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THOUGHTS ON THE ALLOCATION OF NUTRIENTS: THE ISSUE WITH NATURAL CAPITAL ALLOCATION

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Background

With the advent of the Resource Management Act (1991) and particularly the National Policy Statement on Freshwater Management (NPS-FM, MfE, 2014, 2017), Regional Councils are required to have regional plans in place by 2025 which address issues of water take and water quality within the region.

As part of these regional plans, councils may look to cap and reduce nutrient discharges from farms, particularly nitrogen. Often this cap is in the form of a per farm allocation, i.e. x kilograms of nitrogen leached per hectare per year, based on various criteria.

The form the allocation takes tends to be contentious because although the water quality target may represent the optimal water quality for society, achieving it potentially limits current and future economic activities of individuals and businesses. While economic, environmental and equity arguments can be made for all allocation mechanisms, there is no single approach that can make all those with an economic interest (either actual or opportunity cost) at least as well off as they currently are.

In this context, this paper looks at (a) the concept of a natural capital allocation, where currently Land Use Capability classification (LUC) is being used as a proxy, and (b) at the economic sense of natural capital as a means of allocating nitrogen

Natural Capital and Land Use Classification

In some submissions on proposed regional plans, there has been a request to allocate nitrogen leaching on a "natural capital" basis, and as is the case for Horizon's One Plan, and Hawke's Bay Plan Change 6. A natural capital approach to nutrient allocation is often argued for as providing better economic (i.e. increased productivity), environmental and equity outcomes than alternative allocation mechanisms. The term "natural capital" is a concept used to liken natural resources to other forms of capital such as manufactured capital (e.g. buildings) that policy makers may be more familiar with (Roberts, 2012).

In a broad sense the definition of natural capital is "the total stocks and flows of natural resources and services in a given ecosystem or region" (Pembina, 2008). Mackay (2010) provides a definition of natural capital:

… the ability of a soil to sustain a legume-based pasture that fixes N biologically under optimum management, before the introduction of additional technologies, which is a measure of the productivity of soils, notwithstanding the need to define what "optimum management" means.

While natural capital can take many forms (depending on the outcome being sought and the social application of that outcome[1]), LUC is frequently seen as a proxy.

LUC was developed in the 1950s and 1960s in New Zealand and is defined as *a systematic arrangement of different kinds of land according to those properties that determine its capacity for long-term sustainable production.* Capability is used in the sense of suitability for productive uses based on physical limitations and site-specific management needs (Landcare Research, 2009, pp7-8).

Under the LUC system, productive capacity depends largely on the physical qualities of the land, soil, and environment, with five primary physical factors involved, namely; rock type, soil type, slope, erosion potential, and vegetative cover. Limitations to land use therefore include; susceptibility to erosion, steepness of slope, susceptibility to flooding, liability to wetness (i.e. poor drainage), liability to drought, salinity, depth, texture and structure of the soil, natural fertility, and climate.

The system comprises eight land use classes, with limitations to use increasing, and versatility of use decreasing, from LUC 1 through to LUC 8. This is illustrated below.

Table 1: LUC Classification and land use suitability

LUC Class	Arable Cropping/Horticulture Suitability	Pastoral grazing suitability	Production forestry suitability	General Suitability
1	High	High	High	Multiple use land
2				
3				
4	Low			
5	Unsuitable			Pastoral or forestry land
6				
7		Low	Low	Conservation land
8		Unsuitable	Unsuitable	

Source: Landcare Research 2009

Land assigned to LUC Classes 1–4 must be suitable for arable use, which is interpreted as being suitable for tillage for cropping, and the land is capable of growing at least one of the common annual field crops (e.g. wheat, barley, maize) with average yields under good management without any permanent adverse soil effects (Lilburne *et al* 2016).

This means that the land's suitability for arable use does not necessarily equate with its potential pastoral productivity, especially for those Classes of land with a wetness, wind erosion or climatic limitation. In other words, the LUC Class focuses on soil versatility, which is not the same as its 'capacity … to sustain legume and grass growth', which contributes to the variability of pasture growth within a LUC Class (Lilburne *et al* 2016).

