CLEARVIEW (BALLANCE PGP)
– A FIRST LOOK AT NEW SOLUTIONS FOR IMPROVING NITROGEN AND PHOSPHORUS MANAGEMENT

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Abstract
Ballance recently embarked on a 7-year research program -entitled 'Clearview' -under the Primary Growth Partnership scheme that is jointly funded with the Ministry for Primary Industries. The Clearview programme of work is largely focussed around increasing nitrogen and phosphorus use efficiency and reducing losses. This presentation gives an overview of the high level objectives of this programme, and provides a first look at two product and/or service development initiatives that are nearing commercialisation.

The first of these, 'MitAgator' is a GIS-based water quality decision support tool that links with OVERSEER® to refine the latter models output. In doing this, MitAgator will provide greater insight into the spatial variability of nutrient (as well as sediment and microbial) loss within a farm landscape. This will allow users to identify critical source areas ('hot spots') for nitrogen, phosphorus, sediment and microbial loss within the farm landscape. Targeted application of mitigation and management strategies to these critical source areas will help to provide more cost-effective environmental management solutions for farmers.

Currently, there are few 'precision-ag.' tools available to pastoral farmers to assist them in targeting nitrogen fertiliser application within the farm landscape to maximise nitrogen response efficiency and return on their investment. Within the Clearview work programme we have described/quantified the relationship between soil nitrogen content and pasture responsiveness to nitrogen fertiliser application. We are currently developing a graphical user-interface that will allow farmers to evaluate and optimise fertiliser nitrogen application strategy specific to their property.

Introduction
Over the past decade there has been an on-going drive for increased agricultural productivity, however, over this same period, the required increase in productive output required to remain economically viable, has been increasingly tempered by a need to deliver this production with lower environmental footprint.

OVERSEER® is being used by the industry as a nutrient management decision support tool. Further to this, it is also being used by regulators as a means for estimating nutrient loss from farm properties, hence it is a key enabler that allows for development of output rather than input based regulation.

Nationally we are seeing rapid development of regulation on agriculturally-derived water quality contaminant losses, by local government bodies mandated (and under pressure) to uphold the Resource Management Act. Allocation of nutrient loss loads back to farming properties within a catchment context is beginning to develop, in-line with the recommendations of the Land and Water Forum (Land and Water Forum, 2012) - a collaborative, multi-stakeholder working group tasked with developing strategy to address freshwater management. Hence, further to the initial developments in nutrient sensitive catchments such as those surrounding Lake Taupo and the Rotorua lakes, we are starting to see more widespread regulatory development. Examples of this are ‘intensive farming’ operations captured within Horizons Regional Councils ‘One-Plan’, and various catchments throughout the Canterbury plains.

In this new era, where caps on nutrient loss are being imposed so as to prevent further degradation of surface water quality, production efficiency will begin to be assessed by new and additional performance metrics. New tools will be needed to assist farmer and consultants in their decision making processes, and new scientifically-robust ‘low footprint’ products will be needed to allow flexibility in system design to manage for high production and low environmental loss.

This paper provides an overview of two new nutrient management technologies being developed through ‘Clearview’; the Ballance Primary Growth Partnership (PGP) programme of work.

An overview of ‘Clearview’

In October 2011 Ballance was awarded government funding towards a selected portfolio of work. Over seven years, the $19.5m dollar 50:50 co-investment between Ministry of Primary Industries and Ballance Agri-Nutrients that is named Clearview, is focussed on fast-tracking development and bringing to market new technologies that will benefit ‘New Zealand Inc.’.

The Clearview programme is centred on delivering on three core themes:

1) Increase fertiliser nitrogen (N) use efficiency and decrease N-losses from the farm system
2) Increase fertiliser phosphorus (P) use efficiency and decrease P-losses from the farm system
3) Develop new low-footprint, scientifically robust biological solutions to control insect pests (biopesticides) and improve nutrient cycling (biofertilisers)

Of note is that the Clearview programme is additional to Ballance’s existing R & D budget, hence it is not subsidising existing R & D, but allowing for a wider research program that also includes some high-risk / high reward projects that might otherwise not have made it past the internal Ballance ‘gating’ process.

Importantly, it is also worth noting that with the government investment into Clearview, a clause in the PGP contract stipulates that beyond a defined limited period of commercial exclusivity, all technologies must be made available to add value to all New Zealand farmers, not just those that are clients of Ballance.

