BEFORE COMMISSIONERS APPOINTED BY THE WAIKATO REGIONAL COUNCIL

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of the First Schedule to the Act
AND	
IN THE MATTER	of Waikato Regional Plan Change 1- Waikato and Waipā River Catchments and Variation 1 to Plan Change 1
AND	
IN THE MATTER	of submissions under clause 6 First Schedule
BY	**BEEF + LAMB NEW ZEALAND LIMITED** **Submitter**

BRIEF OF EVIDENCE OF DR ALEC MACKAY
3 May 2019

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INTRODUCTION

1. My name is Alec Donald Mackay.

2. I hold a Doctor of Philosophy (PhD) degree in Soil Science from Massey University, Palmerston North, New Zealand. I also hold a Bachelor of Agricultural Science Honours Degree from Massey University.

3. I am currently a Principal Scientist in AgResearch based on the Grasslands Campus Palmerston North.

4. I have previously worked as a Post-Doctoral Scientist in the Agronomy Department of Purdue University, Indiana, US (1982-84); Research Scientist, DSIR Grasslands, Palmerston North (1985-90); Research Scientist/Officer-in-charge, DSIR Ballantrae Hill Country Research Station (1990-92); Research Scientist/Officer in Charge, AgResearch Ballantrae Hill Country Research Station (1992-95); and Research Scientist and Programme Leader, AgResearch Grasslands (1996-2007).

5. The current focus of my research is exploring the relationship between farm production and the environment, with a particular focus on the impacts of land use on those soil properties (e.g. physical integrity, organic matter content) and processes that regulate the soil's supporting, provisioning and regulating services. Developing methodology for quantifying and valuing the ecosystem services of pastoral agricultural systems and the use of a natural capital-ecosystem service approach to resource management are also current research programmes I am involved and lead. The inclusion of ecosystem services, as part of land evaluation processes, is another current project, as is the inclusion of indigenous biodiversity into farm planning and the development and testing of a new generation of farm systems modelling capability with the capacity to optimise the farm system within defined ecological boundaries. I have published over 120 refereed journal and 220 conference papers and have a long history of post-graduate student supervision.

6. I was a principal in the development of the SUBS (Soils Underpinning Business Success) education package, which was developed to assist

land managers gain a few simple, easily learned skills for describing and mapping their own soils. I have a long history of working in land evaluation and planning, being responsible for the development of the whole farm plan template for the Sustainable Land Use Initiative (SLUI) of Horizons Regional Council, the Land and Environment Plan (LEP) Tool Kit of Beef +Lamb New Zealand and am currently a member of the Red Meat Profit Partnership working group developing the Sustainable and Ethical NZ Farming Assurance Programme to underpin the Red Meat Story. I have been a member of the Horizons SLUI advisory and technical groups since 2005 and am currently a member of the Land Use Capability Classification System Governance Group that provides overall direction for the maintenance and future development of the Land Use Capability Classification System in New Zealand.

7. I was the principal investigator in the development of the Natural capital allocation approach and the use of Land Use Capability (LUC) as a proxy for natural capital. This approach enables allocation to be decoupled from current land uses and linked, instead, directly to the underlying natural biophysical resources in the catchment. I have provided expert evidence in several Court processes including those relating to Horizons Regional Council's One Plan (One Plan) and Hawke's Bay Regional Council's Plan Change 6 for the Tukituki River (PC6).

8. I have read and am familiar with the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014. I agree to comply with that Code. Other than where I state that I am relying on the advice of another person, this evidence is within my area of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

PURPOSE AND SCOPE OF EVIDENCE

9. My evidence explains the principles of natural capital allocation in the context of the natural capital allocation approach that forms the basis for the nitrogen (N) allocation approach Beef + Lamb New Zealand (B+LNZ) are proposing as part of their submission to the matters in the Waikato Regional Council's proposed Plan Change 1 and Variation 1 (PC1).

10. My evidence covers the following natural resources; approaches for setting N loss limits; methods of allocation, the B+LNZ approach, existing natural capital allocation approaches.

EXECUTIVE SUMMARY

11. My evidence explains the principles of natural capital allocation in the context of the natural capital allocation approach that forms the basis for the N allocation approach B+LNZ are proposing.

12. Approaches for setting N loss limits to tackle diffuse N pollution of surface and groundwater in regional plans falls into two distinct camps: those linked to land use (i.e. grandparenting); and those independent of current land uses and linked directly to the land resource (i.e. natural capital). The strengths and weaknesses of each approach is explored, as the former is the allocation approach used in in the Waikato Regional Council's proposed Plan Change 1 and Variation 1 (PC1).

13. Allocating a nutrient loss limit based on the natural capital (inherent capability) of the soil offers an approach for developing policy that is linked directly to the underlying land resources. It was first proposed in 2007. By linking N loss limits to each landscape unit, this recognises that soils differ in their productive capacity as well as the provision of other services such as nutrients filtering.

14. Direct methods for calculating a soil's natural capital are still in development, but the frameworks for classifying and measuring soil natural capital and ecosystem services, based on current understanding of soil forming processes, soil taxonomy and classification, soil processes, and the links between climate and land use are developing.

