Thoughts on the allocation of nutrients; the issue with Natural Capital allocation

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Invited paper presented at the New Zealand Agricultural and Resource Economics Society (NZARES) Conference, October 19-20, 2017, Rotorua, New Zealand.

Paper to NZARES Conference 2017

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1. 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 are often looking 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.

Although the cap may in principle represent the optimal water quality for society, the form that allocation takes tends to be contentious because it is highly likely, in the absence of technological change, to limit 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 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

2. Natural capital

In some recent submissions on proposed regional plans dealing with nutrients there have been requests to allocate nitrogen leaching on a “natural capital” basis. A natural capital approach to nutrient allocation is often argued for as providing better economic outcomes (i.e. increased productivity), better environmental outcomes, and better equity outcomes. 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 of natural resources and services in a given ecosystem or region” (adapted, Pembina, 2008). Mackay (2010) provides a definition of:

the ability of a soil to sustain a legume-based pasture that fixes N biologically under optimum management and before the introduction of additional technologies, which is a measure of the productivity of soils. In terms of allocation, natural capital could be thought of as the underlying natural biophysical resources (such as soil type and rainfall) associated with a unit of land that are relevant to meeting an environmental outcome (such as a sustainable nitrogen load from a catchment).

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. For example, in the Hearings for BOPRC Plan Change 10 the commissioners noted:

> [383] *The most common alternative sought was a natural capital approach, which appeared to be derived from the productive capacity of land, based on land classification* (BoPRC, 2017).

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 use.* Capability is used in the sense of suitability for productive uses after taking into account the physical limitations of the land (Landcare Research, 2009).

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. LUC 1-4 are also assessed on arable cropping suitability, not pastoral suitability.

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

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[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.

3. 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 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. species, 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 farm management.

In other words, there are many factors driving nitrogen leaching. Of the variables above, soil type is covered by LUC, rainfall is not part of LUC but is a natural process, and the balance of variables 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 variables will alter the quantum of nitrogen leaching.

As previously noted, LUC includes five primary factors, each contributing to the classification. The interactions of these factors result in a complex and sometimes inconsistent set of attributes in any LUC classification. This complexity can lead to counterintuitive outcomes with nitrogen leaching. 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 an LUC class than between LUC classes due to different soil characteristics.*

Ledgard (2012) concludes that '*the main drivers of N leaching are not well aligned to the LUC classes'*.

In a real life example of the described complexity, a dairy farm near Tokoroa on a pumice soil (LUC 3) leaches 59kgN/ha/year (based on OVERSEER®). A farm near Morrinsville on an ash soil (LUC 3) using the same farming system leaches 53 kgN/ha/year. There is a significant difference in average rainfall between Tokoroa and Morrinsville; 1600mm versus 1150mm, which directly affected nitrogen leaching. For the purposes of this analysis rainfall was held the same for both areas, so the only variant was the soil type. If the correct rainfall is entered, the nitrogen leaching figures are; 83kgN/ha on the Tokoroa farm versus 51kgN/ha on the Morrinsville farm. The LUC remains the same.

A similar example illustrating the effect of rainfall is; a hill country sheep and beef farm on LUC 4 land, if average rainfall is 1,000mm/year, N leaching = 14 kgN/ha/year. If average rainfall is 1,500mm/year, N leaching = 23 kgN/ha/year. Same farm, same system, same everything, except a difference in rainfall.

It may be possible to combine some or all of the variables bullet-pointed at the start of this section to develop a nitrogen leaching estimate, although developing a system which incorporates a wide range of varying factors in order to provide a simple allocation approach, is difficult to envisage.

4. Land Use Capability 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 readily 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 to improve 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 16SU/ha for the high fertiliser input farmlet (Roberts, 2012).

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

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

When LUC was first developed, dairy farming on lower quality land (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 with could improve productivity and/or lessen environmental impacts.

In summary, changing technologies can directly improve the productive capacity of the land, along with actual physical production from the land, which directly differs from LUC-based potential production.

5. Economics, allocation and natural capital

The placing of a nutrient cap on a catchment, or region, will have economic and social consequences. In respect to allocation, good policy should be to minimise the costs of achieving the environmental objective.

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

Although economic theory asserts that if trading is fully efficient, any allocation option will result in the same overall cost to society, at the individual and community level 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 (e.g. achieving a desired environmental objective), in cases where an allocation system is both distant from the status quo and not reliably and consistently correlated with nitrogen leaching, the outcome is inefficient.

