Natural capital, land-use planning and nutrient issues

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Introduction

The soil-plant-atmosphere systems which cloak our earth provide valuable ecosystem services. Only a fraction of the goods and services they provide are valued within the world's economy. In a landmark paper in Nature, Costanza *et al.* (1997) estimated the annual value of 17 terrestrial ecosystem services, all involving the soil-plant-atmosphere system, to be US$5.74 trillion. When oceanic services were added in, the global value of the earth's natural capital, and ecosystem goods and services, amounted to US$33 trillion per year. Gross global economic productivity only sums to $18 trillion per year.

In New Zealand, some 20% of our gross domestic product, through agriculture and horticulture, relies on a benign climate, productive plant systems, and the top 150 mm of our soil. The natural capital value and ecosystem goods and services provided by our weather, plants and soils are our pots-of-gold. Over the last decade, agricultural production has grown at about 4% per annum, more than twice that of other sectors of the economy. This growth spurt has been sustained by intensification of existing land uses, and the move of intensive land uses onto new soils, many of which have limitations to use.

Through intensification we could, as Hawken *et al.* (1999) assert in their very interesting book 'Natural Capitalism', "temporarily exceed the carrying capacity of the earth, but put our natural capital into decline". This is a fool's paradise, for they warn that "… the ability to accelerate a car that is low on gasoline does not prove the tank is full". New scientific understanding and better management of our plant systems and soils are therefore critical, not only for our economic futures, but also for the health of our environment. Sustainable use of our natural capital stocks will derive from sound policies for resource management, and good land-management practices within agricultural and horticultural enterprises. Evidence-based science must underlie these policies and practices.

In "Growing for Good", Morgan Williams (PCE, 2004) noted that New Zealanders are highly dependent on our natural capital stocks of our waters, soils and biodiversity to sustain our wealth-generating capacities.

By referencing projects carried out by our multi-CRI Sustainable Land Use Research Initiative (SLURI - www.sluri.org.nz), we show how taking into account the value of a region's natural capital stocks, and ecosystem goods and services, an assessment can be made of the future options for land-use (Mackay *et al.*, 2005). Next, we show how, by using natural capital valuations, a nutrient-loss limit can be ascribed to a diverse landscape in a water-management zone as part of a policy for sustaining and protecting ecosystem health (Clothier *et al.*, 2007; Mackay *et al.*, 2008).

Natural Capital and Land-Use Planning

Productive-sector environments are undergoing rapid land-use change in many regions of New Zealand, including the northern region of the Kapiti Coast District. The northern region is currently characterised by dairying, other pastoral and horticultural activities. But competition from urban subdivision, and an increase in lifestyle properties are rapidly encroaching on the viability of the land-based primary production sector. Our study (Mackay *et al.* 2005) provided information on the rural productive potential in the northern region of the Kapiti Coast District, to assist the local community in long-term planning for the District Council, through their Long Term Council Community Plan (LTCCP).

Horticultural enterprises appeared to offer the greatest scope for expansion onto the soils of highest natural-capital value across the northern region of the District. Seven broad horticultural use classes were examined for their potential, and included commercial vegetables, nurseries, berries, flowers, olives, pipfruit and viticulture. The suitable area for these horticultural activities was determined by first interrogating the necessary conditions from the ecosystem services provided by the local climate. Next, the Land-Use Capability (LUC) data from the New Zealand Land Resource Inventory served to provide the basis for establishing the natural-capital value of the soils in relation to horticultural land-use versatility - the soils with the higher natural-capital valued land (soils on Classes I and II) will have more options for horticultural activities. Figure 1 outlines the SLURI Decision Tree we developed to determine the potential land area for each horticultural activity in relation to the natural capital values of the soils grouped by the LUC. The exercise did not include an analysis of the environmental consequences of the use of the land for horticulture.

The SLURI Decision Tree identified significant potential for areal growth in horticulture within the northern region of Kapiti Coast District. This productive potential is based on the ecosystem services of the climate and the natural capital values of the land. This productive potential does not reflect market potential, or the impact of potential sites for various crops outside the northern

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region that could be more attractive to growers who wish to expand. These data show that the ecosystem goods and services of this region are not a constraint for horticultural expansion.