MitAgator

As already mentioned, OVERSEER® is widely being used by regulators to provide an estimate of the nutrient loss footprint from farming properties. OVERSEER® is a long-term annual average, whole farm nutrient management tool (Wheeler, 2011); underpinning it is a long-term annual average hydrological balance that determines drainage and hence nutrient leaching and runoff risk, which is then overlaid with farm-specific physical and ‘steady-state’ farm management attributes.

OVERSEER® operates at a block level – blocks are set up within the property, usually according to variations in soil type or management history. OVERSEER® is capable of generating nutrient balances and nutrient loss estimates at both the block and property level. Regulators are primarily concerned with the N & P loss footprint at the property level; whereas traditionally, for the farmer and the fertiliser representative, the units of interest are generally the blocks within the property.

With the development towards nutrient loss 'capping' it would seem logical a property owner would want to interrogate specifically where within the property the nutrient loss was occurring from and how to manage this, in as much detail as possible - going beyond the current limitations of OVERSEER®.

This is where the concept of 'critical source area' modelling developed. From a landowners perspective, if an '80:20' or similar rule applies (i.e. whereby 80% of the nutrient loss occurs from 20% of the land area) then it would be far more cost effective to target mitigations / management strategies to the hot-spots that really needed targeting, rather than apply them generically and blindly across the majority of the landscape, for little further gain but far greater cost. This is the concept that has led to the development of the decision support tool 'MitAgator' – a spatial critical source area model for predicting N, P, sediment and bacteria loss and management within agricultural land.

How MitAgator works

MitAgator is a GIS-based decision support system. Simplifying it down, it takes the input and output data from a given OVERSEER® file, and links this with other spatial data layers, including a geo-referenced farm map, a soil map and a digital elevation model (DEM). Using the added spatial data sets, a hydrological flow model is produced that describes risk of water movement through the soil (driving leaching) and across the landscape (driving runoff).

When a geo-referenced farm map is imported, MitAgator automatically links this with the corresponding soil map and DEM datasets. Currently, a limitation to the accuracy of MitAgator is the resolution of the underlying DEM and the soil map. At present, a national DEM is available at 15 m resolution, which is unlikely to be satisfactory to describe the typically subtle topographic variations that drive hydrological flow paths in many dairy farms. Higher resolution DEMs are available, but come at additional cost – these could be anywhere from a few hundred dollars to a couple of thousand dollars, depending on how the DEM was produced and the efficiency of doing so (G. Peyroux, personal communication, March, 2013). Similarly, detailed farm scale soil map information is somewhat limited. The S-map database being developed by Landcare Research will assist with this, although due to underlying scale limitations and lack of on-farm verification, there is still likely to be reliability issues in this database, especially when applied at paddock or sub paddock scale. Paddock scale soil maps being produced for a nutrient management project in the Mangatainoka catchment typically cost around $1000-1500 for a typical dairy farm of 100-150 ha (P. Taylor, personal communication, March, 2013). This process involves a combination of on-farm assessment coupled with GIS landscape analysis.

The underpinning algorithms that form the 'engine' powering MitAgator have been developed through the Clean Water, Productive Land programme, a $3.3m/year multi-Crown Research Institute Ministry of Business, Innovation and Employment (MBIE) project. Within Clearview, Ballance has been able to achieve the role of commercialisation partner for the

MBIE project, taking the resultant spatial / temporal nutrient loss algorithms, linking them together, and then wrapped a new Graphical User Interface (GUI) around them, customising the look and feel of the resultant decision support tool.

Risk maps

Risk maps (Figure 1) are produced for N, P, sediment and bacteria loss, by linking together the spatial hydrological model with the nutrient, sediment and bacteria loss algorithms described above. Importantly, the hydrological model describes connectivity of the contaminant 'source' with a receiving surface water body. If there is loss of nutrient from an area within the property, but there is no connectivity to a surface waterway, then this is simply a transfer of fertility, and therefore it is not a 'source' area.