[1] For example, areas of a class of natural capital land may not be given an allocation – such as urban land - because it is deemed unusable for primary production purposes.

Productivity indices for LUC classification units were developed based on three levels of stock carrying capacity, for pastoral use. These were assessed for each LUC Unit, based on:

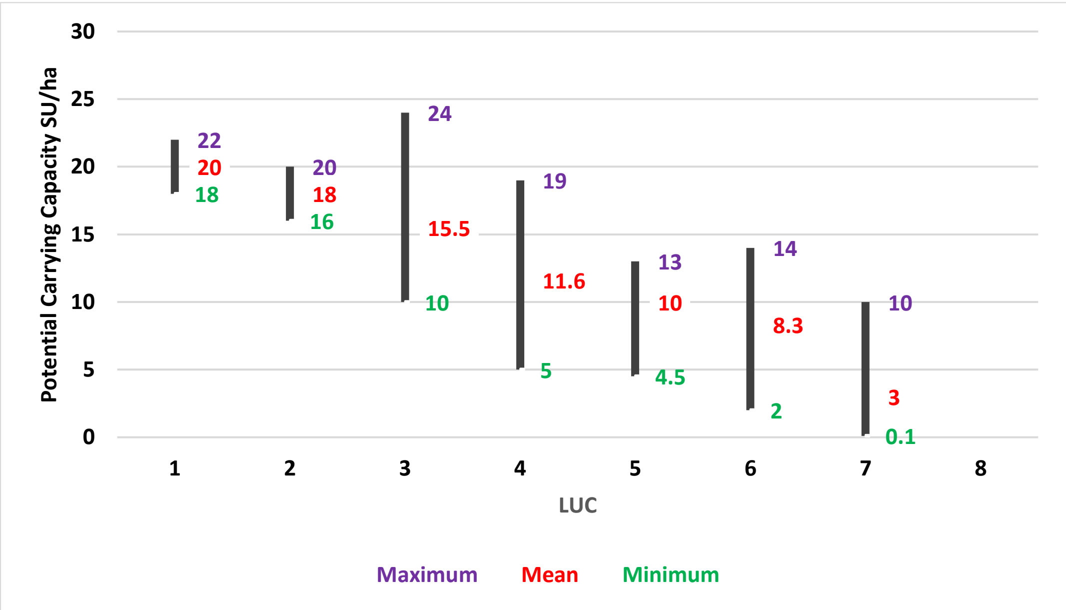
(i) Present average: The number of Stock Units per hectare (su/ha) that the 'average farmer' was typically carrying on a particular LUC Unit.

(ii) Top farmer: The number of Stock Units per hectare that the farmer with the highest level of stocking rate, with at least average stock performance, was carrying on a particular LUC Unit.

(iii) Attainable potential (rain-fed): The number of Stock Units per hectare capable of being carried on a particular LUC Unit, assessed within the limits of present technology (i.e. 1950s-60s) and given favourable socio-economic conditions. (Lilburne *et al* 2016).

These stock-carrying capacities only apply to sheep & beef farming systems, and not to dairying or arable farming systems. Research in Canterbury has shown:

