MITAGATOR™ - IN ACTION SOLUTIONS FOR MANAGING NITROGEN, PHOSPHORUS, SEDIMENT AND *E. COLI* LOSS

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Abstract

With ever increasing pressure to address farm nutrient losses to the environment while maintaining productivity and profitability, land owners require the appropriate decision support tools (DST) to support nutrient management decisions. With many regions throughout New Zealand either part way through or entering the process of nutrient limit setting, the need to be more efficient in the area of nutrient use and loss is becoming of increasing importance.

Through Ballance's Primary Growth Partnership programme (co-funded by MPI) a new decision support tool called MitAgator™ has been developed to help landowners make more informed decisions about where nutrient loss occurs and the most appropriate mitigation options.

MitAgator is a farm scale GIS-based DST that has been developed to identify and estimate nitrogen, phosphorus, sediment and *E. coli* loss spatially across a farm landscape. It draws on a wide base of New Zealand relevant science.

MitAgator™ requires base data, which includes the relevant farm's Overseer® file, geo-referenced farm map, soil, elevation data and aerial photo. Overseer® data is linked with spatial soil and elevation data allowing MitAgator™ to make more refined calculations of the relative risk of nutrient loss in a spatial context.

Loss areas are shown for each nutrient on risk maps which allows those areas of higher nutrient loss to be identified and targeted (as a starting point) with the most suitable and cost-effective mitigations.

Where a reduction in nutrient loss is required or targeted for a particular farm to achieve (e.g. 10% reduction in P), MitAgator™ will inform the user if the desired target is met, and if not, additional scenarios can be run, applying either further mitigations or mitigations to other areas of loss. If in the first instance mitigations are targeted to areas of higher loss, such an approach will be more cost-effective as opposed to applying mitigations across the entire property.

MitAgator™ will be of value to land owners who are looking at ways of reducing nutrient loss, particularly those who are in catchments that may have nutrient limits imposed or catchments where there are concerns around nutrient loss and associated water quality.

Whether in a catchment with restrictions, areas of nutrient concerns or looking at where nutrient losses can be managed more effectively, MitAgator™ allows the user to better understand spatial variability of nutrient loss providing the opportunity to be strategic in

mitigation placement. This provides the ability to plan and cost mitigation strategies, implementing them as finances and time frames allow.

Introduction

In 2011 Ballance entered to a Primary growth partnership (PGP) programme of research and development entitled 'Clearview'. This program is co-funded by Ministry of Primary Industries (MPI) and is largely targeted at increasing the efficiency of nitrogen (N) and phosphorus (P) use.

It is this funding that has allowed Ballance to develop a new decision support tool called MitAgator™ to assist landowners in making informed decisions about where nutrient loss occurs in a spatial context and the most appropriate mitigation options.

In developing MitAgator™ the PGP funding has allowed findings from a previous project funded by Ministry Business Innovation Employment (MBIE), called 'Clean Water, Productive Land' to be utilised. It was this research program that was responsible for developing the under pinning algorithms that drive the MitAgator™ program.

With ever increasing pressure to address on farm contaminant (e.g. N, P, sediment and the faecal indicator bacteria – *E. coli*) losses to the environment while maintaining productivity and profitability land owners require the appropriate decision support tools (DST) to support nutrient management decisions. With many regions throughout New Zealand either part way through or entering the process of nutrient limit setting, the need to be more efficient in the area of nutrient use is becoming of increasing importance.

Therefore it is important that any such tools are of value in assisting land owners in not only meeting future nutrient loss targets but allowing for improved efficiency in nutrient management.

With this in mind there is a need to continually improve the understanding of where nutrient loss occurs across the farm landscape. Critical source areas (CSAs) are areas that produce the majority of contaminant loss, but come from the minority of the paddock, farm or catchment's area (McDowell, 2014). Through the identification of CSAs nutrient loss can be more efficiently targeted by the strategic application of mitigations to areas where they are most required. This in turn allows a more flexible approach in the application of mitigations utilising an optimal mix of not only the most effective but also cost effective mitigation strategies to reach a target tailored to an individual's needs (McDowell et al., 2014).