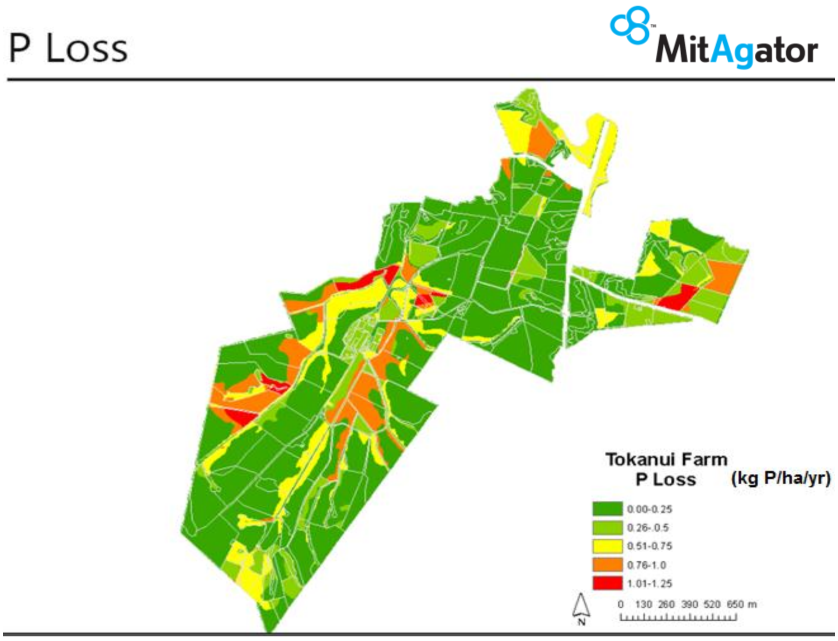

Figure 1. Risk map for P loss and sediment loss generated by MitAgator for AgResearch Tokanui. This map was produced using a 2 m resolution DEM and a soil map data developed at a scale of 1:5000 (G. Peyroux, personal communication, February, 2013).

Resolution of output generated by MitAgator is limited by the resolution of the input data. For example, if only three soil testing transects are used across the property, then this will limit the resolution of the effect of Olsen-P on risk of P loss. Importing an OVERSEER® file that only has soil fertility data described for (e.g.) three blocks will still give useful information by linking this with hydrological connectivity information. However, to improve risk-resolution it is possible to override the OVERSEER® block-level soil fertility data with that at a paddock level - made more feasible since farmers are beginning to adopt 'all paddock testing' for fertiliser strategy optimisation and economic reasons.

Currently, the prototype version of MitAgator is spatial only and hence it is operated at a strategic level. Once the temporal aspect is built in, the model will allow for real-time management tactics to be developed – for example assessment of soil moisture and forecast rainfall with farm management practices including timing of stock grazing to sensitive parts of the property, or effluent application management.

Being able to identify where and when nutrient, sediment or bacteria losses are occurring from the farming landscape with use of MitAgator is important, however, we recognise there is a shortage of options available to farmers to manage / mitigate these losses. Development of new solutions to build a broader 'mitigation toolbox' is a fundamental component of our Clearview programme of work. Once developed, these mitigation solutions can then be built into scenario analysis tools such as OVERSEER® and MitAgator.

Mitigation modelling

Once the base risk maps are generated, it is possible then to evaluate the effect of various mitigation and management strategies overlaid on top. First, the user selects the output that they want to target (N, P, sediment or bacteria, or a combination of these). The user then has several choices, they can choose either to:

1) Automate the mitigation selection

   This prioritises and optimises on a single solution or combination of solutions, applied to the areas where they have most impact, based on:
   a. Cost-effectiveness – useful, for example, when restricted to a certain budget
   b. Effectiveness – identify and prioritise the most effective solutions and target these for maximum effect

   Depending on which automation option is selected, the operator then uses a sliding scale to indicate what their target is from the status quo. For example, it may be to achieve a reduction to specified level of nutrient loss, a percentage reduction in nutrient loss, or reduce nutrient loss by as much as possible based on a specified cap on spend.

2) Target areas and mitigations based on a manual selection process

   This allows the user to select the areas that they wish to target. This can be done by selecting individual paddocks or sub-paddock management zones (critical source areas) identified in the risk maps. Alternatively, it could be that the user chooses all critical source areas that are indicated to be of similar loss-intensity (colour coded on the risk map). This is done by selecting the critical source area by colour within a pie chart that indicates contribution to the total farm loss. The user can view and select mitigation options filtered by cost and effectiveness.

