Memo

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CC	Leo Fietje
From	Ognjen Mojsilovic

Assessment of nitrogen losses from commercial vegetable operations in Canterbury

Introduction

The purpose of this technical memo is to assess the scale of root zone nitrogen losses from commercial vegetable operations in Canterbury at the Land and Water Regional Plan (LWRP) sub-region catchment level in comparison to the total nitrogen losses for those catchments. In particular, the nitrogen loads have been assessed in the context of the spatial units defining the nutrient allocation frameworks (Nutrient Allocation Zones).

Outdoor commercial vegetable operations currently occupy a relatively small area in the Canterbury region. Its relative size varies across the sub-regional catchments in the LWRP due to factors such as a high reliance on the proximity to buyers, favourable soils and climate, availability of water, and high integration with the other rural enterprises such as arable farms.

A number of commercial vegetable growers periodically shift parts of their operations by leasing land. The grandparenting nutrient allocation mechanism established by the LWRP operates at a property basis, meaning that any nutrient losses allocated by the plan, including those associated with leasee's activity, are retained by the property. This creates a problem for both the land owner and lessees.

This report summarises the methods used in The AgriBusiness Group (2019) report to model nitrogen loads from commercial vegetable operations in Overseer and then upscales those modelling results to estimate the loads associated with the activity in the context of wider catchment loads.

Data sources and methods

The nitrogen losses for both the commercial vegetable operations and total root zone sub-region catchment were estimated using a look-up table approach. The GIS process matches the spatial layers of land use, soils, and climate to rows in a table of modelled nitrogen root zone loss rates, including Overseer root zone losses, and then multiplies matched areas with nitrogen leaching rates to estimate the nitrogen losses.

The catchment root zone nitrogen load was estimated for each sub-region catchment that has commercial vegetable operators using a 2014 land use and nitrogen loss GIS layer (Hill

and Ford, 2016). The layer is derived from an older Overseer version, but the layer remains the latest consistent estimate of regional nitrogen root zone loads. Its data sources were obtained during the 'nitrogen baseline' period of 01 July 2009 to 30 June 2013.

Nutrient Allocation Zones and LWRP Sub-Regional Chapter boundaries were used to aggregate the total catchment and the commercial vegetable operations nitrogen load layers.

Modelling root zone nitrogen losses for commercial vegetable operations

This section describes how representative commercial vegetable crop operations were modelled in Overseer, and how the root zone N losses from those Overseer budgets were extrapolated to estimate the catchment loads.

Commercial vegetable crop rotations and nitrogen look-up data

The AgriBusiness Group (2019) created three representative commercial vegetable operation crop rotations in Overseer. One scenario is typical of an intensive market garden activity and the other two specialise in root and green vegetables. These rotations capture the main variability in crops and management practices for the key soil and climate zones.

Crops grown, typical crop rotations and management practices (e.g. irrigation and fertiliser application) data, was supplied by local growers. The data was integrated into the crop rotation structure of representative cropping Overseer files developed in the Canterbury Matrix of Good Management (MGM) project[1]. In order to isolate the nutrient budgets to pure commercial vegetable rotations, The AgriBusiness Group eliminated the crops belonging to mixed arable and livestock forage components from MGM rotations. Irrigation management was modelled in Overseer to be at good management practice, as defined by Schedule 28 of the LWRP[2].

The Overseer nitrogen results from The AgriBusiness Group (2019) work produce a look-up table of data. For the differences described above, The AgriBusiness Group nutrient budgets improve on the available datasets of the Overseer-based scenarios for modelling vegetable production activities.

Catchment data on the extent and distribution of commercial vegetable crop areas

I used information from AgriBase® and 2017 Statistics NZ agricultural production survey to populate a model that spatially distributes of the representative green, root and intensive

[1] The Matrix of Good Management project was a collaboration between six primary sector organisations: DairyNZ Ltd, Beef + Lamb New Zealand, Deer Industry New Zealand, NZPork, Horticulture New Zealand and the Foundation for Arable Research, three Crown Research Institutes (AgResearch, Plant & Food Research and Landcare Research) and Environment Canterbury. The purpose of the project was to define industry-agreed Good Management Practice and to estimate the typical nutrient losses (including nitrate nitrogen) that are expected to occur from the range of farm systems across Canterbury when managed according to industry-agreed GMP.