15. In the absence of a method for calculating a soil's natural capital, a proxy that serves as a useful alternative is the ability of the soil to sustain a legume-based pasture fixing N biologically under optimum management and before the introduction of additional technologies (e.g. N fertilisers, effluent and manures, intensive cropping and irrigation) under the pressure of the grazing animal. To date this approach has been used in the Horizons Regional Council One Plan and Hawkes Bay Regional Council Plan Change 6.

16. While PC1 stops any further decline, nowhere in PC1 is there any recognition of the differences in the underlying land resource or mechanism for exploring the sustainability of existing uses and practices. Putting aside the uncertainty that in 10 years further reductions will have to be found, regardless of the current N leaching loss of individual operations and the reduction they might make in the interim, there is no obvious next steps. This makes it very difficult to plan into the future

17. The B+LNZ proposed an approach that like PC1 recognises the need for improved water quality through the management of all four contaminants. For N it is advocating shifting over time from the allocation link to current use to the underlying land resource, using soils ability to sustain a legume-based pasture as a proxy for natural

18. The productive potential of a legume-based pasture makes sense as a threshold, below which development could continue, while operators with production systems beyond a legume-based system, would have to over time progressively bring their N leaching losses back (e.g. as proposed the top quartile of dairy operations would bring their losses back to in time).

19. The B+ LNZ natural capital approach

- Recognizes that land varies in natural capital, value, optionality, and productivity;
- Treats owners with the same land resources in the same manner;
- Places no restrictions on future land use options beyond limits on emissions
- Provides a policy framework for advancing sustainable management;
- Aligns with land values and with soil quality indicators for soil management; and
- Offers a road map or pathway beyond 10 years

EVIDENCE

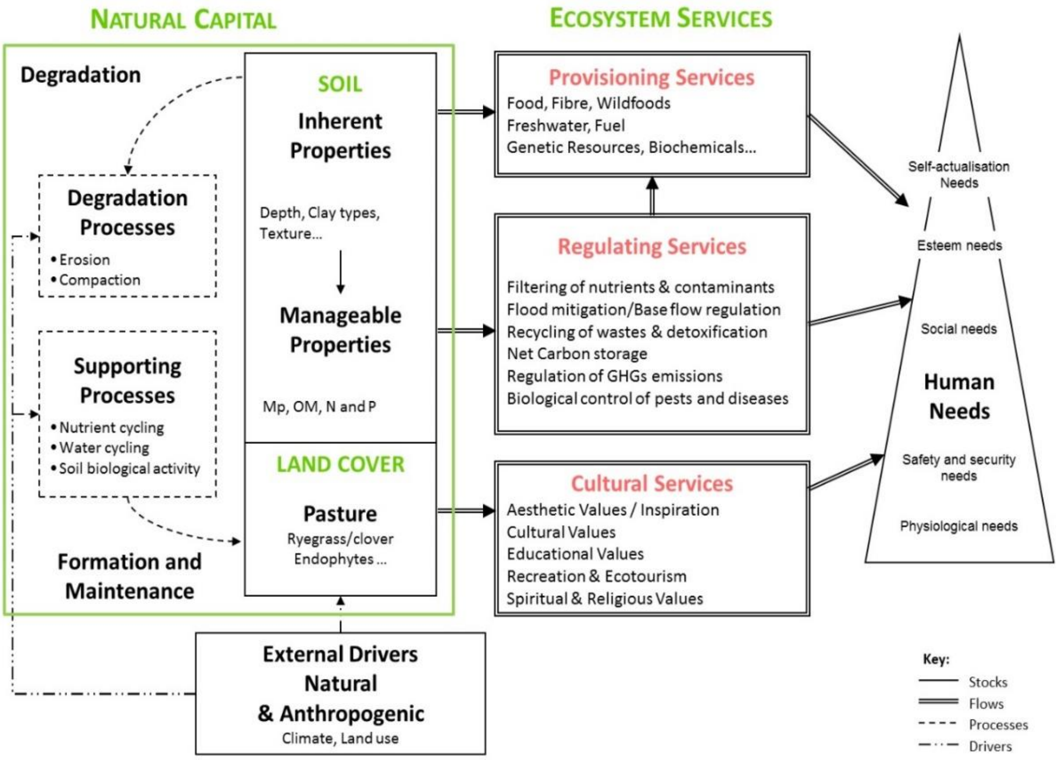
20. The following paragraphs set out my substantive evidence.

Land and Freshwater Natural Resources

21. Land and freshwater natural resources are the backbone of New Zealand's economy. In addition to the primary sector, these natural resources are also pivotal to tourism, recreation, power generation and our cultural identity. New Zealand is unique amongst developed countries with nearly three quarters of its export earnings generated from the primary industries of agriculture, horticulture, viticulture, forestry, fishing and mining, with a goal of reaching export receipts of over NZ$64 billion by 2025 (Ministry for Primary Industries, 2015). There is also growing recognition that in addition to food and fibre, our land and water resources provide a wider range of other benefits (services), including the supply of clean water, habitat, physical support, filtering, greenhouse gas regulation, vista, recreation, and social and cultural services. As the competition for these services from our finite land and water resources increases, a more integrated approach to policy development is required (Mackay et al., 2011).

