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PROTOTYPE TESTING OF LUCI SOFTWARE FOR DETERMINING ON FARM NUTRIENT LOSSES AND MITIGATION OPTIONS IN THE MANGATARERE CATCHMENT

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Introduction

Fresh water is one of New Zealand's most valuable natural resources and our ecology and economy is heavily dependent upon it. It is used to irrigate crops and pastures, produce hydro-electric energy and dispose of or dilute sewage and trade wastes (Ministry for the Environment, 2016). However, the intensification of agricultural land use is resulting in increased levels of diffuse pollutants such as sediment, nitrogen and phosphorus in New Zealand waterways, degrading the water quality (Duncan, 2017).

Recent and incoming regulation on water quality places farmers and other land managers under pressure to reduce nutrient losses to waterways while retaining profitability and production. The Land Utilisation and Capability Indicator (LUCI) can assist farmers and land managers explore solutions to degraded water quality. LUCI is a land management decision support framework that evaluates the effect of current and future management on a range of ecosystem services (Jackson et al., 2016). LUCI conveys this information through spatial maps and other outputs. A recent collaboration with Ravensdown has focused on enhancing LUCI's ability to predict water quality outcomes given a range of farm environments and management practices, and to quickly target where management interventions could improve water quality while minimising productivity loss (Jackson et al., 2016). The overall objective of this collaboration is to provide a decision support tool identifying opportunities for cost-effective nutrient mitigation on farms (Jackson et al., 2016).

The main aim of this project is to establish how credible and accurate predictive models such as the enhanced LUCI model are for a group of 6 farmers in the Mangatarere Catchment. We evaluate LUCI's ability to manage nutrient losses to waterways and explore a range of potential mitigation scenarios that could achieve environmental benefits such as improved on-farm nutrient management. This paper presents the ground truthed baseline maps of the 6 farms and showcases preliminary results examining potential on-farm mitigation scenarios and their predicted impacts. Any changing perspectives on potential mitigation measures and the usability and value of the LUCI model will also be commented on.

Method

This research used the LUCI framework to present a range of visually explicit maps to 6 farmers within the Mangatarere catchment, focusing on the benefits of potential low-cost mitigation measures. Figure 1 summarizes the methodology and changing focus of the consecutive farm visits to each farmer.

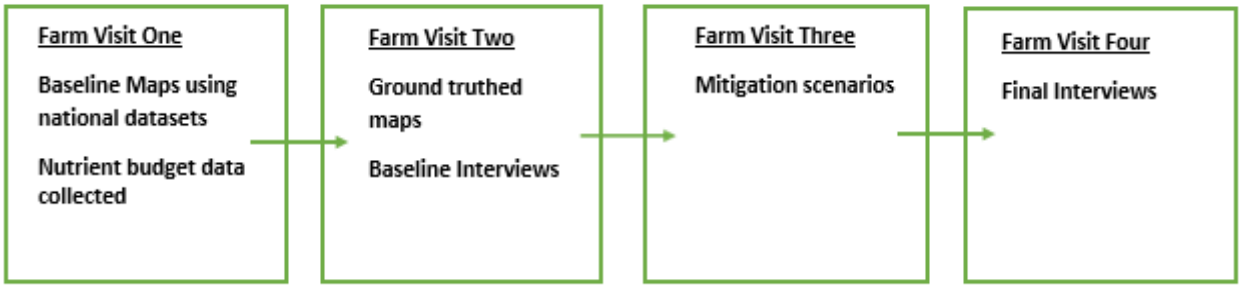


Figure 1: Illustration of the four farm visits and what occurred at each one

Farm Visit 1:

Baseline maps of each farmer's property were presented. These maps were generated using LUCI and regionally available national data sets of soils, stream network, rainfall, landcover and topography. The maps portrayed total nitrogen and total phosphorus loads and concentrations both in stream and on land. These maps were presented to check that they were an accurate farm representation by looking at the farm boundaries, productivity and waterways.

A Ravensdown environmental consultant accompanied the researcher during this visit to complete an Overseer nutrient budget. A nutrient budget accounts for all the nutrients coming onto the farm, calculates where all the nutrients are going and then completes a balance to determine if the inputs are equal to the outputs. It includes information about stock movement, effluent, fertiliser application etc. This step was important as the information gathered from the nutrient budget can be integrated into LUCI, making the tool more accurate and specific at the farm level.

Farm Visit 2:

An interview was undertaken at the beginning of this visit to provide a baseline to determine how, or if, participant perceptions of LUCI change throughout the project. This interview included a series of semi-structured, open ended questions about current farming practices and mitigations and knowledge and expectations of software modelling tools such as LUCI.

