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SELECTION OF CATTLE SUPPLEMENT FEEDING AREAS TO REDUCE NUTRIENT AND SEDIMENT LOSS IN SURFACE RUNOFF FROM HILL COUNTRY

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Abstract

Pastoral grazing can enhance the loss of nutrients (nitrogen and phosphorus) and sediments from hill country farms to receiving streams and rivers. This study quantified the surface nutrient and sediment runoff loss associated with feeding hay supplements to cattle in hill country, on two contrasting soil types. The research was carried out at Tuapaka, Massey University's Agricultural Experiment Station, which is at a hill country farm located near Palmerston North, NZ. Two sub-catchments (~0.3 ha in each area) were defined using 1 m LiDAR digital elevation data and then instrumented to collect surface runoff and associated nutrient and sediment runoff. One sub-catchment was comprised of a Korokoro soil which has a medium phosphorus (P) sorption capacity and is at higher risk of surface runoff due to its imperfect drainage. The second sub-catchment was made up of Ramiha soil which has a higher P sorption capacity and a low risk of surface runoff, due to good drainage. Runoff samples were collected over a 43-day period during the winter of 2015. During this time, two herds of 16 mixed-aged Angus cows were fed 2 kg DM/cow/day of hay in a defined feeding area within each sub-catchment. There were 7 runoff events over the study period, during which there were 5 times the volume (L/ha) of surface runoff measured from the Korokoro soil, compared to the Ramiha soil. As a result, the Korokoro soil lost 4.5, 7.3, 5.5 and 2.5 times the amount of total N, total P, dissolved reactive P, and sediment, respectively, compared to the Ramiha soil. Surface losses of nitrate-N from the Ramiha soil were undetectable over the study period and amounted to <0.07 kg/ha from the Korokoro soil. Whilst total nutrient losses were low over the short study period (<0.22 kg total P/ha and <0.7 kg total N/ha from both sub-catchments), the results highlight the benefits of strategically placing cattle feed supplements during winter on areas less prone to surface runoff in hill country farms. These findings are important, as they present a simple, cost-neutral method of reducing nutrient and sediment losses in sensitive agricultural environments.

Background

Thirty seven percent of New Zealand's total land area is classed as hill country under the New Zealand Land Resource Inventory (Landcare Research 2017). Under this inventory, hill country is defined as land with slopes >15 degrees and elevations <1000m. The New Zealand beef and sheep industry is predominantly based in hill country and this sector generates approximately $7.5 billion annually in export earnings (Morris 2013). Hill country catchments are complex due to steep slopes and fragile soils. Areas of high nutrient input and compact soils, as a result of the congregation of animals along shelter belts, around troughs and supplement feeding areas, can create critical source areas (CSA) that generate elevated surface runoff and associated nutrient and sediment losses. Although CSA's generally make up only a small area of a farm, previous research by Lucci *et al.* (2012) has shown that these areas can produce disproportionately more P loss than non CSA areas, making them a priority area in terms of sediment and nutrient management.

Winter feeding of hay to cattle in hill country is a common practice which potentially creates CSA's, elevating the risk of sediment and nutrient loss. We hypothesise that sediment and nutrient loss will be less if cattle are fed hay supplements on soil types which are well drained and less likely to generate surface runoff.

Methods

The study area was located at Massey University's Agricultural Experiment Station, Tuapaka. Tuapaka is a 365ha hill country farm which backs onto the Tararua Ranges, east of Palmerston North. Two sub-catchments (Fig. 1) were selected for the study using a 1m LiDAR digital elevation model to define the sub-catchment area and surface flow pathways. The Korokoro sub-catchment was 0.33ha, whereas the Ramiha sub-catchment was 0.36ha.