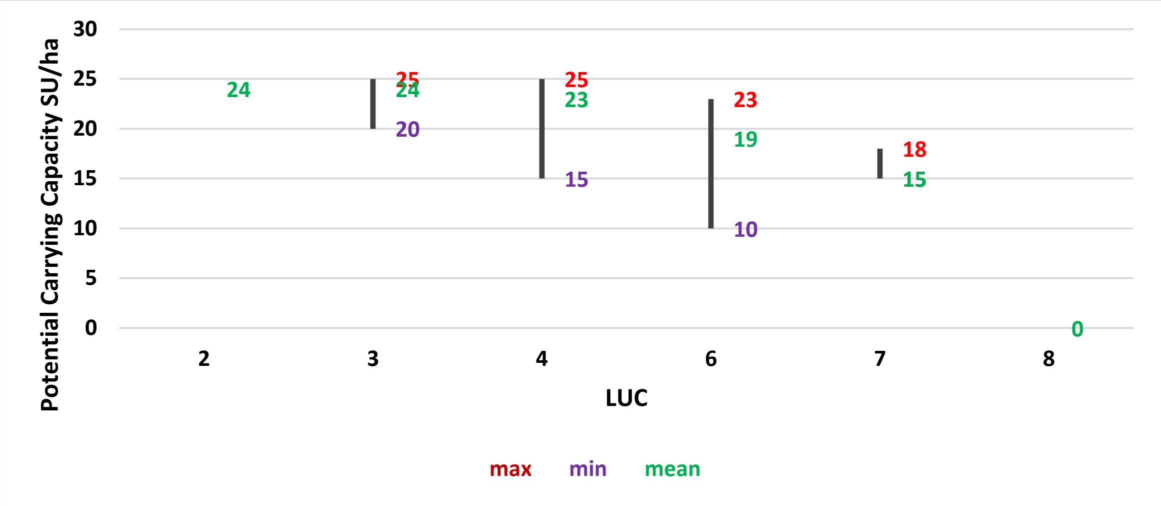
Figure 1: Estimates of NZLRI attainable stock-carrying capacities for LUC Classes mapped in the Canterbury Region under rain-fed agricultural conditions (based on Table 2, Lilburne *et al* 2016)



What this shows is the significant variation of stock-carrying capacity (Potential Carrying Capacity – PCC) within and between LUC classes, and Lilburne (*et al* 2016) point out that some Class 3 soils have a higher carrying capacity than Class 1 and 2 soils, and some Class 6 soils are comparable to some Class 3 soils.

Work in the Rotorua Lakes Catchment also shows a wide variation within and between LUC categories.

Figure 2: Variation of Potential Carrying Capacities within and between LUC classes, Lake Rotorua Catchment



Note there are no LUC 1 and 5 soils in the catchment.

What Figure's 1 & 2 show is that the relativity between the LUC classes in reality is significantly less than is typically portrayed in generic LUC categories.

All of which underlines that LUC classifications are a poor proxy for soil "natural capital".

Land Use Capability and nitrogen leaching

While LUC can be a useful tool in assisting in land use decisions, its use as a proxy for nitrogen leaching allocation suffers one serious drawback – it was not designed for nitrogen leaching, and as a result the relationship between LUC and nitrogen leaching is tenuous and unreliable. LUC can show a relationship to productivity and productivity can show a relationship to nitrogen loss. The range of factors used to inform LUC, however, can cause substantial differences in nitrogen leaching rates.

The amount of nitrogen leached from a farming operation is a function of a wide range of variables, including;

- Soil type, particularly drainage characteristics
- Rainfall
- Farming type, i.e. dairying, drystock, cropping, permanent horticulture
- Type of pasture/crop
- Fertiliser; timing and amount of nitrogen fertiliser
- Effluent management
- Farming system and grazing management
- Stock type, e.g. specie, age, sex

Another important determinant of nitrogen leaching is land management, or what could be called "human capital", related to *farming system and grazing management*. This is the difference between farmers regarding their skill, expertise, and experience in managing a farm.

The end result is that similar farms, on the same LUC, will leach differing amounts of nitrogen due to differences in farm management.

In other words, there are many factors driving nitrogen leaching. Of the variables above, soil type is covered by LUC (although a LUC category can have soils of differing drainage potential), rainfall is not part of LUC but is a natural process, and the balance are about how the land is used and managed, including such aspects as stock type, the farm system, stocking rate, and grazing management. A change in any one of the above factors will alter the quantum of nitrogen leaching.

Because LUC includes five primary factors, each contributing to the classification, the interactions result in different characteristics making up any particular land use capability class. Ledgard (2012) notes:

For two farms with the same level of productivity and N excretion in urine, N leaching losses will be higher on a moderate LUC site with shallow stony or sandy soils than on LUC I soils. However, an anomaly to this pattern of increased N leaching with increased LUC class is that N leaching will generally be lower from poorly-drained soils in mid LUC classes than from LUC I soils (with the same productivity and N excretion) due to greater gaseous N losses. Thus, there may be greater variation in N leaching within a LUC class than between LUC classes due to different soil characteristics.

