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Comparing OVERSEER® estimates of N leaching from grazed winter forage crops with results from Southland trial sites

RE500/2013/123

September 2013

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Report prepared for Environment Southland

September 2013

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Table of Contents

1. Introduction

The change in land use from sheep to dairy farming in Southland over the past two decades has raised concerns about the environmental impacts of a growing dairy industry. Monitoring by Environment Southland indicates that N concentrations in rivers and in 36% of the region's aquifer monitoring sites are increasing, in some instances to levels close to or above maximum permissible concentrations for safe drinking water (Environment Southland, 2010). Dairy cow wintering on grazed forage crops is perceived to have a relatively large environmental footprint, particularly when it occurs in sensitive catchments. This animal management practice normally occurs over a 10 week period during winter and is seen as a cost-effective strategy for meeting animal feed demand in winter and avoiding treading damage to soils and pastures during wet and cool winters in southern New Zealand. Research in Southland has indicated that N leaching losses from areas used for forage crop grazing over winter are relatively high (Smith et al. 2012; Monaghan et al. 2013).

Environment Southland has requested that these measured losses be compared to those derived using the OVERSEER® Nutrient Budgets model (hereafter referred to as "*Overseer"*) for a typical dairy farm in Southland.

2. Methods

A typical farm was created within *Overseer* based on the Tussock Creek Dairies' Farm, near Invercargill, Southland. This farm was selected as it is the site of a long term grazing and drainage experiment (on-going since 2000: Monaghan et al. 2009).

This farm is a mainly flat dairy farm, milking 745 cows (3.1 cows/ha) and producing 1037 kg milk solids/ha/year, with an annual rainfall of 1120 mm/year. The farm is on a mixture of Pallic and Gley soils, though was modelled as all Pallic as the drainage trial is located on that soil type.

Two scenarios of contrasting wintering approaches were created around this farm as described below.

2.1 Scenario 1

For scenario 1 the farm is split into 3 blocks,

- An effluent block (25 ha)
- A main milking block (212 ha), and
- A winter crop block (30 ha) which rotated round the main milking block.

The model farm was set up to allow for 5 ha of sheds, laneways and other non-effective areas. Nitrogen fertiliser (a total of 100 kg N/ha/year) was applied to the pastoral block in March and April only, in line with the management of the trial area. Phosphorus fertiliser (20 % K Super) was applied in late summer. In this scenario all stock were wintered on, grazing the 20 ha winter forage crop block. A poorly drained Pukemutu (Pallic) soil was assumed for all blocks in Farm Scenario 1.

2.2 Scenario 2

For scenario 2 the farm is split into only 2 blocks:

- An effluent block (25 ha), and
- A main milking block (212 ha).

A 5 ha area was again assumed to account for all non-effective hectares. Nitrogen fertiliser (a total of 100 kg N/ha/year) was applied to the pastoral block in March and April only, in line with the management of the trial area. Phosphorus fertiliser (20 % K Super) was applied in late summer. In this scenario all stock were wintered off during June and July, grazing a 30 ha winter forage crop block at Five Rivers in northern Southland.

The crop block at Five Rivers was set up using the arable model with the modelled year being the second year of winter crop, whereas the experimental measurements used were the mean of 3 years of data (Smith et al. 2012). A shallow, free drained Lintley (Brown) soil was assumed for the winter crop block in Farm scenario 2.

For scenario 1, a kale crop yielding 14.6 t DM/ha/year was assumed and allocated to the herd over June and July. For scenario 2 the fodder crop was swedes, with yields of 16 and 13 t DM/ha for the two years required for the crop model. These crops and yields are in line with those measured in the wintering experiments (Monaghan et al. 2013; Smith et al. 2012).

2.3 Model comparisons

All data from the two farms were entered in *Overseer* v 6.1 following best practise input guidelines (EUG 2013). The results from *Overseer* were compared with average N leaching losses measured from the milking platform (from Monaghan et al. 2009), and average leaching losses measured from grazed winter forage crops (from Monaghan et al. (2013) and Smith et al. (2012)).

