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# THE VALUE OF NITROGEN FERTILISER TO THE NEW ZEALAND ECONOMY

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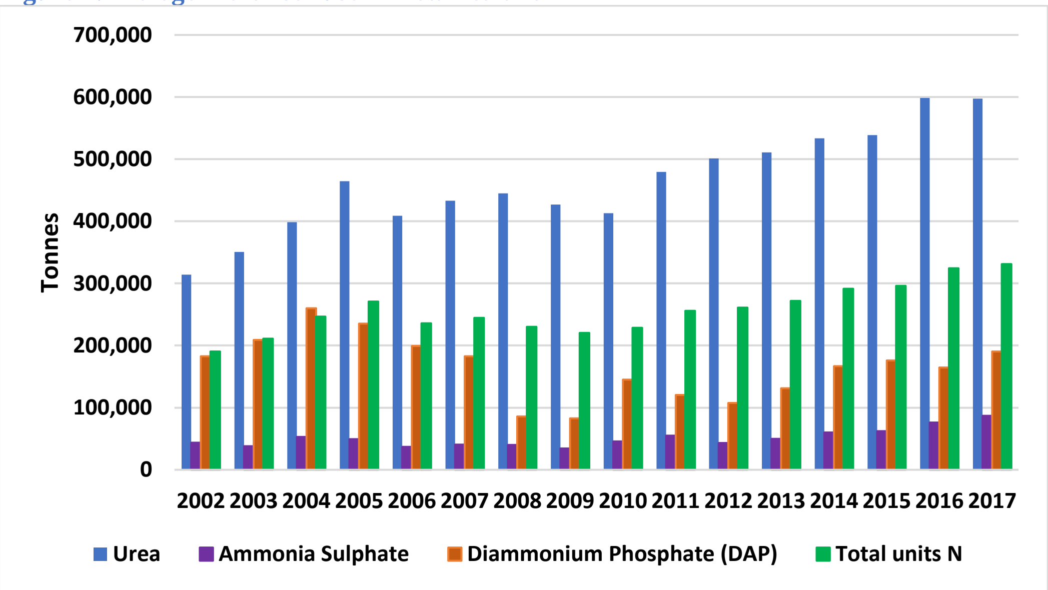
## Background

Most crops, including pasture, are nitrogen limited at various stages of their growth, which means that responses to nitrogen fertiliser are generally good. As a result, nitrogen fertiliser is an integral component of the farming scene within New Zealand, constituting an important input across a wide range of farming systems, and usage of nitrogenous fertilisers has been increasing over recent decades:

**Figure 1: Nitrogen fertiliser use in New Zealand**




Source: Statistics NZ

The main driving force of this in the pastoral sector is that nitrogen-boosted pasture is the cheapest form of supplementary feed available to farmers, often less than half the cost of any alternatives. In the horticultural/vegetable/arable sectors it is a crucial input in ensuring high yields and good quality crops.

Nitrogen fertiliser usage varies across the different agricultural sectors, with the majority used in the pastoral sector, especially on dairy farms.

**Table 1: Nitrogen fertiliser usage by sector (2017)**

| | Tonnes N* | % of Total N |
|---|---|---|
| Miscellaneous Horticulture | 222 | 0.05% |
| Vegetables | 5,670 | 1.3% |
| Horticulture | 1,994 | 0.45% |
| Arable | 29,415 | 6.6% |
| Sheep & Beef | 108,668 | 24.5% |
| Dairy | 294,551 | 66.5% |
| Other | 2,525 | 0.6% |
| **Total** | **443,044** | **100%** |

*This is based on the use of various fertilisers, converted back to their constituent N component
Source: 2017 Agricultural census, Fertiliser Association

## Methodology

The methodology involved an analysis of the value on a 'with' versus 'without' basis, where the 'with' scenario is essentially the current situation regarding profitability and production.

The 'without' scenario was split into two aspects:

(i) No nitrogen fertiliser + no substitution; and
(ii) No nitrogen fertiliser + use of substitutes (e.g. supplementary feed/organic nitrogen fertiliser) as appropriate.