22. A rapidly-emerging, multidisciplinary approach to assess the multi-functionality of natural resources is based on the concepts of natural capital and ecosystem services. Natural capital is defined as the "stocks of natural assets that yield a flow of ecosystem goods or services into the future" This definition and the connection between stocks and flows are illustrated in Figure 1 below. The notion of natural capital comes from trying to frame the contribution of natural resources alongside manufactured capital (factories, buildings, tools), human capital (labour, skills) and social capital (education, culture, knowledge) to the economy. Ecosystem services are defined as "the benefits people obtain from ecosystems". The 'ecosystems approach' has its origins in ecological economics, recognising that the economy is a subsystem of the ecological system, and that sustainable economic activity needs to be performed within the biophysical limits of the natural environment. Natural resources scarcity is nowadays the limiting factor to economic development.

Figure 1: Framework linking natural capital stocks under a land use to the provision of services (from Dominati et al., 2010, reproduced in Mackay et al., 2015)



23. Pastoral agriculture is the dominant land use on the approximately 11 million hectares in primary production in New Zealand. It is the predominant land use in 43% of streams and river catchments and 40% of lake catchments (Ministry for the Environment, 2007). The link between pastoral intensification and declining water quality is increasingly being acknowledged (Ministry for the Environment, 2013). The contaminants of greatest concern for diffuse pollution of New Zealand's freshwater in rivers, lakes, aquifers and wetlands are pathogens, sediments, and nutrients (PCE, 2015). These widespread diffuse pollutants are strongly linked to pastoral agriculture as the dominant land use and are mobilised by livestock through the concentration of nutrients in the process of grazing and return in dung and urine. Pathogens come from the diffuse entry of faecal coliform bacteria from farm animal excreta leaching into waterways, sediments from erosion of steep hill land and along water courses, and nutrients

(nitrogen (N) and phosphorus (P) in particular) from animal urine (N), fertilisers (N and P) and P associated with sediments.

24. Sediment and associated P losses are the major challenges from hill land environments used for sheep and beef farming. In lowland environments, nutrient enrichment (N and P) of water bodies continue to rise by diffuse pollution of surface and groundwater, particularly from dairy farming (PCE, 2015). The quality of freshwater draining from New Zealand's landscape into water bodies is the subject of increasing public concern and considerable scrutiny and debate, with planning processes underway throughout the country at present to address this issue. The decline in water quality has been rated the country's number one environmental problem in opinion surveys dating back to 2011 (Howard-Williams et al., 2011).

Limit Setting and Methods Allocation

25. Regional councils have taken a variety of approaches to address the issue of setting nutrient loss limits. Catchments in the Waikato (the Waikato and Waipa River Catchments), central North Island (Lake Taupo and Lake Rotorua), Manawatu-Wanganui (e.g. Mangatainoka, Upper Manawatu River), Hawkes Bay (e.g. Tukituki Catchment), Canterbury (e.g. Hurunui-Waiau Zone), Otago and Southland all have N-leaching loss limits set in notified or operative regional plans or plan changes. All these processes have been based on extensive scientific advice and modelling, in conjunction with broad community consultation. The limit setting process for N, P, sediment and pathogens will affect farming businesses through: a) constraints on the expansion of current production systems; b) cost of mitigation of current contaminant losses; and c) influences on the land use options into the future as part of any integrated catchment management approach.

26. The limit setting processes in place for tackling N diffuse pollution of surface and groundwater in regional plans falls into two distinct camps: those linked to land use (i.e. grandparenting, sector averaging, matrix of good management); and those independent of current land uses and linked directly to the land resource (i.e. natural capital). Both approaches are discussed in the following sections. The former approach is the

allocation approach in the PC 1, while a natural capital allocation proposed by B+L NZ advances the use of the latter.

Allocation to a land use

27. Grandparenting and sector averaging are examples of approaches that calculate the diffuse N leaching losses based on levels of emissions from current land use or the average of emissions from land use in previous years. As an interim measure this is a very effective action to immediately stop any further increase in N leaching and any further decline in water quality, assuming no lags. It enables existing land uses to continue with no upfront costs and, as far as practicable, the immediate viability of existing land uses would not be significantly compromised.

28. The major weaknesses of a grandparenting approach emerge when it forms the basis for permanent. While in the short-term it allows high N leaching activities to continue, it disadvantages operators actively conserving N and prevents landowners with the potential for growth to realise opportunities into the future. Further it offers no flexibility for low emitters. The lack of flexibility, the in ability to explore other land use options under a grandparenting approach, coupled with the limited ability to mitigate over time to a better match between the inherent capabilities of the underlying resource, all risks and undermining innovation, sustainable use and the future prosperity of communities.

Allocation directly to the land resource

29. Allocating a nutrient loss limit based on the natural capital of the soil (inherent capability) offers an approach for developing policy that is linked directly to the underlying land resources and was first proposed by Clothier et al., (2007). By linking N loss limits to each landscape unit the natural capital allocation approach recognises that soils differ in their productive capacity and in the provision of other services such as nutrients filtering. It also aligns with land values and with soil quality indicators for soil management. It is therefore independent of current land use and matches restrictions on future land use options to the productive and regulatory capabilities. It treats owners with the same land resources in the same manner and rewards good practice within

that land unit. Importantly, it does not place limits on inputs, but on the emissions. Finally, it avoids the difficulties associated with having to define and describe land uses and associated practices.

