OVERSEER® NUTRIENT BUDGET MODEL – WHAT IT IS, WHAT IT DOES

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What the model is?
The OVERSEER® nutrient budget model is an on-farm decision support model to help users develop nutrient budgets for nitrogen (N), phosphorus (P), potassium (K) and sulphur (S), calcium (Ca), magnesium (Mg), sodium (Na) and hydrogen (potential acidity) on a block and farm scale. It also provides a greenhouse gas emission and energy inventories for each farm.

The model uses farm and block specific data to prepare nutrient budgets, which are tables showing nutrient inputs and output from a blocks within a farm, or on a whole farm basis. From this information reports are prepared so that maintenance nutrient and lime recommendations, nutrient use efficiency and potential environmental effects can be assessed. These reports include environmental and productivity indices, with comments to assist in interpretation of the information. Additional information such as the 'Use of fertiliser' booklets and 'Fertiliser Code of Practice 'is also supplied in electronic form, with direct links from the model at appropriate places. The model also has features the ability to select mitigation options to reduce environmental effects, and these can be shown in comparative tables.

The model was primarily designed as decision support software to aid with maintenance nutrients and lime recommendations, nutrient use efficiency and environmental effect reports. The model has expanded in capacity over time in response to additional drivers, and this process will continue with new management and mitigation options planned.

Ground rules for model development
An initial set of ground rules were established to guide development of the model, and these were:

- farmer-friendly input requirements
- farm scale
- based on NZ data (model, validation, defaults)
- quasi-equilibrium model (long term average)
- annual estimates
- assumed good management practice was followed
- actual and reasonable inputs
- mitigation options

Farmer-friendly inputs are inputs that farmers know, can be readily obtain, or where reasonable default values can be supplied. These were established by a mix of model requirements along with farmers and consultant comments, end user surveys and feedback from users.

The model operates at a farm scale, but also includes blocks (groups of paddocks with similar site, soil, and management parameters). The model tracks nutrient movement within a block (from zones of depletion to zones of accumulation such as stock camps), and within a farm. Within-farm nutrient movements include nutrients deposited on raceways, supplements brought in and fed on paddocks or feed pads, and effluent-nutrient movements from the farm dairy or feed pad out to the effluent paddocks or through a pond system.

The underlying algorithms are based on research done in NZ, and are linked to current science programs so that the model can be updated as new science results are obtained.

A quasi-equilibrium model means that the model makes predictions for a given management practice remaining 'relatively constant' over a medium time-period. The model was not developed as a day-to-day management tool, nor was it developed to make fertiliser recommendations (nutrient recommendations combined with local information to decide fertiliser type, rate, and application times).

The model was developed assuming that actual inputs would be provided. However, this has a constraint in that if an input parameter is changed, then all associated input parameters, particularly those associated with productivity, should also be changed. Two mitigation option examples may illustrate this:

- reducing N fertiliser is also expected to decrease pasture production, and thus animal production.
- adding a winter feed pad frequently requires a number of other farm management changes. For example, the farmer may hard-graze the farm in autumn before using a feed pad. There may also increased milk production as supplements are brought in over winter to feed animals, yet the same amount of grass is grown over winter and fed in spring leading to higher production.

A range of mitigation scenarios have been added to the model that take account of these changes.

Model construction

The model is constructed from a series of submodels developed by individual research teams (Table 1). For each submodel, the procedure was to identify processes that are important for the submodel, and then to identify a means of estimating that process using farmer friendly inputs or defaults based on other parameters e.g. rainfall, soil type. These submodels were developed from New Zealand field trial data, and were then developed further by extending them to cover the whole farm, and to cover all New Zealand pastoral sites.

A key focus has been the incorporation of a wide range of possible on-farm management practices, including those that can lead to mitigation of environmental impacts.

Block nutrient budgets are weighted average budgets for camp and non-camp sites within a paddock. The farm nutrient budgets are weighted averages of the individual block nutrient budgets, and nutrient flows not included in paddocks such as farm dairies, feed pads, laneways, oxidation ponds, etc. This structure has two implications. First, maintenance nutrient recommendations should not be derived from a block nutrient budget as block nutrient budgets include camp nutrient flows. Secondly, for farms with only one block, the nutrient budget for the block and the farm will differ due to transfers from the block to the race, ponds, etc.