The climate data used were taken from the experimental sites themselves. For the milking platform the rainfall entered was 1120 mm; this was the mean of the 2004 - 2007 measurement years (Monaghan et al 2009) and was slightly higher than the long term average (2000-2012) for that site of 1065 mm/year. This rainfall was, by default also that for the winter grazed crop in scenario 1. It is slightly lower than the mean of 1150mm measured over 3 years (2005-2007) at the winter grazing trail nearby (Monaghan et al. 2013). For the winter crop block at Five Rivers, the rainfall data entered was 760 mm, being the mean of the 2009-2011 measurement years at that trial site (Smith et al. 2012).

3. Results and Discussion

Measured and estimated annual nitrate-N (NO_3-N) leaching losses are presented in Table 1 and Figure 1. The *Overseer* estimate for the milking platform agreed well with the averaged measured data from Monaghan et al. (2009). Leaching losses from the grazed winter forage crop in scenario 1 agreed well when compared with measured data (Monaghan et al. 2013), given the level of uncertainty around the measured values: 52 $\pm$ 19 measured, 53 kg N/ha modelled. For scenario 2, where the cows were wintered off at Five Rivers, *Overseer* estimated N leaching losses from the winter forage crop block of 48 kg N/ha compared with a measured value of 57 $\pm$ 43 kg N/ha. The extremely high standard error (SE) measured for the Scenario 2 wintering block at Five Rivers was a result of large annual differences in N leaching losses measured over the 3 years of the trial (Smith et al. 2012). This is partly attributable to the (expected) time lag or delay in detecting losses that occurred in year 1 of the study.

When comparing measured and modelled values, it is important to recognise (a) the uncertainty that is inherent within Overseer (Shepherd et al. 2013), (b) the paucity of N leaching data from grazed winter forage crop experimental sites that has been used to validate the model and (c) that there is also uncertainty around measured values. Given this, the comparison of measured and modelled values appears very good.

Reasonable agreement was also observed between *Overseer* estimates of drainage volume and estimates derived using a daily soil water balance model. This is remarkable

given that *Overseer* uses a single annual rainfall input combined with typical daily distributions according to region. The level of agreement would be less if rainfall distribution in a single year varied widely with the typical distribution that is contained in the *Overseer* database. This did occur at the winter grazing site in Scenario 1, where rainfall in year 1 of the trial was 20% above normal, resulting in the large drainage volume SE.

Table 1: Comparison of N leaching estimates from *Overseer* (version 6.1) with measured values (± SE) from the Tussock Creek and Five Rivers leaching studies.

	***Overseer* 6.1**	**Measured**
Scenario 1: Grazed at Tussock Creek		
Drainage volume (mm)	434	421 ± 40 (488 ± 160 for crop)[a]
Pastoral block (kg N/ha/year)	15	13 ± 3
Effluent block (kg N/ha/year)	28	No data
Winter crop (kg N/ha/year)	53	52 ± 19
Whole Farm (kg N/ha/year)	22	
Scenario 2: Grazed at Five Rivers		
Drainage volume (mm)	434 (292 for crop)	421 ± 40 (290 ± 86 for crop)
Pastoral block (kg N/ha/year)	13	13
Effluent block (kg N/ha/year)	23	No data
Winter crop (kg N/ha/year)	48	57 ± 43
Whole farm (+ runoff) (kg N/ha/year)	19	

Note:- [a] derived from soil water balance modelling using measured rainfall and local ET data.