The analysis considered the profitability, production, and environmental (i.e. level of nitrogen leaching) effects within each sub-scenario.

The analysis was across three sectors:

### *Pastoral*

This covered the dairying and sheep and beef sectors, and involved the development of representative models, based on Dairy NZ and Beef+Lamb NZ statistics, for analysis in Farmax for production and profitability impacts, and in Overseer for differences in the environmental impact.

These models were:

**Table 2: Pastoral Models used**

| Dairy | Sheep & Beef |
|---|---|
| Northland | North Island Hill Country |
| Waikato/Bay of Plenty | North Island Intensive |
| Taranaki | South Island Hill Country |
| Canterbury | South Island Intensive |
| Southland | |

The 'with' nitrogen fertiliser scenario is the current status quo situation, where a 5-year average usage of nitrogen fertiliser was included. This was based on Dairybase and Beef + Lamb NZ economic Service statistics:

**Table 3: Nitrogen fertiliser usage**

| Dairy | 5-year Av kgN/ha | Sheep & Beef | 5-year Av kgN/ha | Proportion of farm fertilised |
|---|---|---|---|---|
| Northland | 112 | North Island Hill Country | 12.1 | 64% |
| Waikato/Bay of Plenty | 128 | North Island Intensive | 18.0 | 60% |
| Taranaki | 148 | South Island Hill Country | 9.1 | 31% |
| Canterbury | 234 | South Island Intensive | 13.5 | 74% |
| Southland | 171 | | | |

The 'without' scenario involved removing all nitrogen fertiliser and adjusting the farming system (reduced stock numbers) until the system was feasible.

The 'without + supplement' scenario involved removing all nitrogen fertiliser, and substituting this with supplementary feed bought in, such that the status quo system was feasible. Where possible this was a low protein (nitrogen) feed such as maize silage. In many situations maize silage is not readily available or least cost, so often the supplement is relatively high in protein.

***Permanent Horticulture (Trees/Vines)***
This covered the following permanent horticultural crops:

- Grapes
- Kiwifruit
- Pipfruit
- Summerfruit
- Citrus
- Avocados

While nitrogen use on these crops is often very limited in a total sense, again it can have a significant impact on yield and quality.

Similar to the pastoral scenarios, the 'with' nitrogen fertiliser scenario is the current status quo, the 'without' scenario discusses the impact of removing any chemical nitrogen fertiliser, and the 'without + substitutes' discusses the use of composts and legume cover crops.

***Vegetable and Arable cropping***
This analysis considered the impact as to the 'with' versus 'without' scenarios on a range of arable and vegetable crops. While nitrogen usage within these sectors is again not great, for many crops the use of nitrogen fertiliser is the difference between an uneconomic or economic crop.

**Results**

***Pastoral: Dairy***
The initial scenario was the status quo, with the 'with' nitrogen fertiliser scenario assuming the nitrogen input as per Table 3.

In the 'without nitrogen fertiliser' scenario:

(i) All nitrogen fertiliser was removed.
(ii) Yields on any forage crops grown was assumed to be unchanged, given that they could be fertilised with dairy effluent in the absence of nitrogen fertiliser.
(iii) Cow numbers were reduced, but per cow production held at the same level as the 'with' scenario, until a feasible farm system was developed.

In the 'without nitrogen fertiliser + supplement' scenario:

(i) All nitrogen fertiliser was removed
(ii) Yields on any forage crops grown was assumed to be unchanged, given that they could be fertilised with dairy effluent in the absence of nitrogen fertiliser
(iii) Extra supplementary feed was purchased in until total production, and per cow production, was essentially the same as for the 'with' scenario.
(iv) For the North Island models the extra supplement bought in was a combination of maize silage and palm kernel, and for the South Island models the extra supplement bought in was a combination of pasture silage and barley grain.

A standardised milksolids payout of $6.00/kgMS was assumed.