Detailed estimation of nutrient inputs, flows, output, and changes in soil organic pools have been used to calculate maintenance nutrient and lime requirements i.e. amount of nutrient and lime required to maintain current soil test values.

Table 1. Overseer® nutrient budget submodels and references

Submodel	Reference
Pasture intake by animals	Clark (2001)
P soil and plant model	Metherell (1994), Metherell et al. (1995)
Paddock transfer coefficients	Metherell (1994)
	Ledgard & Brier (2004)
P runoff/leaching model	McDowell et al. (2005)
Ca, Mg and Na	Carey and Metherell (2002)
Acidity (maintenance lime)	de Klein et al. (1997)
Greenhouse / energy inventory	Wells (2001)
	New Zealand's greenhouse gas inventory (2005)
Nitrous oxide emissions	de Klein et al. (2001)
Methane	Clark (2001)

Example model: The nitrogen loss model

Reviews of research trials show that the major driver of nitrogen (N) leaching in pasture is urine N deposited on the paddock, with rainfall, soil group and animal types modifying the amounts leached or lost in a gaseous form. The amount of N deposited by animals as urine was dependent on animal N intake, and the proportion of animal excreta N that was deposited as urine, which was estimated from N concentration in the diet (Fig 1).

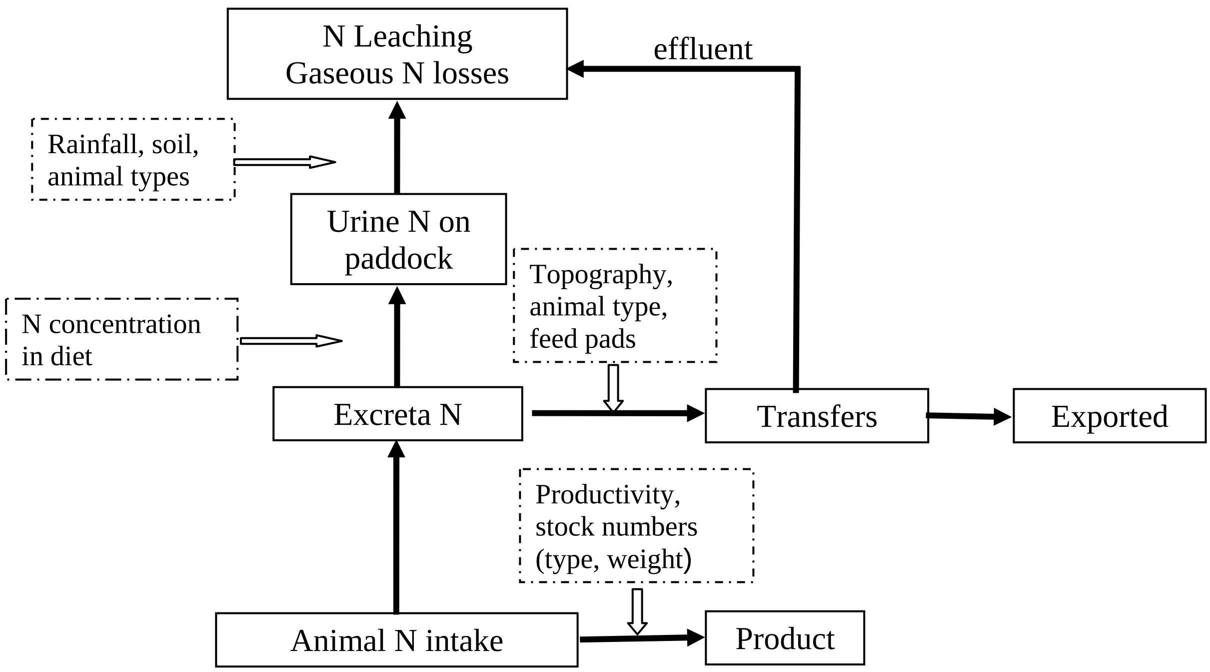

Fig 1. Schematic diagram of key components of the nitrogen loss submodel

This submodel was then expanded to a full farm model of nitrogen leaching and gaseous losses by including transfers and losses from other sources such as dung, fertiliser, lanes, farm dairy, ponds, feed pads, etc (Fig. 1). Losses include ammonia volatilisation from fertiliser, which is dependent on fertiliser rate, form of N and rainfall. Direct leaching of fertiliser was also included, being highest if high rates are applied in high-risk periods. It should be noted that the main effect of fertiliser is from increased plant N concentration, increased animal N intake and thus increased excreta N, and an increase proportion of excreta N lost as urine as average pasture N concentrations were higher.