An economic analysis revealed the productive potential for horticulture in this northern region. An areal increase of just 50% (a simple numeric value) in horticulture would involve a change in land use of only 337 ha of land (50% of the 672 ha currently in horticultural production). At a sum of 1000 ha, this is still well less than 6700 ha of land that could sustain horticulture. Yet this small increase would produce an increase in revenue of $9.3M in gross output at the farm gate (currently $37M), and an increase in employment of 126 FTE (currently 446).

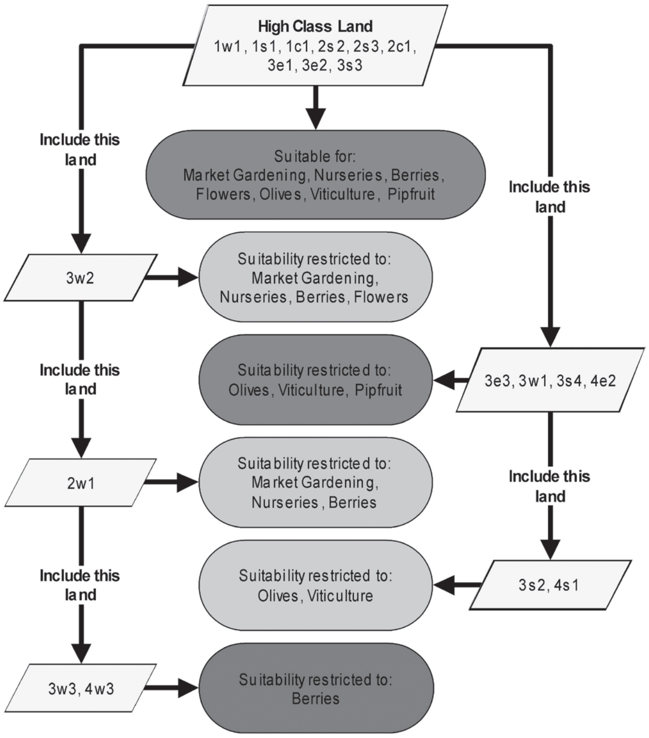

Figure 1. The Sustainable Land Use Research Initiative (SLURI) Decision Tree for linking land use capability class to potential horticultural activities.

Consideration of the natural capital value of a district's biophysical resources, along with consideration of its ecosystem services, provides a means for policy analysts and the community to assess and appraise future land-use options, their potential and the environmental impacts.

Natural Capital and Nutrient Policy

The *Guardian Weekly* noted in 2002 that "water is now known as 'blue gold' … and 'blue gold' is this century's most urgent environmental issue" (Vidal, 2002). Barlow & Clarke (2002) have outlined the risks associated with our rush for 'blue gold'. Land management determines both water quality and quantity. There is increasing urgency to manage our lands sustainably so that the 'gold mine' of our waters, both their quantity and quality, is protected and enhanced. It is imperative for our productive and ecological futures that we sustainably manage our lands to protect the natural capital of our ground and surface waters. We need to understand better how land-management practices control groundwater quantity and quality (Clothier, 1997). Here we focus on how environmental policy for nutrient management, in relation to nitrogen, across a diverse landscape can be developed to protect the quality of our receiving waters better through limiting leaching losses, without the need to be prescriptive about current or future land uses.

Current nitrogen (N) loadings in the Upper Manawatu River and Mangatainoka are more than twice (745,000 and 603,000 kg-N/year, respectively) the N limits (358,000 and 248,000 kg-N/year, respectively) set based on recommended standards for the notified standards in the One Plan. Horizons Regional Council have good data sets on the contribution of the major point source N loadings to the river. Remedial actions have been successful. In a recent study conducted by the SLURI team, the contributions of non-point source N loading from dairy and sheep and beef in the Upper Manawatu catchment were established. In that study the N loss <u>in the river</u> from the average dairy farm was found to amount to 15.4 kg/ha/year and for sheep and beef the N loss was 3.9 kg/ha/year (Clothier *et al*., 2007). Over 90% of the total N in the river is from these two non-point sources, with dairy contributing about half the N loading in the river, despite only representing 16% of the land use in the catchment.

The N loss <u>**from soil**</u> in the average dairy farm calculated using OVERSEER® in the Upper Manawatu catchment was found to be 31 kg-N/ha/year, and for the average sheep and beef farm, 7 kg-N/ha/year. By establishing an N transmission coefficient of 0.50 for both dairying and sheep and beef operations, a direct link could be made between land use and management decisions as they influence N losses and loadings in the river.