30. The natural capital approach also addresses one of the major criticisms of the current approach to land evaluation, that is, the lack of stakeholder participation in defining community expectations on land uses and practices, with respect to their impacts on other ecosystems' services and receiving environments (Dominati et al., 2016). Policy that sets limits on emissions to water that are linked directly to the underlying land resources addresses this gap. It provides a measure of the nutrient losses that would be permissible, before mitigation practices would have to become an integral part of ongoing farm development to prevent a deterioration in water quality.

31. The concept of adding ecological boundaries (e.g. threshold on N leaching losses to limit the impact on receiving environments), within which land use must operate, moves the analysis from managing land to managing a landscape connected to water. The ability to include ecological boundaries within which resources should be managed will be a feature and capability that analytical farm system frameworks will require into the future (Mackay et al., 2015)

32. The natural capital allocation approach proposed by B+L NZ recognises the differences between soils and allocates the N-limit based on the natural capital of the soil, with a higher allocation to the soils with greater natural capital stocks. This encourages more intensive activities on the more versatile and resilient landscapes. It also highlights the need for additional inputs on landscapes that have little natural capital. The more versatile soils offer more options and output for every kg N leached, and less pollution for every unit of production

33. Rather than an 'either/or' approach to an examination of the two allocation options, the options should in my opinion be viewed as parts of a continuum with grandparenting the first step to prevent further intensification and hold the line for higher emitting land uses, then a subsequent transition to allocation directly to the underlying land resource to create the environment for the most efficient use of all the finite resource in the catchment into the future. Flexibility should be

provided to low emitting land uses even in transition to avoid those with the smallest environmental footprint bearing the greatest economic costs including unviability

Other contaminants

34. The approach to date, and into the near future, with the other contaminants, losses of sediment, P and pathogens has and will continue largely around “good” or “best” management practices, through a tailored farm planning mechanism. B+LNZ LEP program as discussed by Mr Parkes, and tailored land use capability mapping as part of this approach as discussed by Mr Stokes, provides the most robust and effective way to ensure that land use and farming systems, are matched to the natural capital of the land and that environmental limitations are understood and actions are being implemented which avoid or remedy land management impacts.

35. As discussed in the evidence of Dr Dewes, Dr Chrystal, and Mr Parkes the primary pathway of losses from these contaminants to freshwater is via overland flow, or preferential pathways, and as such the identification and management of these pathways provides an effective approach for reducing losses to receiving environments. There is good evidence to show that “good” or “best” management practices can reduce the losses of these contaminants, though the calculation of farm scale losses of sediment, P and pathogens. New models such as LUCI and MitAGATOR as well as catchment-based models will assist in this space, and further research is being undertaken.

36. Further, in contrast to N management which is strongly correlated to increasing livestock numbers, reduction in the losses of sediment, P and pathogens to a degree can be progressed in some cases independently of the intensity of the land use activity, although there is a large interaction between stocking rate, LUC Class and rainfall which assists with providing an integrated and holistic approach to linking land use, and land management to freshwater outcomes.

Natural capital based approach

37. If all the land resources in the catchment were the same (i.e. they had the same natural capital and were providing the same ecosystem

services to the community), all landowners would receive the same N-limit allocation per hectare. This would be a very simple, effective and equitable approach for all landowners in the catchment. It would negate the need to develop policy for each land use and would address the major short comings of allocation to a land use. However, land is not all the same; it differs markedly in its natural capital and in the provision of services under a certain use.

38. Contrary to popular belief, the area of versatile and elite soils makes up less than 5% of New Zealand's soils, while more than 65% of the country's soils have at least one physical limitation to productivity under pastoral uses. Common features of many soils derived from alluvium, loess, volcanic materials, coastal sands or in eroding hill and steep lands are their young age, weakly developed soil structure, poor drainage, limited water-holding capacity and limited nutrient/pollutant absorption capacity.

39. Treating all the land the same would fail to recognise that some soils can produce more, and hence are of greater value to the economy, than other soils which are less productive and more fragile. For example, LUC class 2 and 3 are safe to crop, LUC class 4 land subject to some constraints, while LUC class 6 and 7 are not suitable for cropping. The outcome from treating all land the same makes no economic or environmental sense, when added to the fact it is also a finite natural resource, as are the services (benefits) they provide. The growing recognition of the finite nature of our land resources is reflected in the development of a National Policy Statement for Versatile Land and High Class Soils (NPS). Work on the NPS is being led by the Ministry for Primary Industries (MPI) and supported by the Ministry for the Environment (MfE).

40. The market recognises differences in the inherent natural capital of a soil, with land containing the more versatile and elite soils commanding higher prices (Loveridge 2012). Land values are a product of current economic conditions, product prices, the range of future options available, and the potential for future production gains, which are the sum of the soils' natural capital (e.g. texture, organic matter content, soil depth) and added capital (e.g. technologies that address N and P deficiencies, low pH and toxicities through to technologies such as

drainage, irrigation and flood control schemes to assist in water regulation). In addition to differences in productive capacity, soils vary in their ability to absorb and retain nutrients, pesticides and wastes. Soils form the critical link between the atmosphere, land use and water quality by regulating the time span between rain falling on the land and reaching streams, rivers and aquifers. Not only does the soil store and transmit enormous quantities of water, but through the soil biome and vegetation interaction it also acts as a renovator and sink for pollutants. High nutrient absorption capacity and pollutant assimilation are related to the Cation Exchange Capacity (CEC) and organic matter content of a soil (SOM), both of which increase the soil's capacity to absorb and assimilate chemical and organic inputs.