The reduction in stock numbers required to achieve a feasible farm system in the absence of nitrogen fertiliser was:

Table 4: Reduction in cow numbers in the absence of nitrogen fertiliser

| Northland | Waikato/BoP | Taranaki | Canterbury | Southland |
|---|---|---|---|---|
| -12% | -12% | -14% | -24% | -15% |

The greater reduction in the Canterbury model relative to the others was due to the nature of the irrigation system. As a generality, dryland Canterbury will grow 5-6 tonnes DM/ha/year. With the addition of water (irrigation) this will double to 10-12 t DM/ha/year. The addition of nitrogen to this system increases dry matter production up to (circa) 18 tonnes DM/ha/year. The removal of the nitrogen fertiliser therefore has a proportionally greater effect compared to the non-irrigated systems.

The economic impact is:

Table 5: Difference in Dairy EBITDA ($/ha)

| | | | | Difference from Base | |
|---|---|---|---|---|---|
| | **Base** | **No N Fert** | **No N Fert, plus Supplements** | **No N Fert** | **No N Fert, plus Supplements** |
| Northland | $1,572 | $1,396 | $1,296 | -$176 | -$276 |
| Waikato/BoP | $2,515 | $2,248 | $2,097 | -$267 | -$418 |
| Taranaki | $2,276 | $1,959 | $1,908 | -$317 | -$368 |
| Canterbury | $2,900 | $1,626 | $1,098 | -$1,274 | -$1,802 |
| Southland | $2,909 | $2,681 | $2,465 | -$228 | -$444 |

If this is then extrapolated up to the regional and national level, the results are:

Table 6: Cost of dairy scenarios at a regional/national level ($million)

| | No N Fert | No N Fert, plus Supplements |
|---|---|---|
| Northland | -$21.1 | -$33.0 |
| Waikato/BoP | -$158.3 | -$248.1 |
| Taranaki | -$53.9 | -$62.6 |
| Canterbury | -$393.1 | -$555.9 |
| Southland | -$45.9 | -$89.5 |
| | | |
| **National*** | **-$824.4** | **-$1,212.9** |

*Extrapolated across all dairy farms in New Zealand

The environmental impact, as modelled in Overseer was:

Table 7: Dairy model N leaching (kg N/ha/yr)

| | Base | No N Fert | No N Fert, plus Supplements |
|---|---|---|---|
| Northland | 34 | 23 | 24 |
| Waikato/BoP | 39 | 32 | 33 |
| Taranaki | 50 | 37 | 40 |
| Canterbury | 76 | 40 | 47 |
| Southland | 26 | 19 | 20 |

As could be expected, nitrogen leaching decreased in the 'no N fertiliser' scenario, as a direct result of the reduction in stocking rate. The leaching rate then generally increased again, but not majorly, as a result of feeding supplement to make up the difference in feed supply as a result of not applying the nitrogen fertiliser.
The main form of nitrate leaching is from the urine patch, with direct loss from applied nitrogen fertiliser being 3-4%. The main reductions therefore shown in Table 7 are reductions in nitrate leaching from urine patches. In other words, livestock account for approximately 80+% of N leached, moderated by the nitrogen content of supplementary feed.

A similar effect was also identified with biological[1] greenhouse gas (GHG) emissions from the model. The reduction in GHGs in the "No N Fertiliser" scenario is a combination of a reduction in methane (less animals) and a reduction in nitrous oxide (less animals + less nitrogen fertiliser). The reduction in the "No N Fertiliser + Supplements" scenario is basically a reduction in nitrous oxide due to the elimination of nitrogen fertiliser.

Table 8: Dairy model biological GHG emissions (tonnes $CO_2e$/ha/yr)

| | Base | No N Fert | No N Fert, plus Supplements |
|---|---|---|---|
| Northland | 9.6 | 8.6 | 9.0 |
| Waikato/BoP | 12.2 | 10.5 | 11.8 |
| Taranaki | 11.7 | 9.5 | 11.0 |
| Canterbury | 16.7 | 11.5 | 14.9 |
| Southland | 13.5 | 11.2 | 12.6 |

[1] Biological GHG = methane + nitrous oxide

***Pastoral: Sheep & Beef***

The initial scenario was the status quo, with the 'with' nitrogen fertiliser scenario assuming the nitrogen input as per Table 3.