After the baseline interview the participants were presented with the same series of maps as the first visit but with the nutrient budget data included. The maps were explained in detail with an indication of where nutrient loads were accumulating and therefore locations where low-cost mitigation measures would be most beneficial. Once again during these visits the

accuracy of the boundaries and watersheds was checked in preparation for the computation of land use scenarios to present during the next visit.

Farm Visit 3:

A range of appropriate on-farm specific mitigation scenarios were presented to demonstrate the benefits and implications of such land use changes. The aim was to show the areas that provided opportunity for low cost mitigation measures that could be explored using LUCI's mitigation scenarios tools. Cost effective nutrient mitigation requires the correct identification and quantification of sources as well as recognition of critical source areas (areas that contribute the majority of water quality contaminants but account for a minority of the area at the field, farm or catchment scale) (McDowell et al., 2016). Therefore, the mitigation strategies used target either nutrient sources or hydrological pathways that carry nutrients to water bodies and included riparian planting, reduced and strategic fertiliser application and examples of reduced Olsen P levels.

As many of the farmers had already taken initiative and invested in mitigations, such as stream fencing and riparian planting, this visit was also used to show the farmer the benefit of any work already done to optimise land use and protect water quality.

Farm Visit 4:

In this visit, final interviews were carried out with the research participants to determine how they interpreted the information LUCI provided and if any perceptions about the LUCI model had changed from the first interview.

Preliminary Results

As this research project is still in progress, the following section covers preliminary results. At this stage, all four visits for the majority of the farmers have been carried out. Transcription of the interviews is currently being completed and analysis of these transcripts is in the early stages.

Addition of nutrient budget data

Numerous maps are generated by LUCI allowing for the exploration of total nitrogen and total phosphorus loads and concentrations both in stream and on land (Trodahl et al., 2016). The maps are coloured according to nutrient levels, high loads and concentrations are shown in red and low loads and concentrations are shown in green.

The contrast between the maps generated for nitrogen and phosphorus accumulated loads using national data sets and then with the addition of nutrient budget data is shown in figures 2a. and b. and 3a. and b. which show an organic dairy farm on a flat landscape. The addition of the farm specific nutrient budget data to the LUCI maps resulted in more spatially targeted nutrient accumulated loads than the national datasets used for the baseline maps. This in turn allows for more targeted, practical and effective mitigation measures to be explored.

Therefore, farm scale data is more informative for this project than national datasets and this example shows the danger of assuming national data at a farm scale.

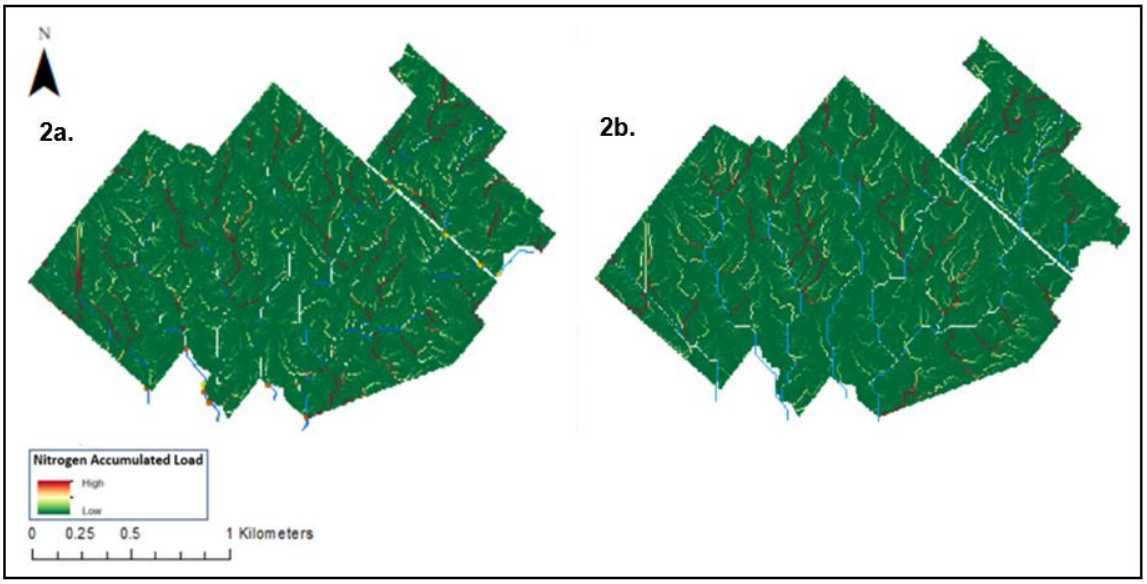


Figure 2: Nitrogen accumulated load maps (2a.), using national datasets (2b.), with nutrient budget data added