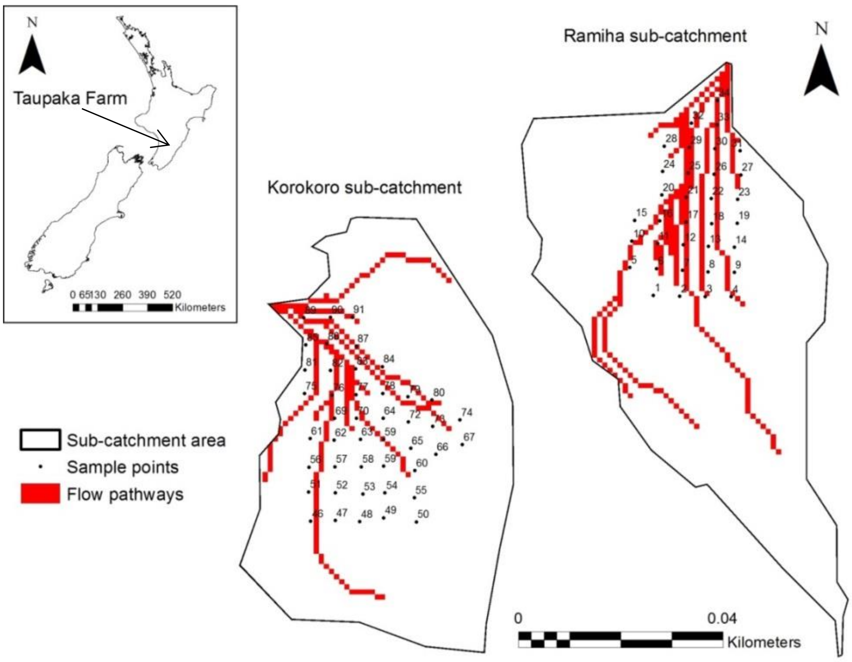

Figure 1. Location of Tuapaka Farm in the North Island, New Zealand and the two sub-catchments examined in the current study, showing flow pathways and soil treading damage sample points.

Sub-catchments were selected on the basis of contrasting soil types. The Korokoro sub-catchment had an imperfectly drained soil, with a silt loam topsoil above a clay loam sub-soil that increased in density with depth. Stones were present in the surface of the Korokoro soil profile. The higher Olsen P (41 mg/L) and potassium concentrations (1.35 cmol/kg) measured from the Korokoro sub-catchment were likely due to hay supplement fed in this area in previous years. Anion storage capacity (ASC) was in the medium range at 32% (Table 1). The Ramiha sub-catchment was a well-drained soil with a silt loam topsoil and a friable soil structure. Due to tephra deposits, the ASC was higher (57%) than the Korokoro soil, whereas the Olsen P (20 mg/L) and potassium concentrations (0.78 cmol/kg) were much lower.

Two herds of 16 mixed-aged Angus cows were fed 2 kg/DM/cow/day of hay from 7 June until the 11 August 2015. This was fed at the same time and location each day, at a similar distance from the bottom of each sub-catchment and the water sample collection point.

Table 1. Soil chemical properties of the Korokoro and Ramiha sub-catchments, sampled to a depth of 7.5 cm.

	Korokoro sub-catchment	Ramiha sub-catchment
Soil description	• Polyhedral, silt loam topsoil • Clay loam subsoil, density increases with depth, firm, polyhedral • Mottling present • Stones 0-10cm	• Medium silt loam texture throughout • Polyhedral structure • Friable • No mottling
Drainage	Imperfectly drained	Well drained
Olsen P (mg/L)	41	20
Anion Storage Capacity %	32	57
pH	5.1	5.3
CEC (cmol/kg)	22	24
Potassium (cmol/kg)	1.35	0.78

The sub-catchments were instrumented to collect surface water runoff. Runoff was collected over a 43-day period and collection began prior to supplement feeding on June 11. Surface runoff samples were analysed for total P, dissolved reactive P (DRP), total nitrogen (N), nitrate-N, ammonium-N and suspended sediment.

Each sub-catchment was assessed for the degree of treading damage before and after animal supplement feeding. Treading damage was assessed using a severity score from 1-5, with 1 representing slight to moderate indentations, low hoof smears and no surface disruption and 5 representing mud and grass mixed, continuous hoof smears and severe surface disruption (J Howes pers. comm.). Degree of treading damage was mapped using a krigging method in ArcMap 10.4 and showed that the area and severity of treading damage was very similar between the two sub-catchments (data not presented).

Results and Discussion

Seven rainfall events generated surface runoff over the study period (Fig. 2). The Manawatu region experienced above-average rainfall for the month of June 2015. This was due to a severe storm event that occurred on 20-21 June 2015. This single event generated 71% of the Korokoro and 69% of the Ramiha sub-catchments total surface runoff volume, over the study period.

