Assessing on-ground works that reduce farm nutrient exports

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Introduction

The project 'Nutrient Smart Management', normally referred to as 'Nutrient Smart Farms' (NSF), was one of seven projects of the Hawkesbury Nepean River Recovery Program (HNRRP), which was funded by the Australian Government's 'Water for The Future' program. The objective of NSF was to improve rural land management and consequently reduce export to the river system of nitrogen (N) by 27 t/yr and phosphorus (P) by 6 t/yr - and thereby contribute to improved health of the Hawkesbury Nepean River, which is considered stressed. The focus was on commercial farmers but NSF engaged with all types of rural landholders in the lower Hawkesbury Nepean catchment, west of Sydney.

NSF was delivered by NSW Department of Primary Industries (DPI) in partnership with Hawkesbury Nepean Catchment Management Authority (HNCMA). It began in April 2009 and concluded in September 2011. NSF disbursed $3.5 m in grants for 187 'on-ground works' that reduce losses of N and P at farm boundaries. The project also provided free soil and water testing, training and extension services to local farmers – with the aim of improving nutrient management.

A research component focused on nutrient movement on dairies and the effects of using compost in field vegetable production. The complementary HNRRP project 'Nutrient Export Monitoring' (NEM), led by NSW Office of Environment and Heritage (OEH) provided useful data. The NEM project intensively monitored some of the NSF sites to quantify nutrient exports from different farm types prior to implementation of the works.

Calculating reductions in nutrient exports from farms, resulting from the works

Before NSF started, a literature review was completed to support the project application and outline intended activities. The review examined nutrient export rates (kg N and P/ha/yr) in surface runoff by agricultural activity – field vegetables, dairy, intensive grazing (hobby farms), extensive grazing; and then considered the potential reductions in nutrient export that could be achieved by activities including stock exclusion fencing, improved fertiliser management, increased perimeter vegetation and the application of compost. NSF adopted export rates and percentage efficiencies that were averages of the findings of studies deemed relevant.

Calculations of nutrient export reduction relied upon estimating the current nutrient load and then applying one or more discounts due to site factors such as perimeter vegetation, distance to property boundary, the presence of a dam, soil fertility, and so on. 'Discounts' were best estimates based on site inspection and available data. Nutrient loads were based on export rates for particular land uses, cattle numbers and time (e.g. hours/week) in certain areas, actual N and P in the reported amounts of fertiliser used, etc.

Types of on-ground works that were funded

These fell into ten categories:

- Fencing to exclude cattle from natural waterways, with or without revegetation
- Revegetation (native trees, shrubs, groundcovers) and pasture establishment
- 'Nutrient retention ponds' and earthworks to control runoff on horticultural farms
- Recycling of greenhouse drainage water
- Soil conservation works (e.g. halt gully erosion or bank slumping)
- Upgrades to dairy effluent systems and dairy laneways
- Supply of greenwaste compost, to improve soil condition and water infiltration
- Use of turf aerators (to improve water infiltration)
- Modified fertiliser application, including better targeting (e.g. fertigation in an orchard)
- Improved poultry manure storages on horticultural farms

Developing proposals for funding

A typical scenario was that a farmer approached NSF at the time of a Smart Farms promotional event, requesting a farm visit. Depending on the expertise and availability of staff, one or more Project Officers made the visit and discussed possibilities with the farmer. Frequently, a decision was made that the proposed works did not meet NSF objectives because the activity was routine farm practice or the potential nutrient export reductions appeared small or absent. Some vegetable farmers asked for new chicken manure spreaders but, even with a change in usage, this was considered not a suitable activity to fund. In the case where poultry manure storage was away from drainage lines and in the middle of a farm, nutrient losses were already minor and the amount of possible improvement was also minor. Where a wetland appeared to be doing a good job of intercepting nutrients the excavation of a 'nutrient retention pond' (and water source for the farmer) would lead to greater nutrient loss – at least in the short and medium terms. Examples of work such as these were not funded.

In cases where beneficial works were identified and there was an adequate in-kind contribution and an indicative budget that was attractive to the applicant, a proposal was developed. The standardised proposal form included a description, landowner's details, budget, property map and nutrient calculations detailing estimates of current losses of N and P and the expected reduction in those losses once the works were complete.

A panel assessed proposals according to the following six criteria:

- Technical feasibility
- Project sustainability – will the works result in a short or long term improvement?
- Applicant's resources and commitment
- Project focus – on environmental benefit as well as private benefit
- Connectivity to waterways
- Comparison of the size of the grant to a 'nominal value' of the expected reductions in nutrient export (see below).

In order to meet its nutrient targets and stay within budget, NSF needed to ensure that it did not consistently spend more than a given proportion of its budget to achieve less than the same proportion of its nutrient reduction targets (of 27 000 kg N and 6 000 kg P p.a.). After first applying a 'safety factor' of one-third of the grants budget, the remaining amount was simply divided by the kg targets to derive 'nominal values' of $35/kg N and $150/kg P. These values were then used in one of the six assessment criteria for proposals. By multiplying the expected reduction in nutrient exports by a value for those losses of N & P, a nominal value was determined for the whole proposal. This value was then compared to the size of the requested grant.