An example of this, calculated by myself: a dairy farm near Tokoroa on a pumice soil (LUC 3) leaches 83kgN/ha/year (based on OVERSEER®). A farm near Morrinsville on an ash soil (LUC 3) using exactly the same farming system leaches 51 kgN/ha/year. There is a significant difference in average rainfall between Tokoroa and Morrinsville; 1600mm versus 1150mm, which directly affects nitrogen leaching. If the rainfall was standardised for both areas, so the only variant was the soil type, the nitrogen leaching figures are; 59kgN/ha on the Tokoroa farm versus 51kgN/ha on the Morrinsville farm. The LUC remains the same.

Another factor is that many farms are a mosaic of LUCs, which means that to provide an accurate allocation, each farm needs to be mapped; a time-consuming and expensive exercise.

It may be possible to combine some if not all of the aspects bullet-pointed at the start of this section, although developing a system which incorporates a wide range of varying factors in order to provide a simple allocation approach, is difficult to envisage.

Land Use Capability, production, and technological change

LUC classification was developed in part to provide an estimation of the "productivity capacity" of the soils, usually expressed as carrying capacity, i.e. stock units/hectare. This was done based on the best information at the time, but technology and farming systems have changed, which has increased the productive capacity of the land.

Examples of this include;

(i) Artificial drainage. One of the classification factors within LUC is the internal drainage characteristics of the soil; poor internal drainage is very likely to result in a lower LUC classification. This can often be remedied via artificial drainage (which will often increase nitrogen loss) but could mean lifting a (say) LUC 3 soil up to a LUC 1 equivalent regarding productivity.

(ii) Use of fertiliser. Most New Zealand soils have relatively low natural fertility, and the addition of fertiliser (NPKS) can materially increase pasture growth across all LUC categories, particularly so with nitrogen fertiliser applications. Improvement in productivity capacity via this technology is likely to continue given the advent of precision application, particularly on hill country. As an example, fertiliser trials on the Ballantrae Research farm have shown a lift in stocking rate from the initial 6 SU/ha up to 10SU/ha for the low fertiliser input farmlet, and from 6SU/ha to 16SU/ha for the high fertiliser input farmlet (Roberts, 2012).

(iii) Irrigation. Liability to drought is a factor in LUC classification. Irrigation can address this and has been seen in New Zealand to significantly lift the productive capacity of soils. For example, irrigation of the west coast Manawatu sand country lifted productivity by around ½ LUC equivalent (Grant, 2012).

(iv) Frost protection. Climate extremes affect LUC classification, and frost can be a significant factor in horticulture production. But again, can be rectified using current technologies, e.g. wind fans, water irrigation.

When LUC was developed, dairy farming on the lower LUC categories (e.g. LUC 4-6) was probably not envisaged. Today, with a combination of various technologies, e.g. irrigation, supplementary crops or bought-in supplements, modern pasture species and good management, this is now economic because the productivity of the land has been enhanced (Edmeades, 2012)

Another factor which could fit within this category is a change in *knowledge* rather than a change in technology per se. As our knowledge around primary production systems and environmental impacts increases, changes can be made in the way land is managed which can improve productivity and/or lessen environmental impacts. An example of this would be the variation in productivity and profitability from similar farms as reported in Beef + Lamb NZ and Dairy NZ economic surveys. This relates to the "human capital" aspect noted earlier; while the biophysical aspects of the soil are important, usually the key driver of productivity from the land is the capability and expertise of the land owner. Part of the definition of natural capital noted earlier was that it is "..*under optimal management*..". Optimal management involves the continual uptake of new technologies and systems, all of which directly affects, and improves, the productivity from the land, which blurs the differences between LUC categories.

In summary, changing technologies directly improves the productive capacity of the land, along with actual physical production from the land, which directly differs from LUC-based potential production, and directly reduces the differences between LUC categories.