MitAgator™ provides this ability through identifying losses on a spatial basis as opposed to an average weighted basis as is typically current practice, allowing for more strategic targeting of mitigations to be possible.

What is MitAgator™

MitAgator™ is a farm scale geographic information system (GIS) based DST that has been developed to identify and estimate nitrogen, phosphorus, sediment and *E. coli* loss spatially across a farm landscape.

MitAgator™ requires base data, which includes the relevant farm's Overseer® file, geo referenced farm map, digital soil and elevation maps and aerial map. Overseer® data is linked with spatial soil and elevation data allowing MitAgator™ to make more refined calculations of the relative risk of nutrient and sediment loss spatially across the farm landscape.

MitAgator™ has been built around the concept of CSAs. Rather than applying mitigations on a farm or block wide basis for little further gain but greater cost, there is now the opportunity to apply mitigations in a more strategic way applying them to where they are most required. Such an approach will also have the advantage of potentially utilising mitigations that may otherwise be cost prohibitive when applied farm or block wide. Utilising a more strategic approach may in fact widen the range of mitigation options that are available to the land owner.

Currently there are 24 mitigations that meet quality criteria to be included within MitAgator™. All mitigations are taken from published scientific papers (see McDowell et al., 2013 for a full list of farm-scale mitigations). Some mitigations are directly applicable to one farming type (such as deer farming), however the majority of mitigations are applicable to all pastoral farming types (Lucci and Smith, 2014).

How MitAgator™ works

MitAgator™ links input and output data from Overseer® with additional spatial data layers. Inputs into MitAgator™ from Overseer® provide farm management data (e.g. fertiliser inputs, soil tests, stock numbers) with spatial data sets providing physical data such as soil types. Required spatial data includes, geo-referenced farm map, soil map, digital elevation model (DEM) and aerial map, while not a compulsory an aerial photo is useful. In addition there is the ability to input additional data where the user has access to better quality information, for example in the situation where soil testing has been under taken on a finer spatial scale. This provides the user the ability to override block level fertility data (which maybe based only on only a small number of transects) with more accurate and an improved resolution of data.

Using the added spatial data sets this helps predict the likely flow paths of water movement through the soil and across the landscape with associated nutrients and sediment (Stafford and Peyroux, 2013).

The first step is putting together the required spatial layers into a map package. This task will be completed by a GIS specialist and not necessarily by the direct user of MitAgator™. The user is then required to import the map package and aerial photo into MitAgator™ along with the appropriate Overseer® file. The imported Overseer® file is then linked to the spatial farm map. Each Overseer® block is assigned to those paddocks that the particular block represents within the farm map linking the relevant Overseer® data (Figure 1).