Most grants ranged in size from $5 000 to $25 000. Farmers were required to make either cash or 'in-kind' contributions, such as labour at installation or for additional maintenance that at least matched the value of the cash grant. Approved projects were developed into contracts between HNCMA and the applicant – and any other owners of the land where the works would occur. Contracts specified that the funded practice had to be maintained or implemented for ten years. NSF was entirely voluntary.

Discussion

NSF relied upon farmers to provide details of fertiliser use, average volumes of poultry manure stored, volumes of water used in greenhouses, the movement of cattle and changes in the sizes of eroding gullies. When combined with a Project Officer's own observations of a site and averages from relevant published information, a reasonable estimate of nutrient movement could be surmised. Before providing two worked examples of the calculation of nutrient exports and reductions in export, it is warranted to discuss considerations relating to some of the funded activities.

Dairy farms tend to be large properties with high volumes of nutrient turnover, including from bought-in feed. In the Hawkesbury Nepean catchment, dairy farms have large accumulations of nutrient resulting from many years of operation. NSF considered the likelihood that nutrient exports would increase, e.g. as effluent dispersal areas became saturated with P, given the same infrastructure, even if milk production did not increase. Funding was not provided where production was increasing or nutrient management was very poor, and therefore any remedial works could be considered the responsibility of the farmer. Instead, NSF focussed on improving effluent management systems where the farmer was operating at industry standard. NSF funded works that more readily dispersed N & P in solid and liquid dairy wastes over receiving areas that could best absorb the additional nutrient.

Some gullies on low intensity grazing properties were spectacular but, because the concentration of nutrient in the eroding subsoil was so low, the amounts of exported N & P were also low. In the following example of halting gully erosion, the nominal value for the project is less than $2 000 - suggesting only a small grant is warranted. In NSF, ten gully projects were funded and these all involved higher losses of nutrients. In the project area as a whole, soil erosion is less of a problem than in many other agricultural districts. Many farmers had owned their properties for considerable time and were able to provide reliable information on the increase in size of a gully and therefore the likely rate of erosion.

In projects involving stock exclusion from waterways, the reductions in N and P export due to improved riparian vegetation tended to be much smaller than those directly due to stock exclusion. As the cattle were kept out of the water this prevented the direct deposition of nutrients by excretion. In many cases, only a small area of catchment drained through the fenced off area. For example, if part of a levee of a major waterway was fenced but the nearest tributary, draining much of the farm and feeding into the major waterway, was outside the area of improvement, then the catchment for the denser riparian vegetation would, for example, be a block 200 m x 30 m (= 0.15 ha), not the 30 ha of grazing area on a property.

The project area included many greenhouse enterprises. Greenhouse operations are very small in area and tend to be recently established but they can be relatively large exporters of nutrient. A typical enterprise has 5 000 m^2 of greenhouse, water use should be around 7 megalitres/year annum and drainage 30% of this figure (Badgery-Parker and James 2010), i.e. 2.1 ML/yr. Concentrations of total N and P in drainage water were often found to be very high, e.g. 140 and 15 mg/L respectively, and on 2 ha blocks there was often limited opportunity to intercept these nutrients before they left the property. On the other hand, many of these small farms discharged into drainage lines that were only poorly connected to permanent, and even intermittent, waterways. On greenhouse properties NSF funded works to reuse drainage water on outside cropped areas, where possible, or back into greenhouses. In the latter case, expensive disinfection was nearly always required due to the risk of plant disease.

The Nutrient Export Monitoring (NEM) project intensively monitored eight of our sites. Where, for example, 50 ha of vegetable field drained through a single large pipe to the Hawkesbury River, losses of N & P were unambiguous. However, the relationship of those losses over several months to long term averages is less clear cut. We had hoped to measure comparisons of ‘unimproved’ and ‘improved’ sites during the 2½ year life of NSF but this did not happen due to a lack of suitable paired sites and delays in completing work. However, NEM did provide data on nutrient export rates from turf farms, which were not covered in the NSF literature review, and refined nutrient export rates for other land uses by combining data collected at NSF sites with literature values. The NEM project’s refined nutrient export rates were similar to those defined in the NSF literature review.

An examples of nutrient calculations in NSF - Stock exclusion fencing

The nutrient calculations for fencing projects could be quite involved. Depending on the site, the justification for fencing proposals was one or more of the following:

A land use figure This applied only to the catchment that drained through the fenced area. This catchment did not have to only be on the applicant’s property. Catchment that did not drain directly through the zone to be improved was not counted. Nutrient export rates of 4.4 kg N and 0.9 kg P/ha/year (NSF literature review, hobby farm) were the default figures to use. These were applied only to the grazed area. There was a lower figure for bushland and a higher figure for more intensively grazed situations (the figure for dairy farms from the NSF literature review was 5.3 kg N and 3.5 kg P/ha/yr).