Estimation of pasture production and utilisation, or pasture intake by animals directly, is difficult, particularly for general users. We circumvented this by estimating pasture intake by animals from productivity using a metabolic animal intake model (Fig. 2). This submodel provides values for animal N intake and N concentration in the diet that are used in the nitrogen loss submodel. All of the nutrient submodels use animal nutrient intake as a driver of some processes.

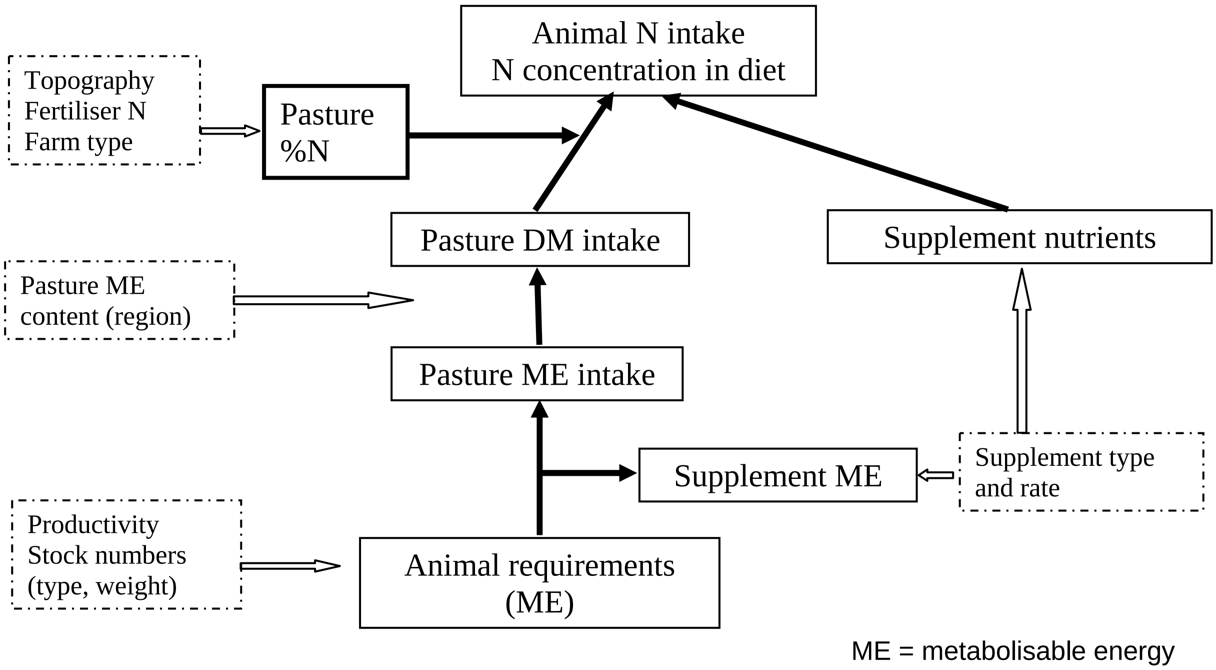

Fig 2. Schematic diagram of animal intake submodel

For dairy animals, sufficient information can be obtained from milk production, cow numbers, breed, and region, along with model defaults, to give a reasonable estimate of pasture intake by animals. The model does provide facilities to override the default with known user information. Supplement inputs may be important, particularly if their N concentrations differ from that in pasture.

For sheep/beef/deer systems, stock units are, in effect, a measure of pasture intake by animals. SUs are relatively easy to estimate for breeding stock, and published tables can be used provided they have taken into account increases in lambing percent, ewe weights and lamb weaning weights that have occurred over time. For trading stock, this estimate is more difficult as account needs to be taken for the time animals are on the property. A stock unit calculator has been added to the model, based on metabolic intake models, as a method to estimate SUs.

Conclusions

The Overseer® nutrient budget model is a decision support tool that helps users develop nutrient budgets, examine nutrient efficiency, assess potential environmental impacts, and evaluate the effects of mitigation practices.

The Overseer® nutrient budget model was developed as an on-farm decision support tool. However it has been selected as a possible tool to help meet regulatory requirements because the is based on best science, has a large research backing, has been checked against NZ field trial results, uses verifiable farmer friendly inputs, and is freely available for use.

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