41. Direct methods for calculating a soil's natural capital are still in development, but a framework for classifying and measuring soil natural capital and ecosystem services, based on current understanding of soil forming processes, soil taxonomy and classification, soil processes, and the links between climate and land use are developing (Dominati et al., 2010). In the absence of a method for calculating a soil's natural capital, a proxy that serves as a useful alternate is the ability of the soil to sustain a legume-based pasture fixing N biologically under optimum management under the pressure of the grazing animal. This is also before the introduction of additional technologies (e.g. N fertilisers, effluent and manures, off-farm grazing, intensive cropping and irrigation)

42. A legume-based pasture is a self-regulating biological system with an upper limit on the amount of N that can be fixed biologically by the legume and retained, cycled, and made available for plant growth. The dry matter base of the legume pasture provides one indicator of the underlying productive capability of the soil, considering the influence of new plant germplasm and the use of N, P, sulphur and potassium fertilisers, lime inputs, trace elements and technologies, to control pests and weeds. It reflects the underlying capability of soil to retain (regulating service) and supply nutrients and water (provisioning service) and the capacity of the soil to provide an environment to sustain legume and grass growth under the pressure of grazing animals (provisioning service) are captured using LUC as a proxy.

43. In the extended legends of the Land Use Capability worksheets the livestock carrying capacity, based on sheep stock units record for three carrying capacities, Present Average, Top Farmer and Attainable Physical potential livestock carrying capacity" (Lynn et al., 2009). A value for each is included in the inventory for each LUC unit. These are essential estimates of the current and potential productive capacity of a legume-based pasture fixing N biologically under a "typical sheep and beef farming system" under optimum management that includes phosphorus and sulfur based fertiliser use, drainage and optimum grazing. These estimates were made in the 1970s and 1980's before significant amounts of N fertiliser were in use, or supplementary feeds or off farm grazing were part of farm system. All these technologies lift per hectare production beyond that of a legume-based pasture (Fig 1).

44. The first use of the attainable potential livestock carrying capacity in the extended legend LUC as a proxy for natural capital in the One Plan back in 2007 and was a new application of this information provided by the LUC survey. It reflects the evolving nature of sustainable land management, with the necessity to set limits on emissions from land to both air and water (in this case emissions to water, and specifically nitrate leaching losses, beyond the root zone). Limits on emissions resets the concept of productive potential, from one where there were no limits on emissions to receiving environments to one where the potential, in the absence of mitigation, are defined the amount the receiving environment can assimilate while continuing to provide the required services.

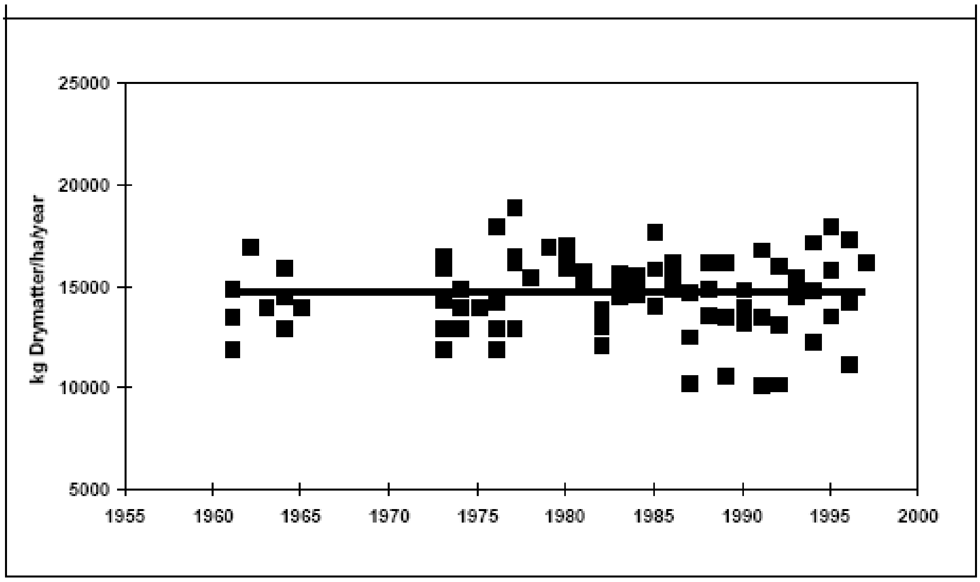
45. An attraction of using LUC and the extended legend is that it is well proven and long established, has national coverage, with the information in the inventory, including the extended legend, available throughout New Zealand.. The LUC Survey Handbook (LUC Handbook) ensure consistency in the identification, description and guiding the field mapping of LUC by practitioners. LUC is an empirical system entirely amenable to field checking, with some potential emerging digital technologies offering some future options for producing inventories at finer scales. Land Use Capability classification is increasingly used in land evaluation, farm planning, catchment, District, Regional and

National policy and planning (e.g. base map for the National Environmental Standard for Plantation Forestry).

Changes in the productive capacity of legume-based pastures

46. There is little evidence to show there has been significant increases in the level of pasture production from our legume-based pastures over the last 50 years. Hodgson (1989) found that ceiling pasture yields had not changed in 50 years. Hodgson’s data was updated by Deane (1999) from research stations in Taranaki and Waikato, and from top farms in the main North Island dairying areas as illustrated in Figure 26 below. Deane (1999) concluded that little had changed.