[2] Schedule 28: Good Management Practice Modelling Rules, was introduced into the LWRP through Plan Change 5.

market garden rotations. This approach is different to the approach taken by The AgriBusiness Group (2019) in upscaling the representative rotations.

AgriBase® is a rural enterprise database produced by AsureQuality which provides spatial information about primary industries and captures a near complete coverage of Canterbury. It reports surveyed information on the land area in different crops, including vegetables.

For each AgriBase property reporting a positive area of a vegetable crop species, I pro-rataed the crop area across the nutrient allocation zones intersecting the property, and aggregated the crop species into the three cropping rotations modelled in Overseer. The spatial data on the distribution and make-up of vegetable crops was then overlain with the MGM soils and climate layers, and related to the table of Overseer nitrogen loss results, meaning that the modelled nutrient loads for the cropping rotations were spatially matched to farm, soil and climate data, and thus extrapolated across the region.

Results

Commercial vegetable production area

The total land in vegetable production is 12,360 ha in the AgriBase release used in the model. Figure 1 highlights that the area of land in vegetable production has been static in the last 10 years of AgriBase data. The NAZs in Figure 1 collectively contain 85% of vegetable crop areas in Canterbury. The spatial distribution is shown in Figure 2.

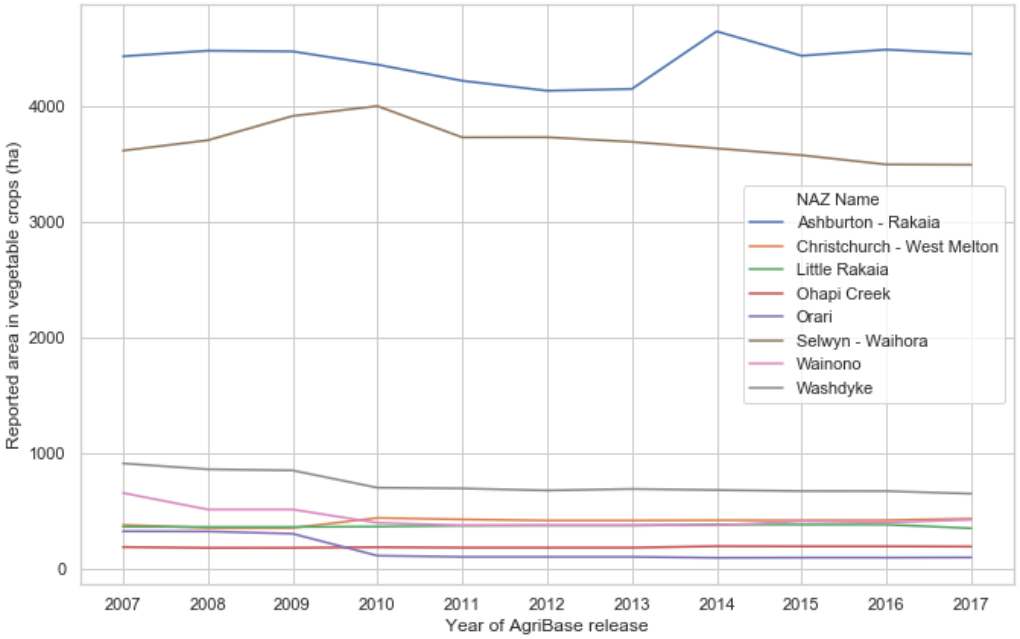

Figure 1: *Sum of area in vegetable crops reported by AgriBase over time for eight nutrient allocation zones (NAZ) that contain the highest proportions, relative to the size of the NAZ area, of vegetable production areas in Canterbury Region.*

When the AgriBase data on vegetable operations area data are aggregated to the district level, the total areas are consistent with the Statistics NZ rural production surveys. Similarly, the AgriBase® data on the distribution of properties with commercial vegetable operations across the LWRP Nutrient Allocation Zones is also consistent with the counts of commercial vegetable growers affiliated with Horticulture NZ.