Economics, allocation and natural capital

The placing of a nutrient cap on a catchment, or region, will have economic and social consequences. From an economics perspective, the best allocation method will be the method that achieves the required environmental outcomes at the greatest net benefit, or the lowest net cost. These may include both monetary and non-monetary benefits and costs.

The issues described in this section are relevant to natural capital as an allocation approach, although the examples use LUC to illustrate points.

Allocation systems that differ from the status quo cause economic and social disruption. The further from the status quo, the greater the disruption. While some disruption may be acceptable for the greater good, in cases where an allocation system for nitrogen is both distant from the status quo and not reliably and consistently correlated with nitrogen leaching, the outcome is inefficient.

An example to illustrate this, based on the Tukituki catchment in Hawke's Bay, where the Regional Council has instigated a Natural Capital allocation scheme for nitrogen, based on LUC.

Table 2: **LUC-based allocations for the Tukituki catchment**

	Base (kgN/ha/yr)	LUC Allocation (kgN/ha/yr)	% difference
Arable	27.6	20	-28%
Dairy	40	20.9	-48%
Dairy/Heavy soil	51.2	21.8	-57%
Dairy/Light soil	59.8	22.7	-62%
Mixed Arable	30	23	-23%
Mixed Livestock	24.3	20.4	-16%
Orchard	18.6	23.9	28%
Sheep/Beef	13.2	16.8	27%
Vineyard	12.7	23.4	84%

Source: Jacobs, 2014

This shows a direct transfer of nitrogen rights from the higher nitrogen leaching systems (dairy, arable, mixed livestock) to the lower nitrogen leaching systems (orchard, sheep & beef, vineyard). The outcome for the properties losing nitrogen is a loss in business income, as well as the potential to have stranded assets (e.g. milking parlour), and a negative impact on land values. This is difficult to quantify generically, as it would vary on a case by case basis, particularly depending on whether the allocation was above or below current leaching levels and the quantity of this difference. In noting this, it is difficult to see a number of dairy farms successfully meeting their new N leaching targets, so they will go out of business, with accompanying economic and social disruption.

The figures above are averages; impacts will differ between farms within the same sector depending on their individual nitrogen leaching level. In essence, there are direct windfall gains for the lower nitrogen leaching systems, and windfall losses for the high nitrogen leaching systems. This translates to high levels of economic cost and social disruption, which means that a LUC allocation would largely be a lottery relative to existing land use, as the allocation would be based on one measure of land quality rather than whatever land use is currently in place. So a farmer, for example, on lower quality land who has employed a range of technology/farm systems to improve the productivity of the land, would lose out, thereby raising the question of equity.

The recipients of any extra nitrogen leaching allowance are in fact being compensated for the potential loss of future opportunities at the expense of other sectors/landowners.

An interesting issue regarding Table 2 is the case of viticulture. It is a high value horticultural enterprise; basically, a "highest and best use" type crop. So, while it has a current leaching of 12.7 kgN/ha/year, it has been allocated 23.4 kgN/ha/year. What "higher and better" use will (or could) the land be put to? This raises the question of the need to allocate more nitrogen to this land use and shows that there is not necessarily a strong relationship between highest and best use of land and the need for a high nitrogen allocation. The same could be said for the allocation to "orchard" as per Table 2. It directly shows that such an allocation is economically inefficient.

Optimal Land Use

One of the arguments for a natural capital allocation is that it would result in optimisation of land use, i.e. the best land would be farmed at their "highest and best use", which is often translated as highest economic return, or that the land use best suits the soil.

The question of land use optimisation raises a number of issues, particularly as to the definition of "optimisation" and who is doing the defining – often it is a matter of personal perspective. Given this latter point, a suggested definition is that landowners make decisions about the most appropriate (= optimal) use of a parcel of land based on a broad range of goals for the farm business. Factors such as economic, biophysical, technological and personal preferences are taken into account. These choices are made within the legislative and policy environment operating at the time.

Optimisation in production or best use can also change dependent on changing circumstances and/or the use of technology. A classical example of this is the Gimblett gravels near Hastings which is classified as LUC 7; rated unsuitable for horticulture and low suitability for pastoral or forestry uses. The land use on these soils is almost totally in viticulture, producing high quality wines, and an economic return much superior to any pastoral activities.