In the 'without nitrogen fertiliser' scenario:

(i) All nitrogen fertiliser was removed
(ii) Yields on any forage crops grown was reduced by 20%, on the assumption that no nitrogen fertiliser would/could be applied, although there would be some nitrogen reserves in the soil given it was coming out of pasture.
(iii) Sheep numbers were reduced but the basic farm system (i.e. proportion of animals finished, finishing weights) were left as per the status quo scenario.

In the 'without nitrogen fertiliser + Supplement' scenario:

(i) All nitrogen fertiliser was removed
(ii) Yields on any forage crops grown were reduced by 20%
(iii) Extra supplementary feed was purchased in until the farm system, and stock numbers, was essentially restored to the same as for the 'with' scenario.

Inasmuch as the amount of nitrogen fertiliser used was relatively small, the change in stock numbers were restricted to sheep. These were:

Table 9: Reduction in stock numbers in the absence of nitrogen fertiliser

| | Reduction in breeding ewes and replacement stock |
|---|---|
| North Island Hill Country | 3% |
| North Island Intensive | 4% |
| South Island Hill Country | 2% |
| South Island Intensive | 2% |

The economic impact of this was:

Table 10: Difference in S&B EBITDA ($/ha)

| | | | | Difference from Base | |
|---|---|---|---|---|---|
| | Base | No N Fert | No N Fert, plus Supplements | No N Fert | No N Fert, plus Supplements |
| North Island Hill Country | $545 | $539 | $502 | -$6 | -$43 |
| North Island Intensive | $777 | $764 | $709 | -$13 | -$68 |
| South Island Hill Country | $228 | $226 | $216 | -$2 | -$12 |
| South Island Intensive | $501 | $497 | $383 | -$4 | -$118 |

Table 11: Cost of S&B scenarios at a regional/national level ($ million)

| | No N Fert | No N Fert, plus Supplements |
|---|---|---|
| North Island Hill Country | -$13.8 | -$99.1 |
| North Island Intensive | -$4.6 | -$24.1 |
| South Island Hill Country | -$2.6 | -$15.5 |
| South Island Intensive | -$1.2 | -$34.6 |
| | | |

| | | |
|---|---|---|
| **National*** | **-$30.4** | **-$237.6** |

*Extrapolated across all sheep & beef farms, excluding South Island High Country

The environmental impact, as modelled in Overseer was:

Table 12: S&B model N leaching (kg N/ha/yr)

| | Base | No N Fert | No N Fert, plus Supplements |
|---|---|---|---|
| North Island Hill Country | 12 | 12 | 12 |
| North Island Intensive | 17 | 17 | 17 |
| South Island Hill Country | 8 | 8 | 8 |
| South Island Intensive | 14 | 13 | 14 |

This shows no discernible differences, largely due to the relatively small amount of nitrogen fertiliser used.

Table 13: S&B model biological GHG emissions (tonnes $CO_2e$/ha/yr)

| | Base | No N Fert | No N Fert, plus Supplements |
|---|---|---|---|
| North Island Hill Country | 3.3 | 3.2 | 3.3 |
| North Island Intensive | 4.5 | 4.4 | 4.4 |
| South Island Hill Country | 1.8 | 1.8 | 1.8 |
| South Island Intensive | 4.6 | 4.5 | 4.5 |

Again very little difference between the scenarios, given the small changes in stock numbers and fertiliser usage.

**Permanent Horticulture**

This section covered a range of permanent horticultural crops:

- Grapes
- Kiwifruit
- Pipfruit
- Summerfruit
- Citrus
- Avocados

The 'substitution' scenario involved either the use of compost, or, given that there would be insufficient compost available, the use of legume cover crops grown between the rows of trees/vines. Legume cover crops comes with its own issues, including maintaining a clover dominant sward, particularly in a shaded environment.