Figure 2 Annual pasture production on research stations and top farms since 1960 (Deane, 1999).



47. The conclusion reached by Hodgson (1989) and Deane (1999) is reinforced by a comprehensive evaluation of cultivars (Crush et al., 2006) on the merits of different age-classes of perennial ryegrass (bred in the 1980s vs 1998) and white clover (bred in the 1960s vs 1998) cultivars. The study found no differences in annual pasture dry matter yield between the different age classes of perennial ryegrass and white clover pastures. Yields averaged 17.2± 0.9 t DM/ha over years 2 through 4 of the trial. To compare values with Figure 2, subtract 1.0-1.5 t DM/ha to compensate for the yield increase attributable to the addition of up to 100 kg N/ha. The study concluded that annual pasture

production from well managed ryegrass-white clover pastures is very close to the practical limit achievable in the Waikato region, and is close to the theoretical Waikato Regional upper limit for ryegrass pastures calculated by Mitchell (1963). On that basis, the estimates of the potential productive capacity of a legume-based pasture, fixing N biologically under a "typical sheep and beef farming system", for each LUC unit in New Zealand listed under "attainable potential carrying capacity" in the extended legend of the LUC are still very relevant today. They are not dated, as suggested by some and, therefore, do provide an excellent proxy for the relative differences in the soil natural capital, before the introduction of other technologies and practices

Production beyond a legume-based pasture

48. Many pasture-based systems now routinely use inputs that enable production beyond that of a legume-based pasture as illustrated in Figure 3 which shows the change in milk production with the increase in inputs

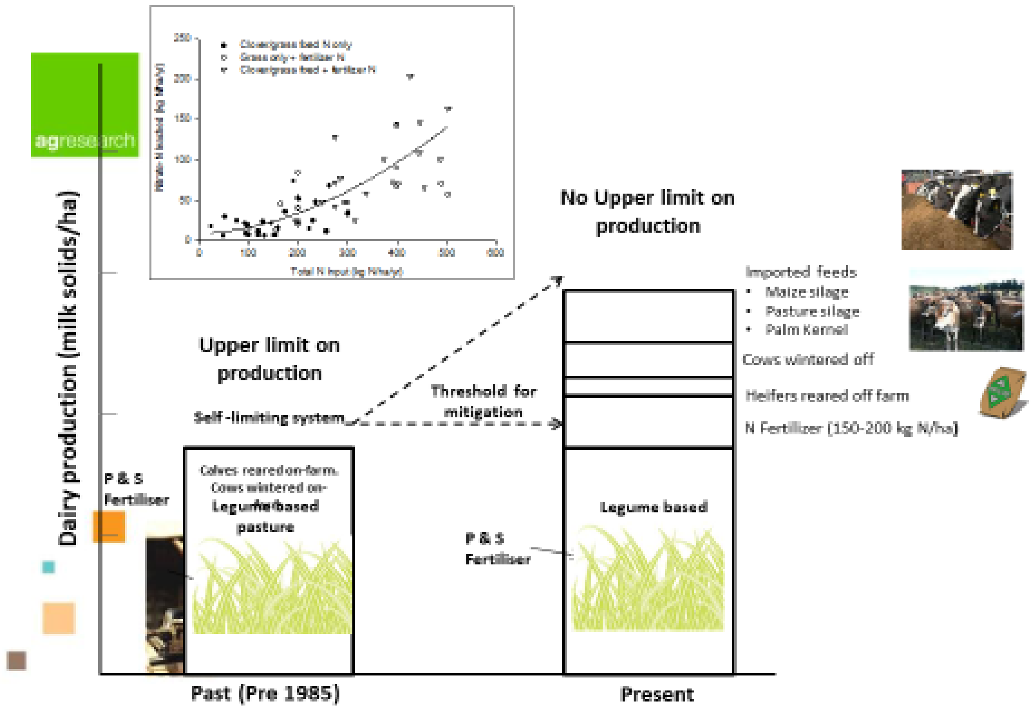


Figure 3. Changes in milk production with increasing use of inputs.

49. For example, in the dairy industry the increases in milk production since the 1990s have at least partly resulted from the increased use of N fertiliser, along with greater use of imported supplementary feeds, including maize silage and PKE, and grazing heifer replacements off-farm for 9 months and the milking cows off-farm for six weeks between seasons. All of these serve to increase the amount of N cycling on the milking platform and thus the potential for N leaching losses (Ledgard et al., 2009).

Waikato Regional Council's proposed Plan Change 1 and Variation 1

50. Plan change 1 and Variation 1 are intended to give effect to the Vision and Strategy for the Waikato River and to implement the NPS-FM to achieve the long-term water quality targets set out for the Waikato river. Plans

51. While sediment P and E coli are being managed under PC1 through tailored property environmental plan, when it comes to N leaching, all farms will be required to provide and then not exceed a modelled N leaching value, referred to as a nitrogen reference point (NRP), based on their 2014/15 or 2015/16 farming systems.