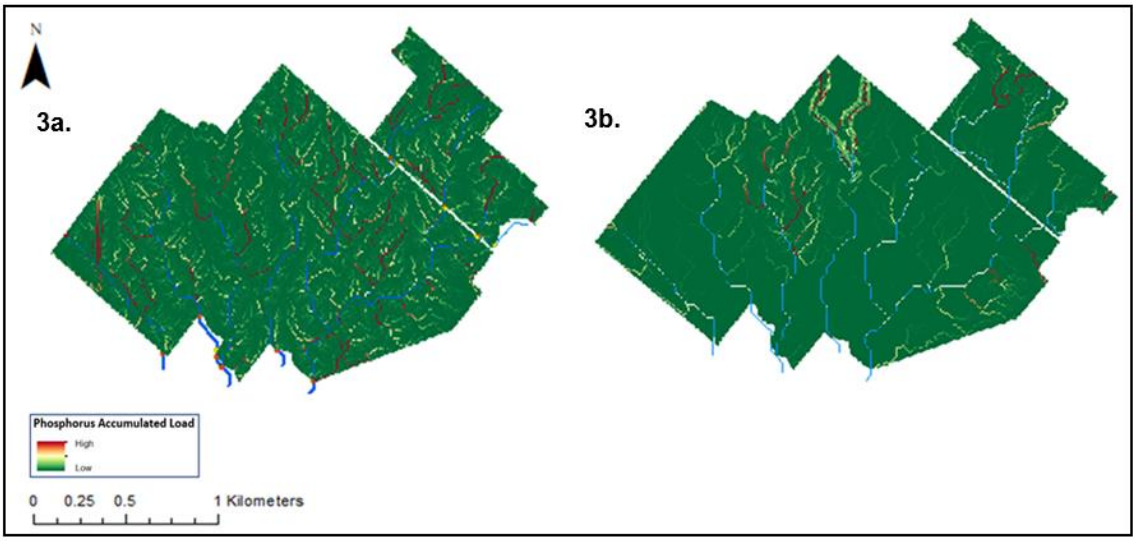


Figure 3: Phosphorus accumulated load maps (3a.), using national datasets (3b.), with nutrient budget data added

First Interview Results:

The interviews were carried out at the farmers home and were audio recorded to be transcribed and analysed at a later date. The questions in this interview covered any prior knowledge of OVERSEER and LUCI, any on farm issue areas and current mitigation measures in place, thoughts and opinions of current and impending water quality regulations and expectations of LUCI through this research process.

These interviews are in the process of being analysed but at this stage there are some preliminary results and conclusions that can be made.

- It was found that the knowledge and or use of OVERSEER was a lot lower than the lead researcher initially expected, with most farmers saying they never use it and have a limited understanding of the tool. This is potentially a region-specific outcome due to the nature of the implementation of the National Policy Statement for Freshwater (NPS-FM). Regional councils are required to implement the NPS-FM as promptly as is reasonable, and no later than 2030 (McDowell et al., 2017). Greater Wellington Regional Council's progressive implementation programme is to be completed by 2025 through Whaitua Committees which are advisory bodies established by the Regional Council (Greater Wellington Regional Council., 2017). This means that although consultation is well underway, no specific statutory regulations have been set for the region. A different result may have been found if this project was undertaken a region such as Canterbury where a nitrogen baseline is modelled using OVERSEER for resource consenting purposes (DairyNZ).
- In general, the farmers found the maps easy to understand and understood the colour scheme. There was an appreciation for the visual nature of the maps. The farmers generally had a good knowledge of their own farm systems, and reasonably easily related it to the information on LUCI outputs portrayed in map form.
- The farmers had high expectations from this project. In general, the farmer wanted to know if they were doing 'good or bad' in terms of on-farm nutrient management. It is not yet clear the extent to which this reflects a general and ongoing openness to new information and feedback, versus a lack of existing information available. It is likely that it reflects both as, a) the 6 farmers voluntarily came forward for the project making them early adopters and therefore open to new information by nature and b) recent and incoming regulation on freshwater is a very current and uncertain topic in New Zealand.