The results of the analysis showed:

Table 14: Summary of impact on horticultural crops of no nitrogen fertiliser or substitution relative to the base situation ($ million)

| | No N Fert | No N Fert, plus Substitutes |
|---|---|---|
| Pipfruit | -159.0 | -2.2 |
| Summerfruit | -4.1 | -1.0 |
| Kiwifruit | -156.9 | -7.7 |
| Avocado | -60.2 | -2.1 |
| Citrus | -7.9 | -0.9 |
| Viticulture | -91.0 | -4.4 |

| | | |
|---|---|---|
| | | |
| **National** | **-479.1** | **-18.3** |

Nitrogen fertiliser use in fruit crops is becoming very efficient via the use of fertigation and foliar sprays, which also reduce nitrate leaching.

The analysis as to the impact of no nitrogen fertiliser was carried out on mature orchards, which are more resilient to reduced nitrogen inputs. Nitrogen is an essential requirement in establishing young plants, so the development of new orchards in the absence of nitrogen fertiliser would be much more problematic. Nursery production would be highly impacted.

The impact of no nitrogen fertiliser is also dependent on the quality and fertility of the soil on which the orchard is established; good free-draining/fertile soils would directly buffer the impact, whereas the impact would be much more pronounced on poorer soils. The results shown are based on a combination of "good" and "poor" soils.

The impact on nitrogen leaching across the models and scenarios was:

Table 15: Horticultural nitrogen leaching summary (kgN/ha)

| | **Status Quo** | **No N Fert** | **Using substitutes** |
|---|---|---|---|
| Pipfruit | 5.4 | 5.8 | 7.4 |
| Summerfruit | 4.2 | 4.2 | 4.2 |
| Kiwifruit | 6.4 | 6 | 9.8 |
| Avocado | 16.2 | 17.4 | 16.8 |
| Viticulture | 6 | 5 | 5 |

This shows minimal improvement as a result of non-use of nitrogen fertilisers. In the compost/clover scenarios, plant uptake may become less active by the time the nitrogen is half mineralised. This would increase risk of nitrogen loss and may result in the grower applying more than is necessary to compensate for the lack of ability to time applications and amounts very precisely.

Under the no nitrogen fertiliser/plus substitutes scenario, the crop yield is reduced, meaning less nitrogen is exported from the farm in the crop, which in turn means there is slightly more leaching loss (in that less nitrogen is taken up by the plant, hence more is left available within the soil).

**Vegetables and Arable Cropping**

The use of nitrogen fertiliser in the arable and vegetable sectors has a number of advantages, namely for both it provides the ability to grow a greater range of crops continuously and at a much higher yield, and provides a greater range of fresh vegetables to the NZ consumer at an affordable price. In the absence of using nitrogen fertiliser all these factors would be adversely affected. In addition, a significant proportion of vegetables produced are exported so there would be the flow on impacts to the supporting and exporting industries of the loss of throughput and profitability

The results of the analysis showed:

Table 16: Summary of Arable and Vegetable Impacts ($ million)

| | National EBIT With N fertiliser | EBIT Without N Fertiliser |
|---|---|---|
| Arable | 450 | 171 |
| Vegetables | 228 | 156 |
| Total | 678 | 327 |
| Difference (without versus with) | | -351 |

There are no ready alternatives or substitutes in both the arable and the vegetable sectors to achieve the additional yields that are gained from the use of nitrogen fertiliser. The majority of arable crops are grown for export and therefore these exports would be lost. In the vegetable growing sector there has been little or no evidence of the likelihood of the lost production being substituted by import from overseas, apart from carbohydrates, where limited domestic supplies would most likely divert consumption to alternative food products, for example rice rather than potatoes. The majority of economic activity which would occur in the 'without nitrogen fertiliser with substitution' scenario would therefore occur beyond the farm or horticulturists' financial performance.

In the absence of nitrogen fertiliser, growing arable grain crops such as wheat, barley and maize becomes problematic; while they could be grown via use of legume crops this is more expensive, and in all probability the grain which is used domestically would be imported, at a similar cost to producing it domestically, with nitrogen fertiliser. The cost of this extra importation is estimated at $286 million.

The 'no nitrogen fertiliser + substitution' cost therefore, for the arable and vegetable sectors, would be the cost (i.e. lost production) of not using nitrogen fertiliser ($351m), plus the cost of increased imports, as above, giving a total cost of $637 million.