52. This will see sheep and beef farmers initially grand-parented to N leaching losses in the range of 14-21 kg N/ha (Jane Chrystal para.117), while dairy operations will be initially grand-parented to N leaching losses 2-3 times higher ranging from 45-55 kg N/ha and potentially up to 120kgN/ha for irrigated systems (Alison Dewes para. 129). Over the next 10 years operators in the upper quartile with respect to N leaching loss are required to come back to the 75% percentile of N leaching losses, while most other farmers will be expected to make some small reductions, regardless of the amounts of N leached. Apart from some special cases, land owner will not be able to increase N leaching losses from their farm over the next 10 years.

53. Nowhere in PC1 is there any recognition of the differences in the underlying land resource or mechanism for exploring the sustainability of existing uses and practices. Putting aside the uncertainty that in 10 years further reductions will have to be found, regardless of the current N leaching loss of individual operations and the reduction they might

make in the interim, there is no obvious next steps. This makes it very difficult to plan into the future.

B+ L NZ proposal

54. The B+LNZ proposed an approach that like PC1 recognises the need for improved water quality through the management of all four contaminants. For N it is advocating shifting over time from the allocation link to current use to the underlying land resource, using the soils ability to sustain a legume-based pasture as a proxy for natural

55. The productive potential of a legume-based pasture makes sense as a threshold, below which development could continue, while operators with production systems beyond a legume-based system (Figure 3), would have to over time progressively bring their N leaching losses back (e.g. as proposed the top quartile of dairy operations would bring their losses over time)

56. The B+ LNZ natural capital approach provides greater certainty into the future by providing a road map for land owners beyond 10 years.

57. The N risk score card (Marshall, 2019) could be used as the first step to help identify livestock operations operating beyond the legume pasture base. OVERSEER® could also be used to assist in this space to qualify reductions in emissions overtime. In the long-term the N allocation to land will be defined by the amount of N the river network can assimilate and still deliver on the required water quality outcomes.

58. The B+ LNZ natural capital approach

- Offers a road map or pathway beyond 10 years
- Recognizes that land varies in natural capital, value, optionality, and productivity;
- Places no restrictions on future land use options beyond limits on emissions
- Provides a policy framework for advancing sustainable management;

- Aligns with land values and with soil quality indicators for soil management; and
- Treats owners with the same land resources in the same manner;

Mechanism of allocation of diffuse N leaching losses proposed by B+L NZ

59. The B+L NZ proposal uses the data from the stock carrying capacities and fertiliser data for the Waikato Region in the paper by Jessen & Booth (1980). In absence of a direct measure of natural capital, the Top Farmer livestock carrying capacity for each LUC unit in the Waikato Region broken down into the four Freshwater management units are used as the proxy for natural capital.

60. These are listed in Table 1 and were compiled by taking the stocking rate for each individual LUC unit within each LUC Class, multiplying that number by the total area of each unit by the area in hectares and then summing to obtain for each LUC class a weighted average stocking units/ha for each LUC Class found in each of the four Fresh water management units.

61. The data in Table 1 is used in three ways. The weighted average stock units/ha provide an indication of the productive potential of a legume-based pasture on each of the LUC Classes within each of four Freshwater Management zones. Below that number there is opportunity to continue to develop while operations with productions systems beyond a legume-based system would have to over time progressively bring back either production or introduce mitigation to reduce N leaching losses (e.g. as proposed the top quartile of dairy operations would bring their losses back over time).

62. In the expert evidence of Alison Dewes she has independently developed from over 200 case files a profile for each FMU representative of the top farmers utilising low input and profitable farming systems. Which has been used to estimate the amount of N leaching that would be expected from each LUC class under these systems. Dr Dewes analysis supports the Top Farmer livestock carrying capacity for each LUC Class approach for each Fresh water management unit (Table 1), which can be used to derive an initial N allocation for each LUC Class

Freshwater management unit	Weighted average stock units/ha	Land Use Capability (LUC) Class							
		1	2	3	4	5	6	7	8
Upper Waikato	Top Farmers	27	23	16	16	14	12	8	0
	Average farmers	18	17	13	13	12	11	4	0
Waipa	Top Farmer	27	23	18	18	14	14	9	0
	Average Farmer	18	17	14	13	12	11	6	0
Middle Waikato	Top Farmer	27	22	17	17	14	14	9	0
	Average Farmer	18	16	14	12	12	11	6	0
Lower Waikato	Top Farmer	24	20	18	16	14	12	8	0
	Average Farmer	17	16	15	12	12	9	4	0

Table 1. The weighted average stock units/ha for each LUC Class in each of the three fresh water management units within the Waikato

63. In the expert evidence of Dr Tim Cox the Top Farmer livestock carrying capacity for each LUC Class for each Fresh water management unit (Table 1) is used in N allocation. Ultimately the amount of N the river network can cope with, will define the amount of N that is available for allocation across the landscape. An N allocation based on natural capital using LUC as a proxy, requires a working N Accounting budget for the catchment. The accounts must include the allocable N loading in the River and a link to the N leaching losses from the root zones through an attenuation factor and the areal extent of each of the LUC classes found in the catchment. In Dr Tim Cox evidence the ratio between LUC classes (relative productive capacity) was derived from the Top Farmer Livestock Carrying Capacity Column for each LUC unit listed in the Table 1. The catchment load is then proportionally allocated according to the area-weighted productive capacity of each LUC Class

64. Dr Jane Chrystal has modelled case study farms to determine the flexibility required for them to optimise their farming systems to the natural capital of the land, taking into account seasonal changes. In the expert evidence of Dr Jane Chrystal the Top Farmer livestock carrying capacity for each LUC Class for each Fresh water management unit (Table 1) provides a useful risk threshold which provides for land use flexibility, innovation and adaption while incentivising changes in farming systems where required which carry a higher risk to freshwater environments. In these circumstances increased mitigation can be adopted to internalise environmental externalities.