On a wider level, the interviews also found that there was a large interest in the use of deeper rooted plants for pasture as a mitigation strategy. This was a useful outcome for future development of the LUCI model as it hadn't initially been considered as a priority mitigation measure for the model to include. The interest however is logical for the Mangatarere catchment due to the susceptibility of the area to flood and drought. There is also an increased level of research in progress by organisations such as DairyNZ to determine the effectiveness of using deeper rooted plants such as plantain in pasture to reduce nitrogen leaching while maintaining or increasing milksolids production (DairyNZ).

The rural/urban divide and the need for better representation in the media as a rural sector was also a common theme. Many of the farmers believed that they were being portrayed as the villains and much of the hard work and progress that they have made was not being highlighted to the wider public.

Scenario Results:

When discussing potential mitigation scenario options with each farmer, it became clear that all of the participants had fenced and/or riparian planted the majority, if not all, of their waterways. In most cases this was as a result of implementing a Farm Environment Plan in conjunction with the Greater Wellington Regional Council. Farm Environment plans were introduced into the wider Wellington region in 2012/13, after a pilot programme in 2011/12 that focused on this (the Mangatarere) catchment. This pilot was commissioned on the basis of a water quality report on the catchment produced in 2010 (Greater Wellington District Council; Milne et al., 2010). The aim of the Farm Environment Plan is to identify options and encourage landowners to mitigate nutrient and sediment discharges from properties in accordance with an overall catchment plan (Greater Wellington District Council). Farm environment plans are 50% funded by general rates and 50% by user charges.

As a result of this finding it was decided that a beneficial use of the LUCI tool for the 6 farmers was to show the tangible benefits they were already incurring as a result of the existing riparian planting on their farm. Figure 4a-d. illustrates the removal of riparian planting for the phosphorus and nitrogen load for a sheep and beef farm.

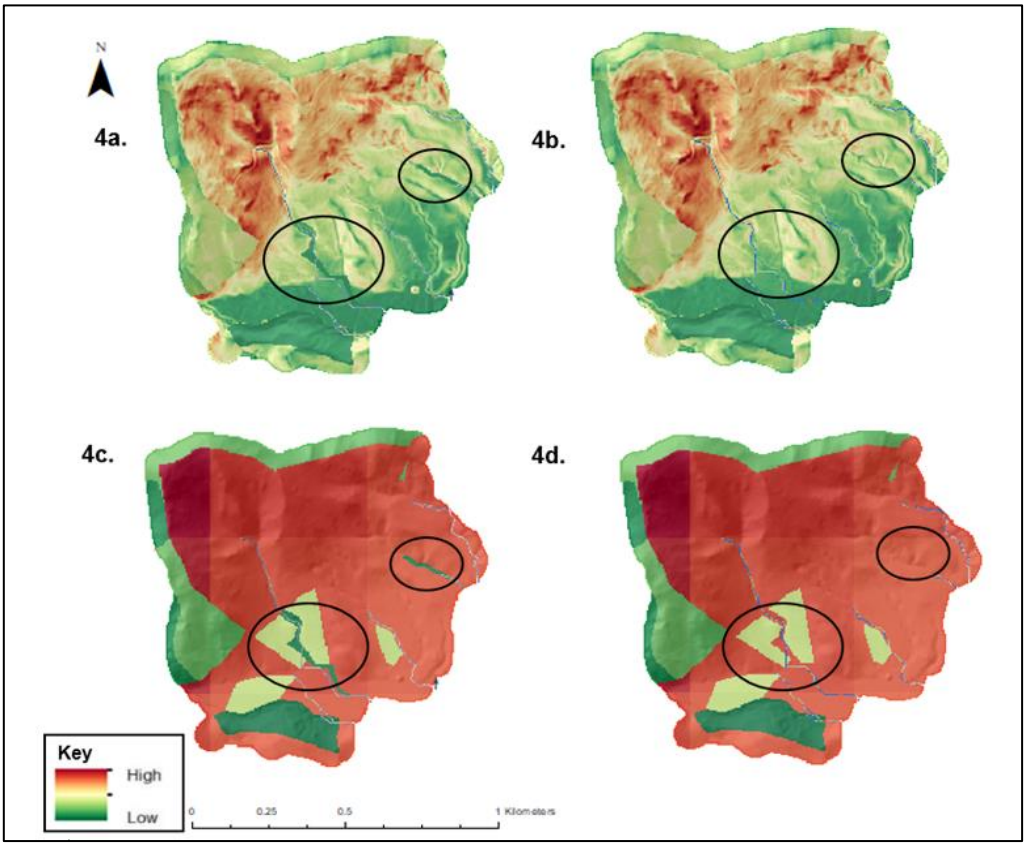
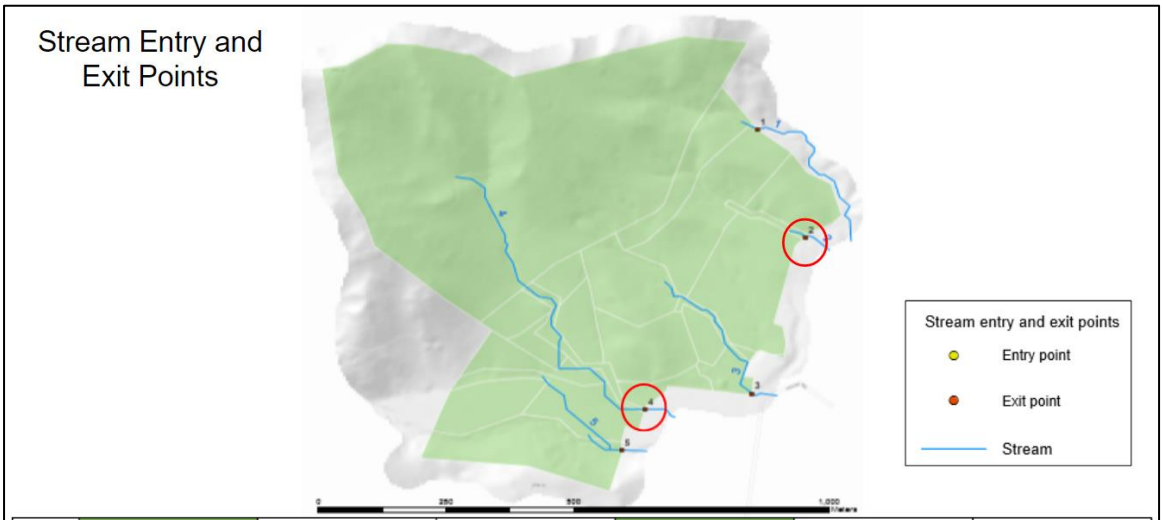