A hypothetical example illustrates this.

Assume a catchment with a range of land uses, with the whole catchment classified as LUC 1 (statistics on land use by LUC are not readily available, so difficult to do a more detailed analysis). Current nitrogen leaching is shown in the following table, along with the nitrogen allocation (as per Horizon's One Plan[2]), and the relative adjustment required.

Table 2: Impact of nitrogen allocation

	Current kgN/ha/yr	N Allocation (kgN/ha/yr)	Difference (kgN/ha/yr	% Difference
Dairy	45	30	-15	-33%
Drystock	20	30	10	50%
Forestry	2	30	28	1,400%
Kiwifruit	10	30	20	200%
Arable cropping	30	30	0	0%
Intensive vegetables	70	30	-40	-57%

What this shows is a direct transfer of wealth from the higher nitrogen leaching systems (dairy, intensive vegetables) to the lower nitrogen leaching systems (drystock, forestry, kiwifruit). Plus, potentially, 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. Intensive vegetable production is likely to cease to exist, as the reduction is too great to achieve with current technology. This translates to high levels of economic cost and social disruption; a natural capital allocation would largely be a lottery relative to existing land use, as the allocation would be based on land quality rather than whatever land use is currently in place. So a farmer, for example, on lower quality land who has made a substantial financial investment and employed a range of technology/farm systems to improve the productivity of the land, would either lose that investment, or if trading was available, would be faced with purchasing nitrogen rights to continue with the same activity.

The allocation approach for the Tukituki catchment also illustrates this.

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[2] Refer table at end of References

Table 3: 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

As shown in Table 3, there is a transfer of nitrogen between sectors, from arable and dairying to horticulture and sheep & beef. Given a 50-60% reduction, it is likely that little dairying would survive, meaning economic and social disruption is high.

The recipients of any extra nitrogen leaching allocation are in fact being compensated for loss of future opportunities at the expense of other sectors/landowners. This approach assumes that the most valuable future opportunities require nitrogen allocation, but this is not necessarily the case.

An interesting issue regarding Table 2 is the case of kiwifruit. It is a high value horticultural enterprise, requiring high quality soils; basically, a “highest and best use” type crop. So, assuming it is being grown on LUC 1 soil, and currently leaching is (say) 10kgN/ha/year, but is then allocated 30kgN/ha/year, what “higher and better” use will (or could) the land be put to? The same applies to vineyards in Table 3.

The other economic impact of allocation is, due to the transfer of wealth, the potential to have stranded capital, 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 magnitude of this difference.

In any allocation system, it is important that all land uses are incorporated, otherwise anomalies can arise. Which is the case with the allocation system used by Horizons Regional Council, namely the absence of the drystock sector (and forestry) from the LUC-based allocation. For example, if you were dairy farming on LUC 8 land (not a high probability, but the principle is there) and leaching say 30kgN/ha/year, then this is bad and you must reduce to 2kgN/ha/year (as per the allocation for LUC 8 land). If you were drystock farming on the same class of land, of which there are 43,600 hectares in Horizons on LUC 8, and leaching say 8-10kgN/ha/year, then that’s fine; no reduction required.

Incorporating all land uses however can generate a higher level of disruption in economic and social terms. For example, if forestry is added to a system with a cap or reducing nutrient limit on pastoral land the available nutrient load will be spread across a wider area of land, placing significantly more pressure on the existing activities and will lead to increased economic disruption. This can be illustrated from the Lake Rotorua situation. Table 4 shows the hectares in drystock and forestry by LUC class in the Lake Rotorua catchment. At an allocation of 25.6kgN/ha for drystock, this provides 419,430kg N for allocation. If allocated by LUC, the equivalent of 5,478 hectares of forestry gets an allocation of 25.6kgN/ha, and 5,478 hectares currently in drystock, the bulk (74%) on LUC 6, must convert to forestry, or purchase N.