65. In the planning evidence of Corina Jordan the Top Farmer livestock carrying capacity for each LUC Class for each Fresh water management unit (Table 1) is used in as the basis for road map to show the migration from an allocation based on current farm N losses, through a transition to an allocation that reflects the natural capital stock that make up the farm. In the short term this will be guided by the amount of pasture produced or livestock that can be carried per hectare with a legume based pasture, an indication of what the N allocation associated with that level of production through to the use of the natural capital approach to allocate the sustainable N load in the river to the landscapes.

Existing Plans using the Natural Capital

One Plan

66. In the One Plan the "Attainable Potential Livestock Carrying Capacity" from the extended legend of the LUC worksheets for the Horizons Region were converted to pasture production and used in OVERSEER® (Version 5.2.6.0) to calculate N leaching loss under a pastoral use for each LUC class in the priority catchments. For soils on LUC class 1 and 2 land, the calculated N leaching loss limit was 30 and 27.4 kg N/ha, respectively; decreasing to 23.5, 17.5, 15 and 8 kg N/ha for soils on LUC class 3, 4, 6 and 7, respectively. As the limitations to use of the soil increase (i.e. class 1 to 7), the underlying capacity of soil to sustain a legume-based pasture system declines, as does the potential N loss by leaching, since carrying capacity also decreases. In the Upper Manawatu catchment, when these calculated N leaching loss limits for all LUC classes were scaled back to 75% of the calculated values, the

total N leaching losses from all LUC classes across the catchment were very close to the loading in the Upper Manawatu River. Scaling back the calculated values for all LUC classes ensured the relative differences between them was retained and, critically, the adjusted values became “independent” of the version of Overseer used. There is more detailed information available for the Upper Manawatu in Clothier et al., (2007), Mackay et al., (2008) and Mackay (2009).

Plan Change 6

67. The Tukituki LUC Natural Capital Leaching rates for Plan Change 6 (Table 5.9.1D) were calculated using the same methodology as the One Plan. The numbers in Table 5.9.1D were taken from Tukituki Choices (2012), a discussion document considering the choices and opportunities for land and water management in the Tukituki catchment. The discussion document included an indication of the scaling that would have been required with the numbers in Table 5.9.1D to align the leaching losses in the root zone with the N loading targeted in each of the five water management zones within the Tukituki catchment.

68. The discussion document also set out the key principles of N allocation using LUC as a proxy, including; land is a finite resource that should be used efficiently; and the same type of land should be treated the same across the zone, unless there is good reason for any differences. The use of good agricultural practices are assumed. Given these principles, it was proposed to allocate N across the five zones in the Tukituki catchment using the natural capital approach. This allows allocated leaching rates to vary spatially across the zones, with the variation linked to the underlying land but are not scaled to align with the targeted N loading in the Tukituki catchment. In arriving at the decision to include LUC Natural Capital Leaching rates in Plan Change 6, the Board of Inquiry made the following observations about LUC.

> [391] *There are distinct advantages in using the well-established LUC system. It takes into account the particular characteristics of the various land use classes in terms of contour, soil type, and other physical characteristics. It is relatively simple and easy to follow. It has an inherent logic because it is based on the actual natural capital of the soils which reflects the uses that are likely to be made of the land in the future.*

Differences and similarities in the allocation approach from previous plans

69. The potential attainable livestock numbers, in both the One Plan and Plan Change 6, were converted to pasture production for use in Overseer to calculate N leaching loss for each LUC class. The B+L NZ approach, unlike the One Plan and Plan change 6 avoids the added complexity created by the use of OVERSEER®, but retains the relative differences in the productive capacity. The B+LNZ proposal uses the Top Farmer livestock numbers directly to provide a ranking of the relative productive capacity of the natural capital of land in the catchment. The allowable N loading in the four water management units was allocated back based on the relative productive potential (See Dr Tim Cox Evidence). The Top Farmer carrying capacity was also used directly to obtain a measure of likely N leaching independent of the link to the N load in the river (See Alison Dewes evidence) and as the basis for road map to show the migration from an allocation based on current N losses, through a transition to an allocation that reflects the natural capital stock that make up the farm (See Corina Jordan evidence).

CONCLUSION

70. In my opinion for policy to be enduring, it needs to advance water quality outcomes using a mix of allocation approaches to ensure: a) there is no further decline in the state of the water body; b) current uses of the land in the catchment are recognised; c) a transition period if the water quality is beyond the required condition is included; d) the underlying characteristics and condition of the land in the catchment are recognised; and e) allocation is linked to the underlying resources to encourage the most efficient use of the natural capital stocks of the finite land resource in the catchment. The natural capital allocation approach proposed by B+L NZ address each of these requirements and is, in my opinion, a logical advancement of the current PC 1 developed for Waikato River.

Alec Donald Mackay

3rd May 2019

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