Part of the argument around optimal land use is at an on-farm level, for example, "farmers should not be running heavy cattle on heavy soils on hill country in winter." Which indeed they shouldn't. But a natural capital (or any) allocation system cannot guarantee this will not occur; it is entirely possible to damage soils while operating under a nutrient cap, as it is related to farmer skill and experience (i.e. the human capital factor).

The land use choices of individuals and businesses are driven by a wide range of factors:

Biophysical, which includes:

- Soil type - whether free-draining or not, whether suitable for horticulture compared with pastoral agriculture, how deep the topsoil, how fertile it is.
- Topography - how flat or steep the land is, the aspect of the land, how suitable for mechanised farming, how prone to erosion.
- Climate - how much rainfall, how windy, sunshine hours, degree of seasonal variation, how hot or cold it is at different times of the year.
- Availability of water - for example, for irrigation or domestic/industrial consumption, and the quality of that water

Economic, which includes:

- Profit - what are the comparative costs and returns from particular land uses.
- Capital - access to capital for investment, development and seasonal finance. This can vary; at an aggregate level New Zealand is not short of capital, but at an individual level it varies widely.
- Markets - is there a market for whatever land use is envisioned, what is the proximity to the market. There is also the issue of market timing – is investment and land use change responding to a market cycle? Once made, investment or disinvestment decisions cannot be altered on a short-term timeframe.
- Infrastructure - whether there is infrastructure available to support the proposed land use – be it servicing firms, processing firms, marketing firms. If no infrastructure currently exists, what is the likelihood/speed of development?
- Access to information - availability of information/technical advice around the proposed land use change.
- Access to (skilled) labour necessary to run the proposed new land use activity.
- Land tenure - if the land owner has secure property rights to the land, then the incentive to consider long-term land use decisions is enhanced. If land tenure is uncertain, then the incentive is to concentrate on short-term farming activities and forgo any longer-term options.

Technology. This was touched on earlier in this paper, where technology or management systems can be used to offset biophysical limitations and/or change the productivity of the soils.

Societal/Regulatory factors. This relates to the concept of "social license to farm", which has always affected farming, and becoming more prevalent around animal welfare and environmental concerns. Which is where the restrictions on nutrient discharges is based, although the manifestation of this will be in economic terms.

Individual factors. This covers the wide range of difference in individuals which may affect their thinking around land use. It would include aspects such as age, education and experience, family circumstances, attitude to risk, access to capital, access to information, and attitude to change. In other words, their personal preference; e.g. some people like working with livestock, others prefer plants.

While a review of the literature (Journeaux *et al* 2017) indicates that the main two drivers of land use change are the biophysical aspects of the land, and economic factors, all of the above factors interact in an infinite array of permutations, meaning that any one factor is unlikely to drive an optimisation of land use. For this reason, restricting land use based on one measure – natural capital – is unlikely to deliver on an optimal land use pattern – but is likely to result in high economic and social costs (disruption to the status quo). This can be demonstrated by using LUC as a proxy for natural capital and analysing current land cover patterns as shown in Table 3.

Table 3: New Zealand Land Cover by LUC Classification (ha)

	LUC								
Landcover	1	2	3	4	5	6	7	8	Total
Cropland	25,378	148,406	143,916	39,858	735	9,924	1,752	167	371,721
Exotic forest	1,621	11,625	92,865	302,476	14,231	987,482	635,234	34,845	2,093,333
Grass and scrub	3,054	21,279	57,791	78,269	8,300	375,173	272,280	408,757	1,244,867
Grassland	136,816	947,837	2,000,541	1,988,679	160,323	4,305,897	2,152,720	1,504,129	13,307,392
Horticulture	12,365	27,547	40,028	13,297	173	7,437	2,600	243	104,458
Natural forest	1,328	12,679	56,966	287,962	19,128	1,704,582	2,521,526	3,035,210	7,656,719
Other	1,093	8,323	23,276	47,169	6,229	66,334	97,262	814,494	1,463,112
Urban	5,454	23,793	27,033	18,768	760	14,373	4,608	966	223,290
Total	187,171	1,202,811	2,444,038	2,778,956	210,389	7,478,476	5,694,999	5,807,314	26,523,681