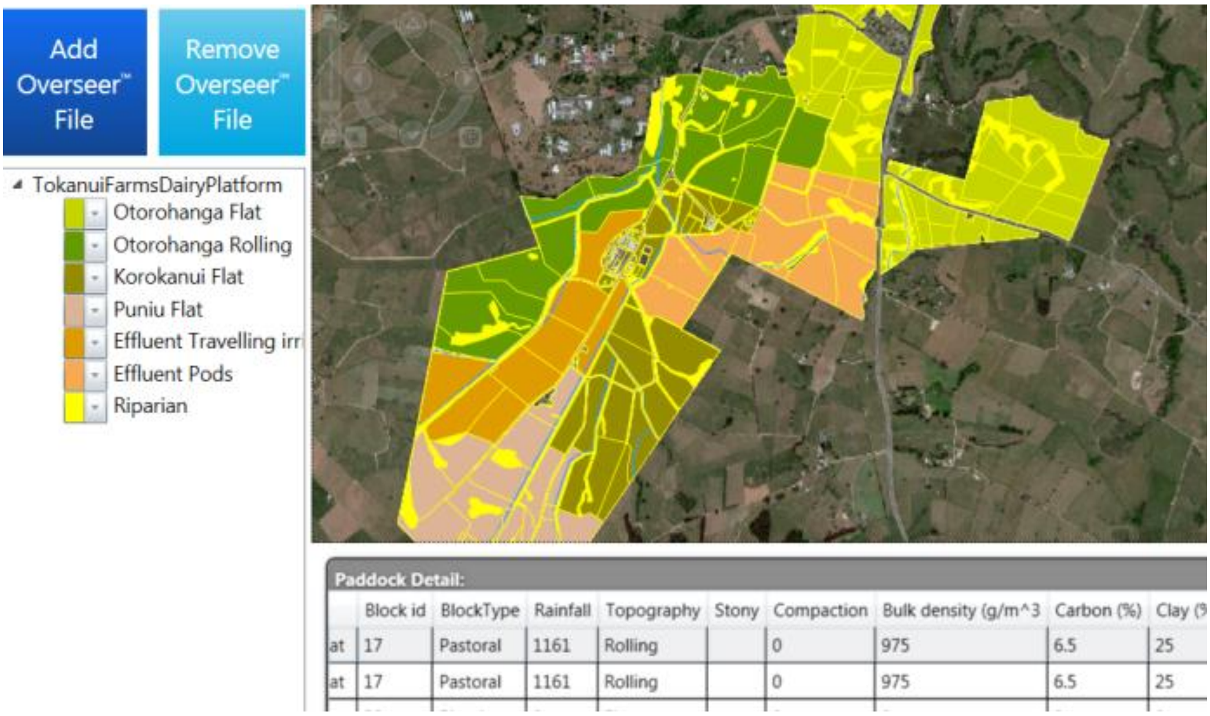


Figure 1. Overseer block allocation to MitAgator™ paddocks.

On completion of the farm setup the user then generates risk maps for each of the four contaminants: N, P, sediment and *E. coli*. Once generated, risk maps estimate losses for each contaminant highlighting CSAs. Losses are represented by five individual range categories which can be displayed using three data classification categories (quantile, equal interval, natural breaks), with the exception of *E. coli* which is based on three categories of risk low, medium and high. Greatest losses are represented in purple with lowest areas of loss in dark blue (Figure 2).