Overall, the area of vegetable crops reported by AgriBase is greater than the area estimated by Statistics NZ or Hort NZ surveys. One potential reason for the difference is that the AgriBase reports crop area and not land area, and therefore partially double counts land which supports more than one crop in a reporting year. This is supported by 2017 Statistics NZ production survey data, in which the sum of outdoor vegetable crop areas is approximately 120% of the total outdoor area in vegetable crops. As a sensitivity analysis, the above factor was used to reduce the vegetable crop area in the model.

Nutrient Load

The results of the comparison of the estimated nitrogen loads for commercial vegetable operations in the LWRP sub-region catchments compared with the total catchment nitrogen load indicates that commercial vegetable growing operations makes up a small fraction of the total loads (Table 1). For the ten LWRP sub-region catchment boundaries, Table 1 provides the comparison between the total nitrogen load estimates and the commercial vegetable growing operations within these units.

Table 2 further identifies the subset of Nutrient Allocation Zones where vegetable crop production contributes 4% or more of the total nitrogen load and is estimated to make-up more than 100 ha, the cut-offs being an arbitrary estimate of margins of error. The data in Table 2 identifies the NAZs where commercial vegetable production is concentrated and may represent more than minor contributions to the total root zone nitrogen loads.

While not provided directly, the data in the tables can be used to estimate the fractions of the nitrogen load that are associated with leased land. Based on responses to the Horticulture NZ survey of its Canterbury growers, leased land vegetable production comprises 20% of the total area, and consequently the load, in vegetable crop production.

Commercial vegetable production isolated in these tables will for many properties represent a small component of a property's land use. The context for viewing the data is that across all the AgriBase properties that report vegetable crop production, the activity represents 14% of the total area. Any policy dealing with the activity will need to consider how the highly integrated land use will be defined.

***Table 1**: Estimated baseline period nitrogen (N) root zone loads associated with the commercial vegetable production for the sub-regional chapter boundaries in the context of the activity areas and the total catchment nitrogen load. Ranges display a sensitivity in the extent to which the vegetable crop area represents the land area.*

LWRP sub-regional chapter boundaries	Total catchment N load (t N/yr)	Commercial vegetable crop N load (t N /yr)	Commercial vegetable crop N load (% of zone load)	Sum of vegetable crop area (ha, source: AgriBase)
Selwyn - Waihora	4,440	165 - 200	4 - 5 %	3,850
Christchurch - West Melton	490	20	4%	410
Ashburton	7,450	230 - 275	3 - 4 %	5,150
Orari-Opihi-Pareora	3,980	70 - 85	2%	1,615
Waitaki	7,940	30 - 35	1%	655
Waimakariri	3,630	15	< 1%	300
Alpine River	3,780	10	< 1%	170
Hurunui - Waiau	6,970	5	< 1%	105
Kaikoura	1,090	< 1	< 1%	20
Banks Peninsula	420	< 1	< 1%	0

***Table 2:** Estimated baseline period nitrogen (N) loads associated with the commercial vegetable growing operations for certain NAZs in the context of the growing areas and the total catchment nitrogen load. Ranges display a sensitivity in the extent to which the vegetable crop area represents the land area.*

Nutrient Allocation Zone (NAZ)	Zone Class	Area of NAZ (ha)	Total N Load for the NAZ (t N /yr)	Commercial vegetable crop area (ha, Source: AgriBase)	Commercial vegetable crop root-zone N load (t N /yr)	Commercial vegetable crop root-zone N load (% of zone)
Selwyn - Waihora	Water Quality Outcomes Not Met	255,885	4,205	3,390	149 - 178	4%
Ashburton - Rakaia	Water Quality Outcomes Not Met	111,648	2,198	4,509	198 - 237	9 - 11%
Christchurch - West Melton	Water Quality Outcomes Not Met	46,215	485	430	18 - 22	4%
Washdyke	At Risk	33,135	377	631	31 - 37	8 - 10 %
Wainono	Water Quality Outcomes Not Met	28,982	263	430	18 - 22	7 - 8%
Little Rakaia	At Risk	7,693	135	425	17 - 20	13 - 15%
Ohapi Creek	Water Quality Outcomes Not Met	4,213	57	207	7 - 9	13 - 15%