Table 4: Lake Rotorua effect of adding Forestry on allocation

LUC	Drystock (ha)	Total Nitrogen at 25.6kg/ha allocation (kg N)	Forestry (ha)	Drystock and Forestry ha	Total Nitrogen at 25.6kg/ha allocation (kg N)	Forestry conversion to Drystock (ha)	Drystock remaining (ha)	Drystock removed (ha)
2	393	10,061	20	413	10,573	20	393	
3	2,671	68,378	815	3,486	89,242	815	2,671	
4	5,005	128,128	2,760	7,765	198,784	2,760	5,005	
6	6,867	175,795	4,559	11,426	292,506	1,883	2,837	4,030
7	1,272	32,563	1,419	2,691	68,890			1,272
8	176	4,506	102	278	7,117			176
	16,384	419,430	9,675	26,059	667,110	5,478	10,906	5,478

Source: Table 2 and Table 4 of Moleta, 2017

Note: Using average allocation to show the impact and ignoring LUC suitability for activities.

From Table 4 it can be seen that either there is a significant wealth transfer (5,478 ha of drystock cannot remain and becomes forestry and vice versa) or all land faces a much tighter nitrogen limit - a 37% reduction from the 25.6 kg/ha average to 16.1 kg/ha so that the total load from drystock is retained but over drystock and forestry.

The other risk with a natural capital based nitrogen allocation is the possibility of creating even more nitrogen as a result. This is illustrated in Tables 2 and 3 by the positive figures, where nitrogen has been allocated above the level of current leaching. The hope is that this is (more than) offset by the reduction in nitrogen as evidenced by the negative figures. But the quantum of this is difficult to readily calculate given the absence of good statistics around land use by LUC or nitrogen leaching rates by land use by LUC. It would largely depend on the proportionality of existing low nitrogen leaching land uses, e.g. forestry, permanent horticulture and drystock, relative to higher nitrogen leaching land uses, e.g. dairy, relative to the quality of land they were being carried out on.

A simple hypothetical example illustrates this:

A catchment is 100,000 hectares, evenly divided between forestry and dairying, and all LUC 1, with a nitrogen allocation of 30kgN/ha/year. The 50,000 hectares of forestry would be allocated a total of 1,400 tonnes on nitrogen (moving from 2kgN/ha to 30kgN/ha). The 50,000 hectares of dairying would "lose" 1,000 tonnes of nitrogen (moving from 50kg/ha to 30kgN/ha). So the overall allocation has increased nitrogen in the catchment by 400 tonnes.

6. 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.

Land use is the result of a wide range of factors that drive the choices of individuals and businesses. These factors are:

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 is becoming more prevalent around animal welfare and environmental concerns. While restrictions on nutrient discharges is based on environmental and social concerns, 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 includes 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, personal preferences; 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 single factor is unlikely to be the sole determinant of 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 it 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 5.

Table 5: 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 5 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 section, plus the changing technologies that make land more versatile than was envisaged when LUC was developed.

Table 5 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.

Optimisation in production or best use can also change dependent on changing circumstances and/or the use of technology. Examples include:

- The use of drainage and/or frost protection, thereby allowing a crop to be grown that would not necessarily be possible in the natural state.
- The recognition that some land use (or crop) is possible on what was previously considered poor soil. The classic example here is viticulture on the Gimblett Gravels near Hastings.

Part of this argument is, 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 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 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. An allocation of nitrogen alone won’t drive land use to optimisation or best and highest use, as there are too many competing influences.

7. Trading and efficiency

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 when considering the desire for compensation for loss of future opportunities. A simple analogy is when a person has an old car and wishes for a new one. The probability of the government or anyone else buying one for them is somewhat remote. But there is a remedy well at hand – they can buy a new one directly, as a functioning market is well established. The main point here is that we live in market economy and accept the "rules" involved.

There is a similar sense with land use; yesterday you could intensify and/or change land use relatively freely. Today you can't because a restriction (i.e. a nitrogen cap or allowance) has been imposed. If a trading system is also in place then this (a) won't necessarily mitigate the impact of the restraint, but (b) does offer some degree of flexibility.

As an example, assume a catchment with a current input of 1,000 tonnes of nitrogen. As a result of the cap and reduction, this is reduced to 600 tonnes. The important thing post the cap and reduction is to make the best use of the remaining nitrogen (i.e. the 600 tonnes), which is where a trading system greatly aids in the flexibility of this use, and enables the nitrogen to move to its highest value use.

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[3].