Source: LRI/LUCAS databases. Note: Totals exceed individual columns/rows, as some categories have been removed

Table 3 shows that there are 106,000 hectares of production forestry on LUC 1-3; the economic returns from those soils is likely to be much higher in another land use, such as cropping or horticulture. Similarly, there is 3 million hectares of grassland on LUC Class 1-3 soils, and again a higher economic return under cropping or horticulture is probable on much of this area. At the other end of the spectrum, there are 11,800 hectares of cropping on LUC 6-8, 10,300 hectares of horticulture on LUC 6-8, and 3.7 million hectares of grassland (presumably drystock) on LUC 7-8 soils. The reasons for these seemingly sub-optimal land uses are broader than the capability of the land and take into account the factors discussed earlier in this paper, plus the changing technologies that make land more versatile than was envisaged when LUC was developed.

Table 3 also indicates that there are several million hectares of land suitable for horticultural purposes, which are currently not in horticulture, despite it being, in general, a higher economic return activity relative to pastoral uses (i.e. a "higher, better" use). This is due to a wide range of factors, of which nutrient discharge restrictions isn't one. If nutrient discharge is restricted, this will not magically drive the development of horticulture, as all the other factors will still be relevant, and highest and best use may not require a large quantity of nitrogen.

The question therefore is whether a natural capital allocation would drive land use towards "best and highest" use. The answer is – very unlikely.

This is not to say that restrictions on nutrient discharge will not affect land use; the likelihood of this is very high and will be manifest over the next two decades as more Regional Councils ratify/review their water quality plans. If nitrogen is available, then farms can convert to a higher nitrogen leaching land use, e.g. from drystock to dairy. If nitrogen is not available, then obviously they can't. It just won't drive land use to any level of optimisation or best and highest use, as there are too many competing influences.

Existing Natural Capital Allocation Schemes

Reference has already been made to the Tukituki allocation scheme, and the inherent economic inefficiencies.

A comment on the Horizon's One Plan also illustrates a range of anomalies. It is important to note that the allocation in Horizons is not a true Natural Capital allocation – the intent of such an allocation approach involves placing a cap on nitrogen leaching according to LUC classification, i.e. across all land, which then applies to all activities on that land. In the One Plan, this does not apply. Four land uses have been identified; dairying, irrigated sheep & beef, arable cropping, and vegetable growing, and a LUC-based nitrogen cap then applied. Other land uses, such as sheep & beef, forestry, and horticulture are excluded. This then gives rise to various anomalies:

(i) A dairy farm on LUC 2 leaching (say) 50kgN/ha/year, needs to reduce this down to 27kgN/ha/year and further in later years. An intensive beef farm, however, leaching (say) 40kgN/ha/year does not need to reduce, and in fact could legitimately intensify.

(ii) A dairy farm on LUC 8 (not a high probability, but the principle is there) and leaching (say) 20-30kgN/ha/year must reduce its leaching down to 2kgN/ha/year (LUC 8 allocation), which is not possible – the dairy farming must stop. A sheep & beef farm on LUC 8 (of which there is 43,600ha in the

Horizon's region[2]) leaching say 8-10kgN/ha/year again does not need to reduce, and again could potentially intensify.

(iii) Forestry is not included within the allocation system. This is perhaps fortuitous, as it could not exist on LUC 8 land. There is 2,696 hectares of production forest and 119,205 hectares of native forest[3] on LUC 8 land in the Horizon's region. Both leach above the allocation of 2kgN/ha/year and therefore would be technically non-compliant.

Another anomaly which arises relates back to the purported optimisation of land use. Under the One Plan, vegetable growing is capped as to nitrogen leaching. The capped level is well below what vegetable growing can currently achieve, and hence land currently under vegetable growing will be largely forced back into a pastural, and less economic use.