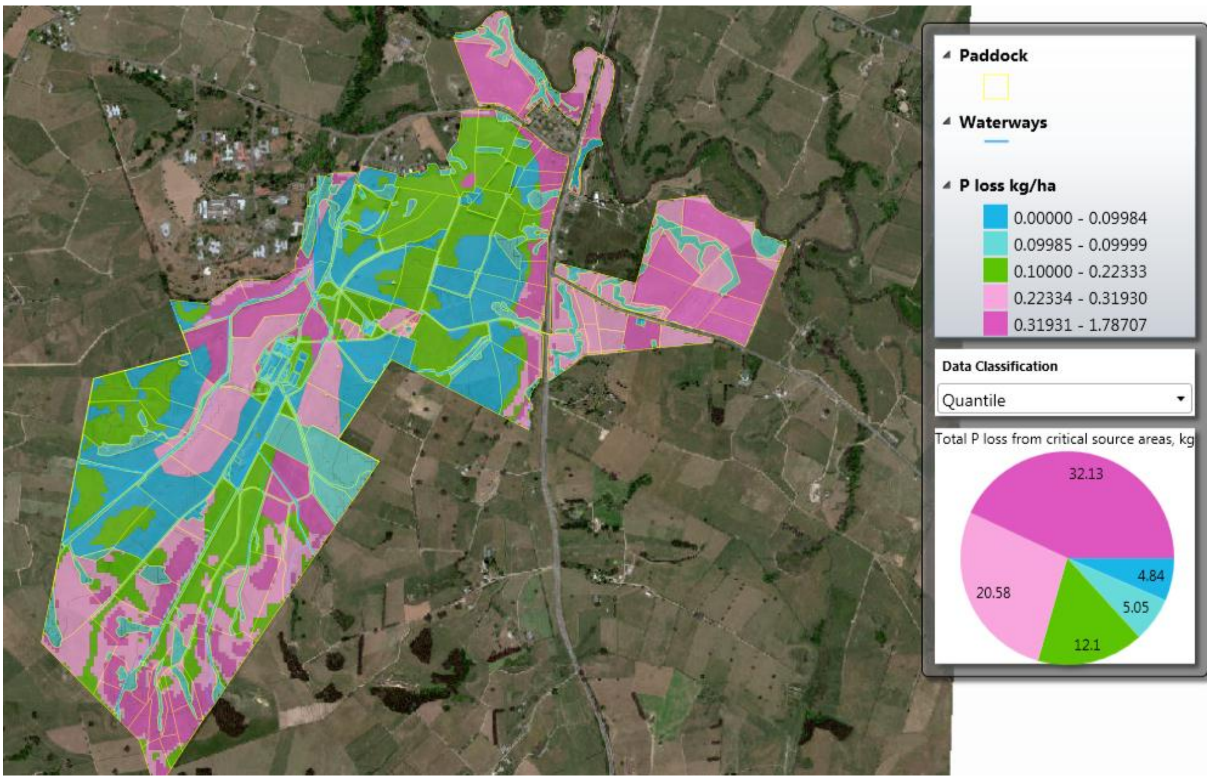


Figure 2. Risk map of estimated P loss

Risk maps provide valuable information to the user allowing those areas of higher nutrient or sediment loss to be identified and potentially targeted as a starting point for the application of the most effective and cost effective mitigation strategies.

Losses are estimated for sediment and *E. coli* using models developed by Dymond, 2010 based on the New Zealand universal soil loss equation, with *E. coli* loss using a risk based approach developed by Muirhead et al, 2011. The risk of *E. coli* loss is estimated for each individual block. Nitrogen is calculated based on Overseer® estimates (Wheeler et al, 2011) with totals from Overseer® equal to MitAgator™. The differentiation is that if the soils are different within a block, N loss is redistributed with greater losses on free draining soils and less on poorly drained soils, but totals remain the same. Phosphorus loss estimates are calculated in same way as in Overseer® (McDowell et al., 2005; 2008), but incorporating the added spatial data sets of slope and soils in order to provide an increased understanding of spatial P loss.

The resolution of output data from MitAgator™ will be a reflection of the resolution of input data (soil and elevation data). Currently, elevation data is available nationally at a 15-m resolution, but finer spatial data can be input (e.g. LIDAR). A 15-m digital elevation model may limit the quality of outputs in areas of flatter topography where subtle changes in topography can affect flow paths of water movement and associated nutrients which may not be as well defined with a coarser resolution of data. Soil data is available via the national soils data base but the scale of mapping will vary depending on the scale at which soils were surveyed. With the increasing availability of S-map soil data a better resolution of soil information will be available in many areas, although this data may still pose limitations of scale when used at the paddock scale.

The corroboration of MitAgator™ outputs, including a comparison against measured data and sensitivity to inputs, is discussed in a companion paper (McDowell et al., 2015).

Running mitigation scenarios

Once risk maps are generated running a series of mitigation scenarios is the final step. The user must first select which contaminant is to be targeted (e.g. P). There are four options in deciding how to target a particular contaminant, automated, target CSA, target paddock/block and manual selection. The user then identifies the how the reduction target will be achieved. This can be either targeted as a percentage reduction in loss (e.g. 10%) or within a budget that can be spent on a $/ha basis.

The first option is the selection of the automated function where-by MitAgator™ automatically applies the most effective and cost-effective mitigation or combination of mitigations to achieve the desired target.

The second option is the use of a targeted mitigation function allowing the user to select specific areas within a farm where mitigations are to be applied, but can be restricted to CSAs (Figure 2). If mitigations are targeted to areas of higher loss, such an approach will likely be more cost-effective as opposed to applying mitigation across the majority of a block or property. The third option allows mitigations to be specifically targeted to individual paddocks or Overseer® blocks.