There is a concern in some quarters that "bad" farmers could buy nitrogen from "good" farmers and thereby stay in business. This is quite possible, given the assumption that "good" farmers are willing to sell. At the end of the day trading is based on a willing seller/willing buyer basis, and as a generalisation, "good" farmers tend to be more profitable than "bad" farmers, so are more likely to be the buyers. Similarly, there is concern that all of the nitrogen will be bought by a few, or one, buyer. Again possible, but not very probable. The question could be raised as to so what; the environmental gain has been achieved via the cap and reduction, and the sellers are again presumably willing to sell their nitrogen leaching allowances.

Trading is the means with which the market achieves the optimal economic outcome, and enables those who have been allocated nitrogen that they do not want to use to sell it to those who do want to use it. Without trading, the cost of the natural capital arrangement described earlier is high; intensive activities on lower LUC classes are reduced, while less intensive 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.

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[3] 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. This is seen for example in the analysis by Parsons et al (2015) and Market Economics Limited (2015) for BOPRC Plan Change 10 in the Lake Rotorua catchment. But the economic impact on individuals will differ widely, and as noted, nutrient trading is likely to be both thin and sticky, rather than "fully efficient".

It has been suggested that trading would not be necessary under a natural capital allocation system, inasmuch as it would result in optimal land use, as discussed earlier. Taking this a step further, if the allocation is based on the principle of natural capital as optimal, it has also been suggested that trading should not be introduced as to do so would undermine the basic principle being applied. 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, 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.

Summary

The purpose of this paper was to discuss the issues around a “natural capital” approach to allocating nitrogen. Given the lack of definition of what this means, Land Use Capability is often used as a proxy, and has been used directly by two Regional Councils.

As this paper has demonstrated there are significant issues with using LUC as an allocation tool given the complex and inconsistent relationship it has with the many factors that influence nitrogen leaching. Further, LUC is not useful as a productivity measure because of the technical changes that have come about over time. In short, LUC is not a reliable indicator of natural capital.

It may be possible to define a “natural capital” allocation system with respect to relating it to nitrogen leaching factors, although developing a system which incorporates such a wide range of varying factors in order to provide a simple allocation approach, is difficult to envisage.

Part of the argument for a natural capital allocation approach is that it is more equitable. Equity, however, is in the eye of the beholder, and the approach discussed in this paper would provide windfall gains for some and windfall losses for others, resulting in a high degree of economic and social disruption. A natural capital allocation potentially results in compensation for loss of future opportunities for some, at the expense of the financial investment made by others, which is perhaps less than equitable.

It is also argued that a natural capital approach to allocation will result in optimisation of land use. While nutrient allocation is very likely to have an impact on both land use and land use change, given the very wide range of factors that interact to drive both these aspects, it is unlikely that restricting a single factor will in fact drive optimisation. Some of our “highest and best” land use, on good soils, is horticulture, which is mostly a low nitrogen leaching land use. So why are they being allocated more nitrogen? Similarly, “bad” farming practices won’t be stopped by any allocation system; the answer here is around education and perhaps in some cases direct regulation.

Trading of nutrients under a capped system provides flexibility to individuals and lowers the cost of the regulation. This directly applies to a natural capital allocation system; changes in technology and farming systems means that trading is necessary to ensure there is flexibility to adjust, and to deliver economic efficiency over the longer term.

The paper has concentrated on nitrogen allocation, as this is currently the only nutrient being allocated. It is possible that phosphorus could also be allocated at some time in the future, particularly as some regional councils (Waikato, Hawke's Bay, Canterbury, Southland) have also targeted phosphorus within their plans. A natural capital approach to phosphorus would also suffer similar limitations as discussed for nitrogen, and allocating them both in tandem would add a new level of complexity.

The issues highlighted in the paper, around nutrient allocation and trading, are critical issues facing regional councils and the primary sector, as water quality plans are being developed and promulgated. It is an area requiring a lot of research, and it is perhaps disappointing how little is being done.

Thanks to Bay of Plenty Regional Council for sponsoring this paper

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Cumulative nitrogen leaching maximum by Land Use Capability Class (Table 14.2, Horizons Regional Plan) kgN/ha/year

PERIOD (from the year that the rule has legal effect)								
LUC	**l**	**ll**	**lll**	**lV**	**V**	**Vl**	**Vll**	**Vlll**
Year 1	30	27	24	18	16	15	8	2
Year 5	27	25	21	16	13	10	6	2
Year 10	26	22	19	14	13	10	6	2
Year 20	25	21	18	13	12	10	6	2