
Not grazed in 2010	1.7	3.6	7.4	9.5
Grazed in winter 2010	2.0	5.7	5.9	4.0
Significance (p<0.05)	*NS*	*NS*	*NS*	*NS*

5. Grain yield

Grazing had no effect on wheat yields at Inverleigh and Lake Bolac in 2010. This was surprising given the severe pugging that occurred during grazing and seems to indicate the resilience of cereals to grazing if favourable conditions after grazing are encountered. In contrast canola at Werneth in 2010 did not handle the combination of grazing and waterlogging, resulting in no commercial yield (table 11). However the yield of the ungrazed canola was also below average because of the severe site conditions.

The crops sown in 2011 were the first to be influenced by any legacy of the winter grazing in 2010 and the summer grazing of 2011. Yields at two of the three sites were significantly lower than the ungrazed trials (table 11). The reason is thought to be the moisture stress the plants encountered after grazing rather than the impact of changes to the soil (see discussion section).

Table 11: Grain yield (t/ha) for winter grazed and ungrazed plots

Crop	Inverleigh		Lake Bolac		Werneth	
	2010	2011	2010	2011	2010	2011
	Wheat (t/ha)	Barley (t/ha)	Wheat (t/ha)	Barley (t/ha)	Canola (t/ha)	Wheat (t/ha)
Not grazed	7.0	6.8	2.5	5.1	0.9	2.3
Grazed in summer	6.9	7.1	2.8	5.6	0.9	2.4
Grazed[7] in winter	6.6	4.8	2.6	5.4	0.03	1.4
Grazed in summer and winter	6.7	4.8	2.8	5.2	0.04	1.3
Significance (p<0.05)	*NS*	*0.76*	*NS*	*NS*	*0.21*	*0.9*

At the Werneth site, one treatment was only grazed in the winter of 2010 and the summer of 2011. It was then sown to wheat in 2011 and not grazed enabling a comparison of the legacy of previous grazing with no grazed areas. There was no significant difference in yield from the grazed treatment in 2010 compared to the never grazed treatment (yields of 2.5 t/ha and 2.3 t/ha respectively).

Four additional experiments were conducted on sites where part of each plot had been grazed and part ungrazed in 2010. Each experiment was sown to wheat in May 2011, not grazed and harvested to compare effects of the 2010 grazing. There were no differences in grain yield (table 12) or grain quality (data not presented).

Table 12: Yield of wheat in 2011 to plots grazed or ungrazed in 2010.

Treatment	Wheat yield (t/ha)			
	Inverleigh		Lake Bolac	
Previous trial	**Canola time of sowing 1**	**Canola time of sowing 2**	**Canola experimental varieties**	**Canola commercial varieties**
Not grazed in 2010	9.0	8.8	4.9	5.2
Grazed in winter 2010	8.7	8.9	4.9	5.3
Significance (p<0.05)	*NS*	*NS*	*NS*	*NS*

Discussion:

The concern that grazing has a negative impact on soil structure is understandable. A pugged paddock in winter or a powdery topsoil in late summer invokes thought of damage to the soil. However the preliminary results from these trials would suggest any 'damage' is minor and does not leave a negative legacy in subsequent crops.

Soils lose their strength as they get wet and this loss of strength is more pronounced when the soil is waterlogged (the space that usually contains air is filled with water). If the soil is subject to pressure from above, either through machinery or hoof impact, the air spaces will deform and often compress, commonly called soil compaction.

The pressure at which the soil fails is referred to as the bearing strength and in practical terms is the pressure at which an animal's hoof will break the soil surface, sink in and form a pug mark. Nie, Ward and Michael (2001) found that soils with a bearing strength of < 0.7 MPa are at risk of being pugged with dairy cattle. The dynamic soil pressure from walking sheep is believed to be lower at around 0.4 – 0.5 MPa. Most soils in Southern Victoria fall below this level in a 'typically' wet winter, but rise above this threshold very rapidly (within days) as the soils dries out.

Soils have a remarkable capacity to 'repair' themselves through microbial activity and the accumulation of organic material such as plant roots, fungal hyphae and 'glomalin', a glue like compound that sticks soil particles together. A recent review by the CSIRO of the impact of soil compaction by livestock in cropping systems (Bell, 2010) suggested:

- the effects due to grazing are mainly in the surface soil[8] (0 - 10 cm)
- there can be immediate changes in soil properties due to grazing, but rarely have reductions in *subsequent* crops been measured.
- because compaction from livestock is shallow, it is not long lasting and is rectified by natural processes (and tillage).

The results from these trials support these conclusions. There were no significant changes in soil bulk density, plant available water, water infiltration or soil moisture where grazing had occurred. Subsequent crop establishment was not affected.

The reduction in grain yield measured in three experiments can be explained by influences other than soil structure changes. The failure of the canola at Werneth in 2010 is variety related, with the cultivar not suited to grazing, especially under highly adverse conditions. Grazing was conducted at this site to achieve the most aggressive soil pugging possible and the crop suffered as a consequence. The yield loss of barley at Inverleigh and Werneth in 2011 was most likely the result of moisture stress between the end of grazing and flowering. Despite grazing having been completed by GS30, evidence is emerging that moisture stress straight after grazing will adversely affect recovery and subsequent grain yield[9]. The crops described only received decile 1 rainfall in the two months after grazing. To further support this conclusion, no yield reduction occurred where decile 2 or 3 rainfall was received.

There is no evidence from this preliminary data to indicate that grazing increases the population of annual ryegrass or wild radish. It is commonly though hoof impact on the soil will bury weeds seeds, leading to increased germination and also a more staggered germination. However grazing has not increased weed numbers (so far) on any of the seven experimental sites. This may be the result of very low weed populations to begin with, effective weed control pre sowing, or that the effect of grazing is not as detrimental as originally thought. Monitoring of weed populations will continue at these sites along with the establishment of additional experiments on known 'dirty' sites.

Other weeds including wireweed, capeweed, sorrel, toadrush and clover were also measured but no influence on weed populations due to grazing were recorded.

References:

Bell L (2010). Soil compaction by livestock – what are the impacts. GRDC WUE Newsletter, Issue 2, May 2010. GRDC Canberra.

Nie, ZN, Ward, GN, Michael AT (2001) Impact of pugging by dairy cows on pastures and indicators of pugging damage to pasture soil in south-western Victoria. *Australian Journal of Agricultural Research* **52**, 37-43.

Footnotes:

1. Grazing was completed when there was less than 40 kg/ha of grain or green material as per the Grain and Graze 1 'rules of thumb' for stubble grazing
2. Highest monthly rainfall since records started in 1912
3. 35 cm row spacing
4. Sown in late April
5. Sown in late May
6. CV of 63% indicating a high level of variability
7. Grazing completed before GS 30
8. May be greater if the soil has been recently cultivated
9. This impact was also measured on late season varieties grazed late in 2007 - see SFS trials