   This is exemplified in Figure 2, where all areas of the farm that were originally shaded orange in Figure 1 have been selected, by clicking on this zone in the pie chart. As the pie chart indicates, despite these areas only accounting for a relatively small area of the farm, the contribution to the farms total P loss is disproportionately high.

3) Target mitigations using editable features

   This option allows users to select a specific mitigation option and physically draw it on the farm map. For example, an area that could be fenced off and retired to a wetland, or a section of stream that is to be fenced.

Once the mitigation assessments that are of interest have been run, the user can then view 'before' and 'after' graphs indicating the impact on N, P, sediment and bacteria loss reduction, for both the area(s) targeted as well as the overall effect at property level.

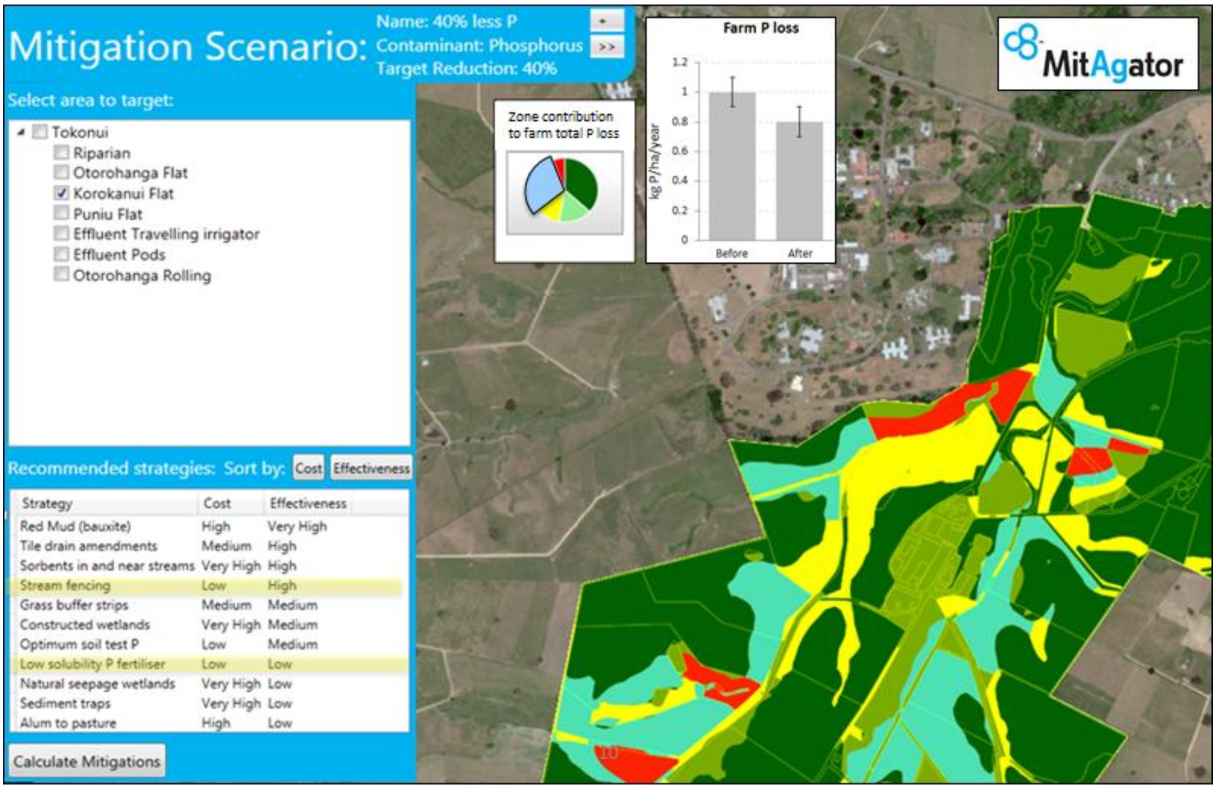

Figure 2. Manual selection of target areas and mitigation options to apply to these areas, within a prototype version of MitAgator.

Decision support system for fertiliser N responsiveness in pasture systems

Nitrogen fertiliser sales increased dramatically during the 1990s to the early-2000's, although since then its use appears to have stabilised (Fertiliser Association of New Zealand, 2011). The majority of the growth in sales to the pastoral sector over this period was due to increased use on dairy farms. The use of N-fertiliser in hill-country sheep and beef properties has not increased to such an extent, largely because the economic return on N is typically much lower due to the lower per-hectare operational margin in these farm classes.