**Macro-Economic Impact**

The summary of the on-farm analysis shows the following impact:

Table 17: **Summary of on-farm impacts ($million)**

| | **Without N fertiliser** | **Without N fertiliser, + Substitution** |
|---|---|---|
| Dairy | -$824 | -$1,213 |
| Sheep & Beef | -$30 | -$238 |
| Permanent Horticulture | -$479 | -$18 |
| Vegetables & Arable | -$351 | -$637 |
| **Total** | **-$1,684** | **-$2,105** |

Within the input/output industry tables, the arable industry is included within the sheep and beef industry, and vegetables are included within the horticultural industry. Realigning the above table gives:

Table 18: **Summary of Direct Impacts aligning with the I/O tables ($ million)**

| | Without N fertiliser | Without N fertiliser, + Substitution |
|---|---|---|
| Permanent Horticulture & Vegetables | -551 | -149 |
| Sheep & Beef & Arable | -309 | -743 |
| Dairy | -824 | -1,213 |
| **Total** | **-1,684** | **-2,105** |

The macro-economic analysis involved a multiplier analysis, whereby both forward and backward linkages were used: backward relate to the services each industry buys in to provide their goods, while forward linkages relate to the processing/manufacturing process through to the wharf.

Table 19: **Summary of macro-economic impacts ($ million) without N fertiliser**

| | Units | Horticulture and fruit growing | Sheep, beef cattle and grain farming | Dairy cattle farming | Meat and meat product manufacturing | Dairy product manufacturing | Fertiliser and pesticide manufacturing | Total |
|---|---|---|---|---|---|---|---|---|
| Gross Output | NZ$2016m | -$2,602 | -$1,447 | -$4,906 | -$1,909 | -$7,866 | -$1,068 | -$19,798 |
| Value Added | NZ$2016m | -$1,142 | -$617 | -$1,929 | -$530 | -$2,173 | -$312 | -$6,703 |
| Employment | MECs2016* | -19,430 | -7,790 | -22,960 | -6,820 | -14,730 | -2,020 | -$73,760 |

* MEC = Modified Employment Counts (a head count of employees and work proprietors)

The above results involved simply modelling what would be the economic impacts if N fertiliser was no longer used and no adaptation took place. In reality farmers would adapt and change, in which case the overall impact is likely to be less than that indicated.

**Summary**

Nitrogen fertiliser is an important input into the New Zealand primary sector. For the horticultural, vegetable and arable sectors it is a crucial input in ensuring high yielding and good quality crops. In the pastoral sector it is primarily used as a substitute for supplementary feed, especially as nitrogen-boosted pasture is around half the cost of other supplements.

While its removal as a farm input would reduce farming impacts on water quality and GHG emissions, there would also be an associated economic cost. At the farm gate this is estimated at:

- $1.7 billion if N fertiliser is removed and no substitution is used; or
- $2.1 billion if substitution with other supplementary feeds and legume cover crops are utilised.

At the national level, these impacts would flow through as:

- A drop in gross output by $19.8 billion
- A drop in Value Add (GDP) of $6.7 billion
- A reduction in employment by 73,760 (MECs)

If nitrogen fertiliser was not available, then the transition cost to farmers and the economy would be considerable. Inevitably, farming systems would evolve, which is difficult to capture directly via the modelling; farms and orchards would still need nitrogen inputs in order to function, but these would be from 'natural' sources, such as legumes and composts, and in general the vast majority of the “no nitrogen fertiliser” systems which evolved would be of lower production intensity.

- Some pastoral farming systems would extensify, reducing output to correlate with a lower nitrogen input
- Many horticultural, vegetable and arable operations would look to use legume cover crops, resulting in a combination of either an expansion in area grown, and/or a lower level of output.
- Some pastoral farming systems would remain relatively intensive, using supplements as a substitute, with potentially much of this imported.
- As noted in this report, the main sectors impacted would be dairying, vegetable production, arable farming and developing orchards/nurseries.
- Within dairying, the main region affected would be Canterbury, given the importance of nitrogen fertiliser within an irrigated system.