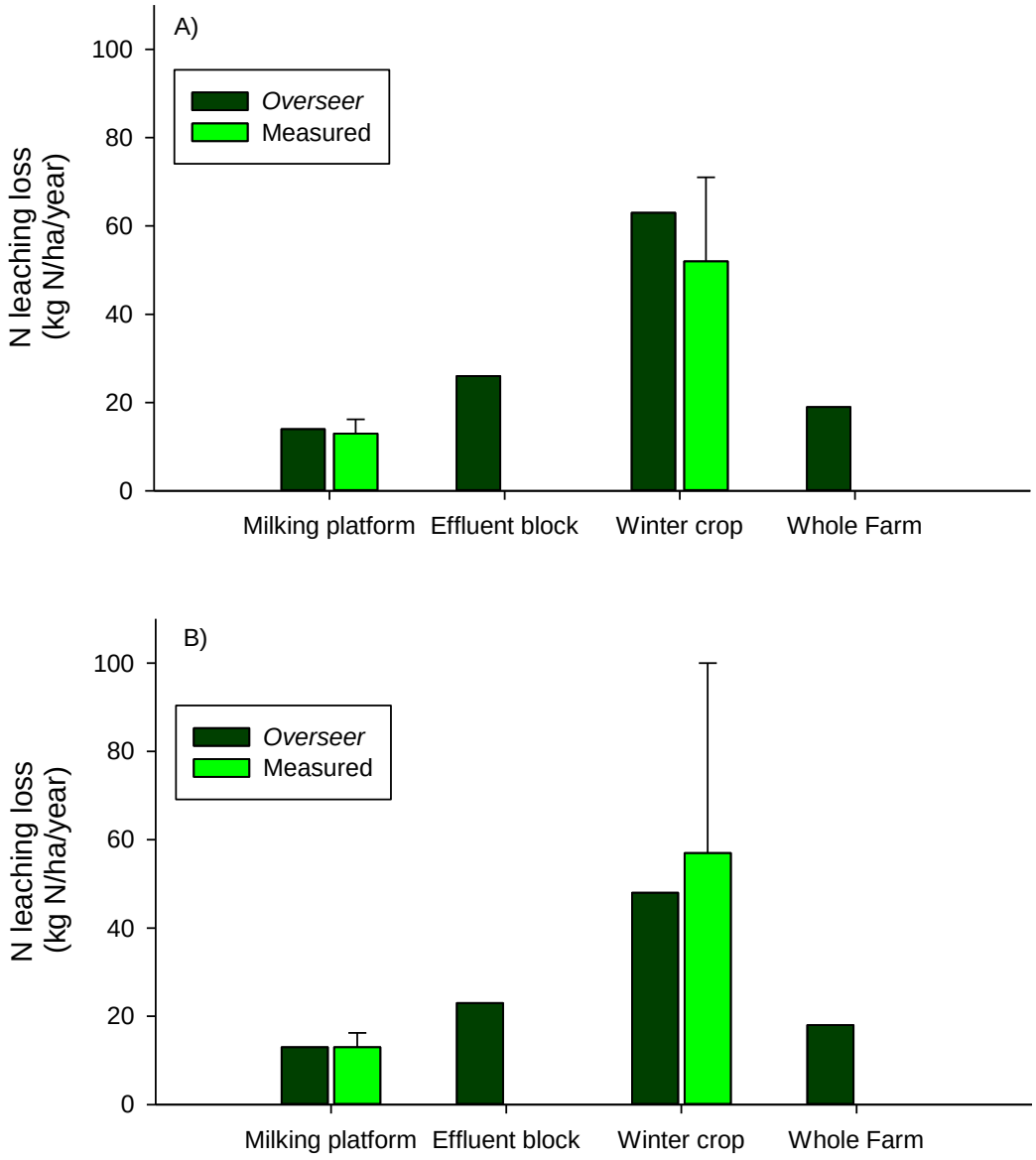

Figure 1: Modelled v measured NO_3-N leaching losses for A) cows grazed on a winter forage crop at Tussock Creek; B) cows grazed off-farm on a winter forage crop at Five Rivers. Bars indicate SE.

4. Summary

- Given the inherent uncertainty associated with measuring and modelling N leaching, there was good agreement between *Overseer* estimates and measured values reported for 3 key experimental sites in Southland.
- Estimates of drainage volumes, based on annual rainfall inputs to the model also agreed reasonably well with those derived from a daily soil water balance model.
- The agreement between measured and modelled values indicates that the *Overseer* model is performing well for this combination of soil-climate-management factors.

5. References

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