Observationally, we know that pasture N responses vary greatly across the landscape. However, as Shepherd (2009) indicated, there are currently no objective decision support tools available to farmers and/or advisors to assist them in making more robust and informed fertiliser-N application plans, in recognition of this variability. By identifying and understanding this variability in N response, there is great opportunity to improve N-fertiliser response efficiency (pasture dry matter grown per kilogram of N applied) giving the following benefits to farmers:

- Greater return on N-fertiliser investment. This may assist with driving adoption of N-fertiliser in the hill-country sheep and beef sector, lifting productivity and profitability.
- Increased milk production while maintaining the same amount of fertiliser-N input, thereby increasing profitability while also assisting delivery on the Dairy industry target of a 4% per year increase in production.
- Maintain the same milk production using lower rates of N fertiliser. With tightening environmental regulation surrounding nitrate leaching, the immediate priority for some farms may not be to increase production, but rather to reduce N leaching to remain viable. Reducing system N-inputs while maintaining milk production will

improve N conversion efficiency and reduce nitrate leaching as estimated by OVERSEER®.

Through AgResearch, Ballance has been researching spatial and temporal variability in soil N and pastoral N response, using this data to develop a decision support tool designed to improve and guide fertiliser N management.

Relationship between soil N and pasture N response

Initial assessment of data from a 'national series' of fertiliser-N response trials, and subsequent trial work at AgResearch Tokanui to further test the hypothesis, revealed that there was a strong relationship between soil 'total-N', base pasture growth rate and pasture response to N-fertiliser. Conceptually, this relationship is described in Figure 3; against soil total-N are lines indicating base pasture yield and also potential pasture yield, with the difference being the magnitude of the potential pasture N-fertiliser response.

Figure 3 indicates that as soil total-N increases, so too does base pasture yield. Largely, this is a consequence of N-mineralisation rates increasing with more organic-N in the soil; hence there is more soil mineral-N made available to stimulate plant growth. Furthermore, as soil organic-N increases, this beneficially impacts on other soil factors that will influence yield (soil water holding capacity, microbial activity, structural properties, aeration etc.). This second factor also explains why there is a gradual increase in potential pasture yield as soil total-N increases.