Figure 4: Phosphorus load with riparian planting (4a.), Phosphorus load without riparian planting (4b.), Nitrogen load with riparian planting (4c.) and nitrogen load without riparian planting (4d.). The black circles are highlighting the areas with and without riparian planting.

Figure 5 shows the nitrogen loads (kg/ha/yr) and concentrations (mg/l/yr) at the two stream exit points on the farm that the riparian planting related to. As can be seen in the table in figure 5 the loads and concentrations of nitrogen were lower when riparian planting was present by approximately 22%. This meant physical values could be attributed to the benefits of any riparian planting for each farmer. This was very beneficial as it showed the farmer that the work they had completed has made a tangible difference to the on-farm nutrient loads.



Point	N load (kg)	N load (kg)	Difference	N conc (mg/l)	N conc (mg/l)	Difference
2	30.54	39.32	22%	0.53	0.69	23%
4	110.26	141.54	22%	0.49	0.63	22%

Figure 5: Stream entry and exit points and the differences in nitrogen load and concentration with and without riparian planting

Conclusions and Future work

This project is still in the preliminary stages but so far there has been good farmer feedback and engagement. The next step is to complete transcription and analysis of the first and second interview. This process will give an in depth understanding of any changing perspectives on appropriate mitigation measures and land use as a result of access to the information produced by LUCI. Results from the final interviews (before analysis has been completed), showed very positive feedback from all farmers. All of the farmers knowledge of the LUCI model increased and they were able to see the value in the tool as they found the exercise to be informative for their farm. In most cases this seems to be as a result of the visual and spatial nature of the maps that LUCI provides. For the farmers who had Farm Environment Plans in place with the Regional Council LUCI gave an indicator that they were on the right track with their mitigation measures and that they were having a tangible impact. For some other farmers, it highlighted some nutrient hotspots that could be planted or fenced. From these interviews, it appeared as though these farmers plan on carrying out these

mitigations as a result of this project, this indicates that they found the information to be credible and accurate enough to take action.

Feedback for future improvements for the model included reducing the number of maps shown and/or condense the information to show only the most important information. This reasoned with the lead researchers own experience of the project as there were numerous maps to show for each farm visit, it was difficult to get the information across without making it seem confusing or complex. Results such as these will provide the important feedback required for model improvement that will make the model more credible and valuable for better uptake by farm and land managers in the future.

Acknowledgements

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