There are a number of approaches that could be used to achieve the water quality standard, including:

1. **Capping current production systems and nutrient (e.g. nitrogen) losses**. Then there would be a managing down regardless of N losses from individual farms, as is the case currently under consideration for the Taupo catchment.
2. **Place a limit on the losses of nutrient (e.g. nitrogen) from intensive land uses**. This approach would place restrictions of any further intensification and requires mitigation practices as an integral part of any ongoing land development.
3. **Calculate a nutrient (e.g. nitrogen) leaching loss limit for each hectare**. This could result in the use of OVERSEER® to achieve the water quality standards and apply them equally to each land owner. For the Upper Manawatu WMZ (Water Management Zone) this would be 6.5 kg-N/ha (Calculation = 341,000 kg-N/

year divided by 130,000 ha; transmission co-efficient = 0.50). At current loading, the average loss per ha is 15 kg-N/ha.

4. **Allocate a nutrient (e.g. nitrogen) loss limit** based on the biophysical potential of natural capital of the soils.

Allocating a nutrient loss limit based on the natural capital of the soil in the catchment offers an approach for developing policy that is linked directly to the underlying natural biophysical resources in the catchment. This is not too dissimilar to the concept of a water-use take limit. It is independent of current land use and places no restrictions on future land use change or options. It does provide all land users in the catchment with certainty by defining a nutrient loss limit, beyond which mitigation will have to be part of any further development.

The natural-capital based nitrogen-loss limit is defined as the amount of N lost by leaching from the soil growing a legume-based pasture fixing N biologically, which is under optimum management (e.g., optimum grazing practice, Olsen P in optimum range), before the introduction of additional production technologies (e.g., N fertilisers, effluent and manures, intensive cropping, drainage, irrigation). A legume-based pasture system is a self-regulating biological process with an upper limit on the amount of N that can be fixed and made available for plant growth, and receiving environments. Potential production therefore reflects the underlying biophysical capacity of the soil's natural capital value and the ecosystem services of the climate to allow production with resilience and durability.

To calculate the N-loss limit for a given landscape unit, the potential animal stocking rate that can be sustained by this legume-based pasture fixing N biological, under optimum management, before the introduction of additional technologies, is listed in the extended legend of the LUC worksheets "Attainable potential livestock carrying capacity". This can be transformed to pasture production and used in OVERSEER® to calculate N leaching loss under a pastoral use (Figure 2).

The approach of allocating a nutrient loss limit based on the ecosystem services of the climate and the natural capital of the soil in the catchment offers a basis for developing policy that is linked directly to the underlying natural biophysical resources in the catchment, irrespective of current land-use or future options.

We stress that this is independent of current land use and places no restrictions on future land use options. It provides all land users in the catchment with certainty, by defining a nutrient loss limit based on their suite of soils. The approach offers the opportunity for innovation and for engagement directly and in a very transparent way with land owners and the wider community in setting the targets.

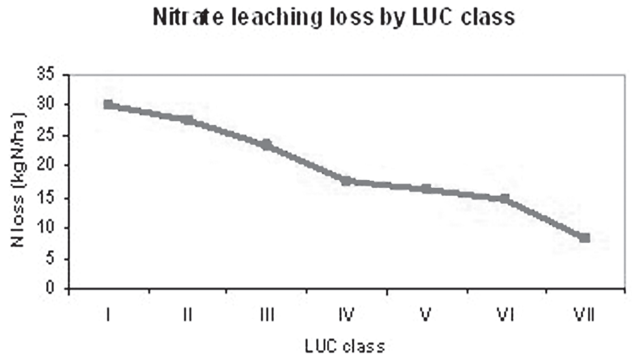

Figure 2. Average Nitrate leaching loss calculated using OVERSEER® (developed dairy operation, annual rainfall 1200 mm) associated with the potential livestock carrying capacity for each soil in Land-Use Capability (LUC) class I-VII listed in the extended legend of the LUC worksheets for the North Island.

Conclusion

We consider that a natural-capital based approach to land-use planning and managing nutrient is a new methodology that should be at the forefront of sustainable developments. We believe that the resilience of our future agricultural production systems will be measured by their sustainable exploitation of natural capital, whilst minimising external costs to the environment. This approach achieve wins both ways: productivity and protection.

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