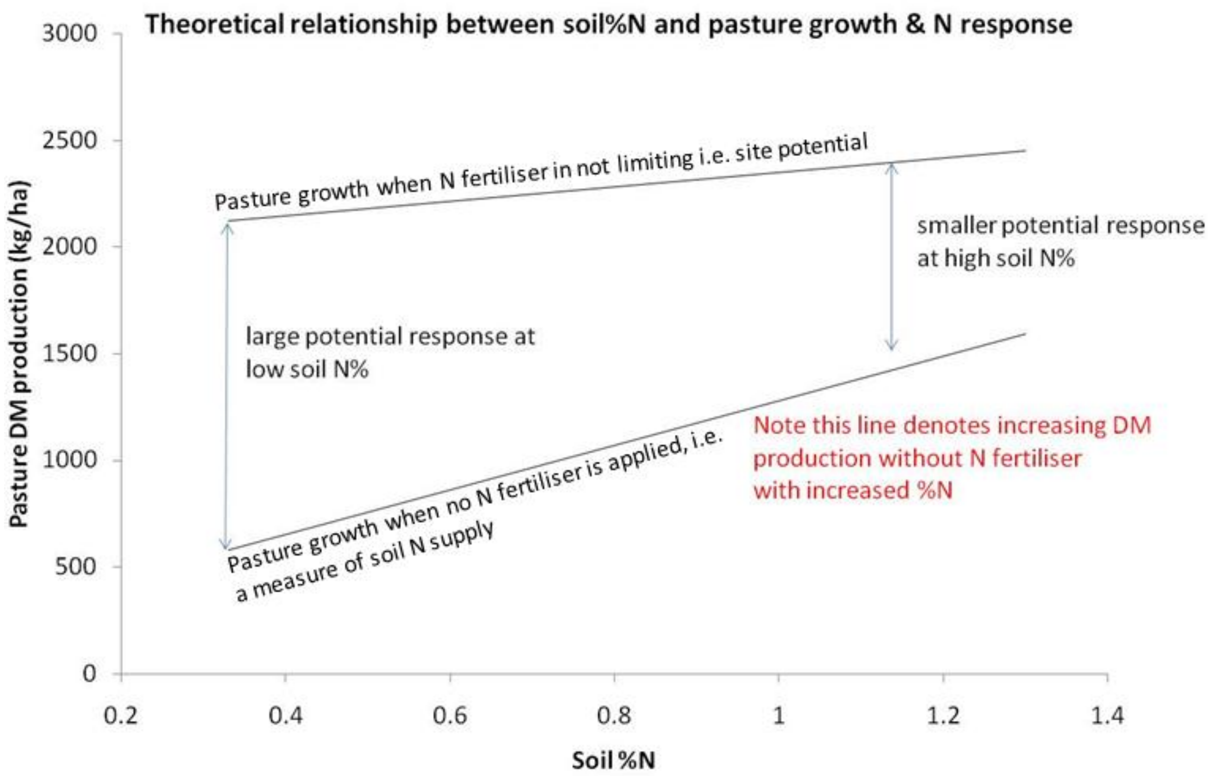

Figure 3. Conceptual relationship between soil 'total-N', base pasture yield, and pasture response to N-fertiliser (M. Shepherd, personal communication, February, 2013).

Establishing this relationship was a critical step towards developing a basic decision support system. Furthermore, analysis of ‘all paddock testing’ data from a number of dairy and sheep & beef properties indicated that there is sufficient variation in soil total-N within typical farming properties to warrant taking the concept further.

Through the Ballance Clearview programme of work, AgResearch has since been tasked with further evaluating and refining the relationship between soil total-N, base pasture yield and fertiliser-N response. This trial work has been focussed on extending the concept to a wider range of detailed trial sites on commercial farms located at various sites around the country, and also confirming that the response pattern / prediction still holds true for both autumn and spring fertiliser-N applications.

This data is still being collected and also cannot be disclosed in detail for the reason of protecting intellectual property. However, results to date indicate a good relationship between soil total-N and pasture response to N fertiliser, with individual site single-factor analysis on total-N giving R^2 values typically around 0.3-0.5. While by no means a perfect correlation, for a soil test as a single-factor predictor of pasture yield / responsiveness to nutrient inputs, this is as good as or better than many of the existing soil tests we routinely use (M. Shepherd, personal communication, February, 2013). Further interrogation of existing datasets is also planned, with the intention of looking into multi-factor analysis to identify whether the N-response prediction relationship can be further tightened.

How will the data be used?

There are a wide range of factors that will influence the magnitude of the pasture response to fertiliser-N for any given application. In addition, for a given single N-fertiliser application, all areas of the farm may still give strong economic responses to fertiliser N applied at a uniform rate (for example, in late winter / early spring when there is little mineralisation occurring and little mineral N in the system following autumn / winter leaching).

Hence, it is unlikely the soil test and decision support tool will be used in such a tactical manner, at least in the short term. Rather, the intended initial use for this tool is to assist development of ‘strategic’ variable rate fertiliser-N management plans; i.e. formulating how best to apply a budgeted total annual amount of N-fertiliser, by varying the total-N-fertiliser application rate in different areas of the property, based on the soil total-N test and corresponding interpretation of relative responsiveness.

Summary

Economic and environmental pressures will create on-going demand for new solutions to improve nutrient management and fertiliser nutrient use efficiency. Ballance is making a large investment into new technologies to increase nutrient use efficiency and reduce nutrient loss, through its joint government-funded Primary Growth Partnership ‘Clearview’ Product Development programme.

MitAgator is a map-based critical source area model that links with OVERSEER® to identify and manage N, P, sediment and bacteria loss hotspots within a farm property. The concept for use of this tool is to provide farmers with objective, least-cost mitigation support. A prototype tool is currently under development with validation and testing planned during 2013-14.

A prototype decision support system is being developed to assist with strategic fertiliser-N planning in pastoral systems, with the intention that this will lead to variable rate management of a properties planned total annual fertiliser-N input. The concept is based around relationship that has been recently defined between soil total-N and responsiveness of the pasture to fertiliser N inputs. It is intended that the prototype is available for user testing and evaluation in 2013.

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