Uncertainties in the data sources and methodology

Using a modelling approach as a tool for understanding the real world introduces a number of uncertainties. It is valuable to understand their potential impact and the risks introduced by choices made in setting the modelling parameters. A number of parameters influence the nitrogen loads results modelled for commercial vegetable operations and the compounded error margin is likely to be high. The main sources are:

- *Overseer modelling*. Assessments done of Overseer cropping modules have critiqued the model's ability to capture the system or its dynamics, including aspects like the depth of its crop and nutrient cycling parameterisations, and the validity of model's assumptions around long-term conditions. These issues remain unresolved. The integration of MGM cropping reference files and growers' management data, by The AgriBusiness Group (2019), builds on the previous characterisation of representative rotations. The losses modelled in their work ranged between 30 and 80 kg N /ha /yr, largely in response to soil and climate and less so in response to the rotation type.

- *There are no long-term records of measured nitrogen losses from New Zealand commercial vegetable production enterprises*. The closest is the fluxmeter network, which has been monitoring nutrient losses from 12 fields on arable and horticultural farms (including commercial vegetable operations) for the past 3 years. Three of the sites are in Canterbury. The recorded nitrogen annual losses from the fluxmeter network for all types of horticultural farms ranged between <1 to 230 kg N /ha. For horticultural farms passing data quality checks, the average nitrogen losses for last 2 years, representing a wet and a dry year is approximately 80 kg N /ha /yr. Nitrogen losses were not related to any specific horticultural crop, but rather to the crop management (e.g. fertiliser use) and the soil nitrogen condition at the time of the drainage, or recharge, events.

- *Using AgriBase property data to estimate the area, distribution and type of commercial vegetable crops grown across the region*. At the level of individual properties, data accuracy of AgriBase is affected by variable frequency of updates and the ability to capture small grower operations. The distribution and crop type data was generally consistent with other data sources considered, including Statistics NZ and Hort NZ data. The total commercial vegetable growing area in Canterbury provided in AgriBase is slightly greater than the total area based on Statistics NZ or Hort NZ survey data, and we tested this sensitivity by inferring that the difference is due to double counting land that supports more than one crop in a reporting year.

- *The 2014 total catchment nitrogen load GIS layer is derived using estimates from an older version of Overseer*. On average, we have seen Overseer nitrogen losses increase with new model versions, although this is not always the case, especially in instances where the irrigation good management practice proxy is applied. Therefore if the same Overseer version was used, on average the percentage of the estimated nitrogen loads for commercial vegetable operations for the sub-region catchments compared with the total catchment nitrogen load would be lower (refer Table 2).

Conclusion

I estimate catchment-scale nitrogen root zone loads associated with the commercial vegetable production through modelling its spatial distribution and using the distribution to upscale a set of Overseer results representative of the main cropping rotations. The activity is concentrated to a small number of the nutrient allocation zones of the Land and Water Plan, where its contributions range between 4 and 15 % of the total root zone loads. The total area associated with the activity has not changed significantly over the last 10 years. The relatively minor contributions from current land use mean that the loads associated with the leased land components of the activity are likely to be minor. The activity and its effects remain a challenge for Overseer, presenting issues in estimating both the actual nutrient losses as well as any effect of changes in management. There are a number of sources of error compounded in the modelling process, and most were not directly assessed, which means that the numerical estimates are subject to broad uncertainty envelopes.

References

Hill, Z., Ford, R. 2015. Canterbury Land Use Statistics and Nitrate Losses. Memo to Environment Canterbury Matrix Group (EMG).

The AgriBusiness Group. 2019. Overseer nutrient modelling of commercial vegetable production. Prepared for Environment Canterbury.