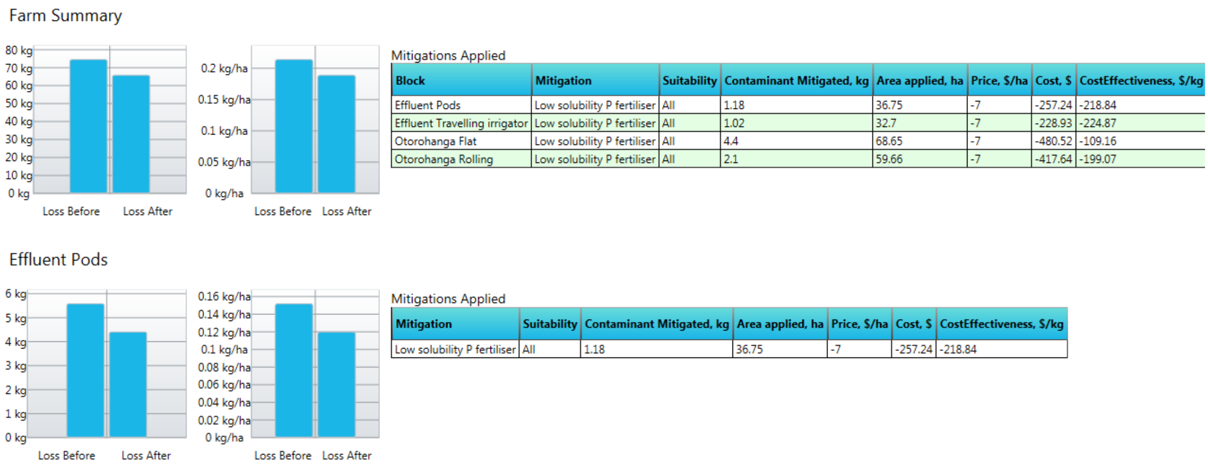
In using either the automated or targeted mitigation functions, the user has the ability to exclude individual mitigations that may not be suited to a particular property or exclude individual paddocks or other areas where mitigations are not desirable.

The fourth option is the manual function where by the user selects the mitigation or mitigations to be applied and the location of mitigations on farm. Within MitAgator™ several mitigations are restricted to this function, due to the knowledge required around the specific placement of mitigations such as wetlands and riparian fencing.

MitAgator™ will inform the user if the desired target is met, if not, additional scenarios can be run, applying either further mitigations or mitigations to other areas of loss. While mitigations are costed within MitAgator (Lucci and Smith, 2014), the user has the ability to input their own cost estimates for mitigations to reflect local costs and up-to date prices.

MitAgator™ result outputs

Once mitigation scenarios have been run the user can then view the results section to assess the effectiveness of individual scenarios and if targeted reductions have been met. Results are displayed in 'before' and 'after' graphs where the user can assess the effectiveness of a mitigation strategy. Data is presented at both the block and overall farm level in total kg's and kg/ha on an annual basis. In addition to nutrient and sediment loss reductions, information on the costings of mitigations is presented and cost-effectiveness of the applied mitigations are reported on $/kg of nutrient and sediment loss reduction (Figure 3).



Block	Mitigation	Suitability	Contaminant Mitigated, kg	Area applied, ha	Price, $/ha	Cost, $	CostEffectiveness, $/kg
Effluent Pods	Low solubility P fertiliser	All	1.18	36.75	-7	-257.24	-218.84
Effluent Travelling irrigator	Low solubility P fertiliser	All	1.02	32.7	-7	-228.93	-224.87
Otorohanga Flat	Low solubility P fertiliser	All	4.4	68.65	-7	-480.52	-109.16
Otorohanga Rolling	Low solubility P fertiliser	All	2.1	59.66	-7	-417.64	-199.07

Mitigation	Suitability	Contaminant Mitigated, kg	Area applied, ha	Price, $/ha	Cost, $	CostEffectiveness, $/kg
Low solubility P fertiliser	All	1.18	36.75	-7	-257.24	-218.84

Figure 3: MitAgator™ results summary

Conclusions

MitAgator™ provides an opportunity to better understand contaminant (N, P, sediment and *E. coli*) loss within a spatial context. It therefore facilitates an improved understanding of where the sources of loss are and mitigations that will be the most appropriate to offset losses and minimise associated impacts on water quality. By providing the opportunity to be strategic in mitigation placement, MitAgator™ can be used as part of farm plans allowing farmers to cost-effectively apply mitigations as finances and time frames allow.

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