Both schemes therefore are quite likely to achieve an impressive double: given the inherent contradictions within a LUC-based allocation, they will very probably **not** achieve the environmental outcomes desired, while at the same time imposing a significant economic and social cost on the rural community.

Trading

The imposition of a cap or allowance on nutrient discharge at a farm level obviously imposes a degree of restraint on the land use, or potential land use change. One means of improving the flexibility of land use within the constraint, is to allow trading in the nutrients (i.e. nitrogen*);* for individuals *trading provides flexibility and, in theory, reduces the cost of regulatory compliance* (Kerr et al, 2015), for society, trading reduces the overall cost of the policy.

This is important, **regardless** of the allocation mechanism; the aim is to allow as much flexibility in the use of the nutrient post the allocation. Some see "cap and trade" as a constraint all in one. It is important to note that it is the cap which imposed the constraint, whereas trading offers a degree of flexibility. Within New Zealand it could be expected that nutrient trading markets will be (at least initially) both thin and sticky (i.e. relatively few traders and some reluctance to trade). But at the very least it provides an opportunity for that flexibility. This is important regardless of the initial allocation system[4].

As well as enabling flexibility for individuals, trading is the means with which the market achieves the optimal economic outcome; it enables landowners with lower costs of reducing N use to make reductions and sell their N allowance to landowners with higher reduction costs.

While trading is desirable from an economic perspective, if N is allocated on the basis of suitability of land for a particular land use, then enabling trading may undermine the basic principle being applied. Without trading, the cost of the LUC arrangement described earlier is high; nitrogen intensive activities on lower LUC classes are reduced, while less intensive nitrogen activities on higher classes are allowed. The Council can demand that the former cease (and unrelocatable assets are potentially lost) but cannot demand that the latter invest.

[2] LUCAS NZ Land Use Map 1990, 2008, 2012 (v016), NZLRI Land Use Capability, Statistics NZ

[3] Ibid

[4] Economic theory would indicate that if trading is fully efficient, then all allocation mechanisms will ultimately result in the same distribution of land uses and farm systems. In noting this, economic impact on individuals will still differ widely, and nutrient trading is likely to be both thin and sticky, rather than "fully efficient".

Trading of nutrients from land with an "optimal allocation" provides for a compensation mechanism but undermines the fundamental allocation rationale.

Apart from the fact that an optimal land use pattern won't happen based on LUC alone, trading is still required; changes in technology and farming systems into the future are very likely, which will affect the productivity of the land, and hence trading is necessary to ensure there is flexibility to allow this to happen and to deliver economic efficiency over the longer term.
The **only** trading market that exists world-wide for diffuse discharge of nitrogen is the trading regime pertaining to the Lake Taupo catchment. Overall the trading system has been quite successful (Duhon *et al*, 2015) with the following outcomes:

- Trading commenced in July 2011. But June 2014 there had been 23 trades with the Taupo protection Trust, and 12 private trades and 3 leases.
- By July 2015 the Trust had achieved its goals of buying out 20% of the manageable nitrogen and since that time further private sales have occurred.
- The trading has resulted in land use intensification, and changes in farm systems to enhance profitability.

The main point is that trading is necessary, regardless of the allocation mechanism, so as to allow for flexibility and greater efficiency of use of the allocated nutrient.

Summary

In summary, there are a number of issues with a Natural Capital/LUC-based nitrogen allocation system:

- Probably the first issue is that LUC has almost no relationship with nitrogen leaching, and there fails the "logic" test as to why it should be used as a proxy to allocate nitrogen. This is especially so given the inherent variation within and between LUC categories
- The differences between LUC categories are increasingly blurred by technological advances – the adoption of which is all part of "optimum management".
- Inasmuch as a natural capital allocation differs widely from the status quo, its application will tend to maximise economic and social disruption, providing windfall gains and windfall loses.
- It will not drive land use to "optimal" or highest and best use. There are a wide range of factors which drive land use and land use change, of which a nitrogen leaching allowance is but one.
- Trading is a necessity to improve the flexibility and efficiency of use of the nutrient allocated, regardless of the allocation scheme.

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