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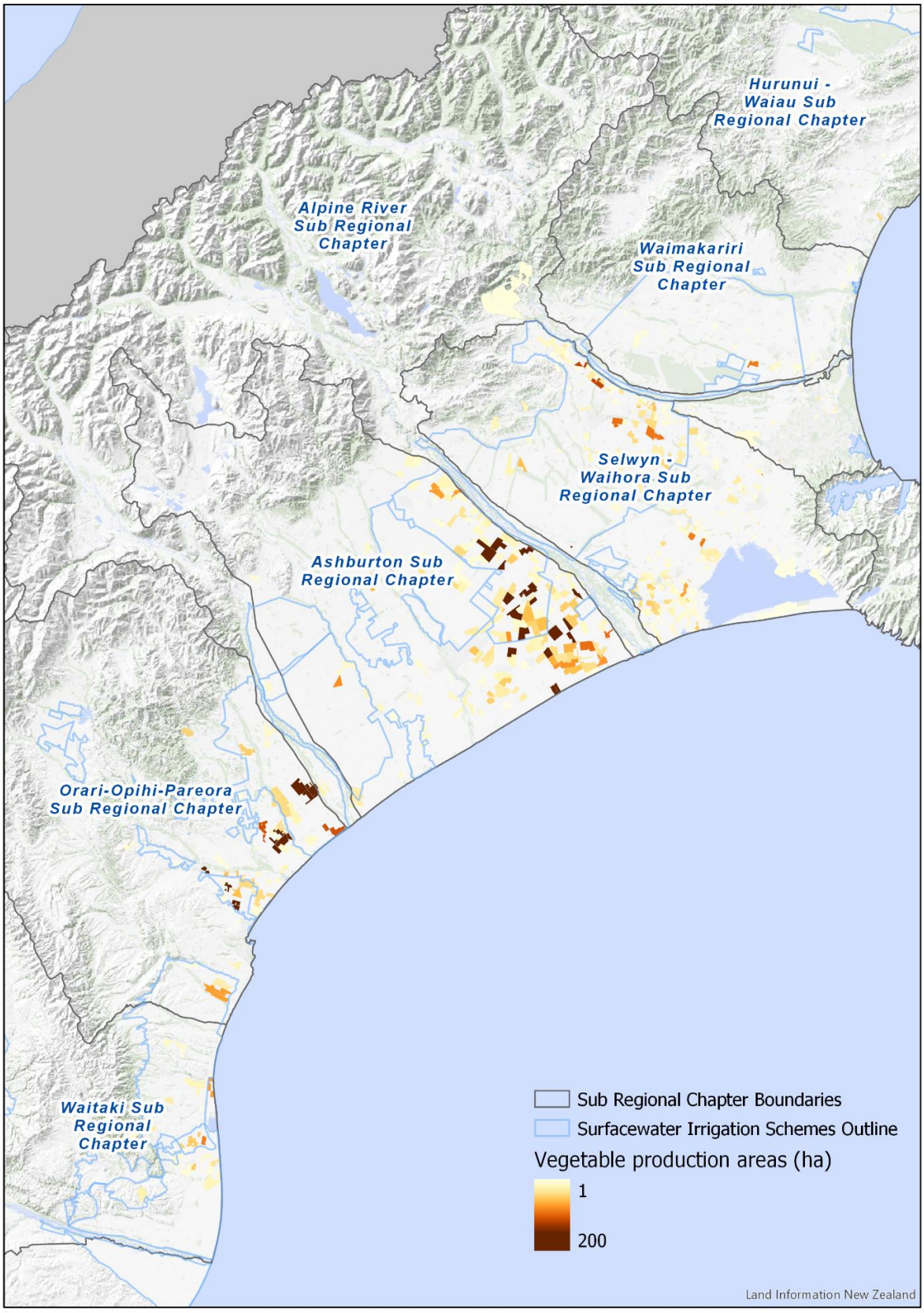

Figure 2: *Location of AgriBase farms with commercial vegetable growing operation areas, related to irrigation schemes and Sub regional chapter boundaries. The colour scale identifies the area of vegetable production within the farm boundaries.*