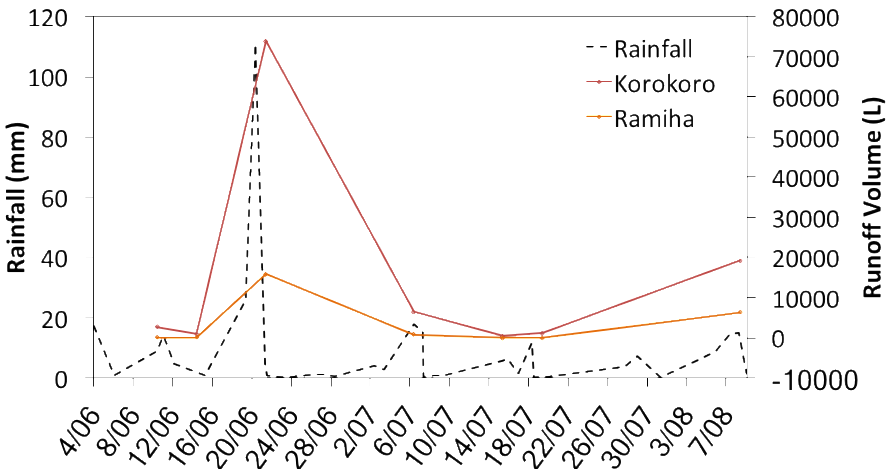

Figure 2. Rainfall and resulting surface runoff generated from the Korokoro and Ramiha sub-catchments over the 43-day study period (June – July 2015).

Despite a similar degree of treading damage between sub-catchments, the Korokoro sub-catchment generated 5 times the volume of surface runoff (L/ha) compared to the Ramiha sub-catchment (Table 2). This was likely due to the imperfect drainage properties of the Korokoro sub-catchment soil, which resulted in a lower rainfall infiltration rate and a higher total surface runoff volume, due to saturation excess. The higher runoff volume resulted in higher sediment and nutrient losses from this site. Consequently, the Korokoro soil lost 4.5, 7.3, 5.5 and 2.5 times the amount of total N, total P, dissolved reactive P and sediment, respectively, compared to the Ramiha soil (Table 2). It is likely that lower P losses from the Ramiha sub-catchment were also due to the higher P sorption capacity and the lower Olsen P of this soil (Dougherty *et al.* 2011; McDowell *et al.* 2001).

Surface losses of nitrate-N from the well-drained Ramiha soil were undetectable over the study period and were low (<0.07 kg/ha) from the Korokoro soil. Although total nutrient losses were low over the short 43-day study period (<0.22 kg total P/ha and <0.7 kg total N/ha), the comparison between the two soil types highlights that feeding hay supplements on well-drained soils provides a simple, cost-neutral method for reducing surface sediment and nutrient loss in hill country.

Table 2. Sediment and nutrient loads in surface runoff generated from two contrasting hill country sub-catchments

Parameter	Korokoro Sub-catchment	Ramiha Sub-catchment
Runoff volume (L/ha)	317,203	64,055
Suspended sediment (kg/ha)	49.6	19.6
Total P (kg/ha)	0.22	0.03
DRP (kg/ha)	0.11	0.02
Total N (kg/ha)	0.68	0.15
Nitrate-N (kg/ha)	0.07	0.00
Ammonium-N (kg/ha)	0.04	0.01

Conclusions

- The imperfectly drained Korokoro sub-catchment produced larger total surface runoff volumes and higher sediment and nutrient losses compared to the well-drained Ramiha sub-catchment.
- A single runoff event contributed to ~70% of the total runoff volume for both sites and accounted for 50 and 66% of total P runoff from the Korokoro and Ramiha sub-catchments, respectively.
- Virtually no P was lost in surface runoff from the well-drained, high P-sorbing Ramiha sub-catchment.
- Strategic placement of supplement feed on robust soils provides a cost-neutral option for farmers to reduce nutrient and sediment surface runoff losses from hill country farms.

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References

Dougherty W, Mason S, Burkitt L, Milham P (2011) Relationship between phosphorus concentration in surface runoff and a novel phosphorus test procedure (DGT) under simulated rainfall. *Soil Research* **49**, 523-528.

Landcare Research (2017) 'New Zealand Land Use Inventory.' Version Available at https://soils.landcareresearch.co.nz/soil-data/nzlri-soils/

Lucci GM, McDowell RW, Condron LM (2012) Phosphorus source areas in a dairy catchment in Otago, New Zealand *Soil Research* **50**, 145-156.

McDowell RW, Sharpley A, Brookes PC, Poulton PR (2001) Relationship between soil test phosphorus and phosphorus release to solution. *Soil Science* **166**, 137-149.

Morris ST (2013) 'Sheep and beef cattle production systems.' (Manaaki Whenua Press: Lincoln, New Zealand)