A factor was applied to the nutrient runoff figures. This factor accounted for an improvement in vegetation in the fenced off zone and therefore more nutrient capture before it entered a natural body of water or crossed a property boundary. The number (from the NSF literature review) used was 46% for N and 39% for P - around half effectiveness.

A direct disturbance figure (only for cattle, not sheep or alpacas) This was to do with a certain number of head being in or immediately next to a natural body of water (e.g. on the water side of a bank). This factor was not normally applied to a dam. The default option was to multiply a figure for excretion of 100 kg N and 15 kg P p.a. per adult animal (e.g. 500 kg cow) by the average amount of time in water – as reported by the landowner. Averaged over a year, cattle might spend a couple of hours a day (2 hr ÷ 24 hr = 8%) in or right next to water or they may spend almost no time there – it depended on factors such as shade and alternate water sources. We increased the time factor by 50% to allow for a greater propensity by cattle to excrete when in or near water (8% increased by 50% = 12%).

A figure to do with erosion Erosion occurs as animals clamber up and down banks and from over-grazed paddocks. The erosion figure was only applied to severely degraded sites. In general, it was double counting to apply both a land use figure and a soil erosion figure to grazed paddocks but reductions in sheet erosion were counted when targeted remediation was carried out.

Example nutrient calculation

A property has, on average, 15 head of cattle, 10 sheep and a couple of horses. They graze 30 ha of a total of 50 ha, the remainder is undisturbed bushland. The property has six paddocks. The livestock spend half their time in two paddocks that have a permanent creek as one boundary. There is little shade in this paddock and no water except that of the creek. The proposal is to fence all of the riparian area (600 m) and provide off-stream water. The creek-side vegetation is quite sparse and degraded. In one place where the animals regularly obtain water, the bank is actively eroding. Part of the paddock behind this is bare and also eroding.

Land use:

It seems virtually all of the 30 ha drain through the riparian area. Use hobby farm figures from NSF literature review (4.4 kg N and 0.9 kg P/ha/yr) and apply efficiency factors of 46% for N and 39% for P as the fenced off vegetation captures more of the sediment and nutrients in the farm's runoff.

N: 30 ha x 4.4 kg/ha x 46% = **61 kg**

P: 30 x 0.9 x 39% = **11kg**

Direct disturbance:

No figure for the sheep and horses.

Use 100 kg N and 15 kg P per head per year for the 15 cattle. Multiply this by half their time in the creekside paddocks and 12% because the landholder says that, averaged over winter and summer and when in these paddocks, the animals spend two hours a day in the water or on the banks.

N: 15 head x 100 kg/hd/yr x 50% in the paddock x 12% = **90 kg**

P: 15 x 15 x 50% x 12% = **14 kg**

Erosion:

According to the landholder, a section of bank around 20 m long and 4 m width (= 80 m^2) has retreated about half a metre in the last ten years. 80 m^2 x retreat of 5 cm/year (= 0.05 m) x bulk density of 1.6 t/m^3 (for undisturbed and subsoil) = 80 x 0.05 x 1.6 = 6.4 t (or 6 400 kg).

Additionally, around 0.25 ha of land next to this area, also very close to the creek, is bare and eroding. This will be fenced off. Assume current soil loss of 25 t/ha, minimal soil loss in the future. In this case, erosion is 25 t/ha x 0.25 ha = 6.25 t (= 6 250 kg)

The test result for this riverbank soil is 0.14% total N and 0.022% total P. Therefore, losses due to erosion are:

N: [6 400 + 6 250 = 12 650 kg] x 0.14% (= x 0.0014) = **18 kg**

P: [6 400 + 6 250 = 12 650 kg] x 0.022% (= x 0.00022) = **3 kg**

Total export for the site is:

N: 61 + 90 + 18 = **169 kg p.a.**

P: 11 + 14 + 3 = **28 kg p.a.**

Under NSF guidelines, the nominal project value (i.e. size of grant that is warranted) is:

[169 kg N x $35/k = $5 915] plus [28 kg P x $150/kg = $4 200] = $10 115

Depending on all factors, including the anticipated cost of works and conservation value, a grant of up to around $10 000 would be justified.

Summary

The range of funded works in NSF and the issues in implementing and assessing these are too great to discuss in one paper. However, some generalisations to guide other projects seeking to reduce nutrient runoff from farmland are made.

Depending on the characteristics of an enterprise and site, ten or more kinds of activity could be used to reduce nutrient exports to a significant degree and in a cost-efficient manner – given our level of funding. The soils of our project area tend to lose N & P via surface runoff, not leaching, and therefore we needed to observe where water flowed. Site inspections and the advice of resident farmers were required to design our projects. Some relevant published studies were found and averages from these were applied in our nutrient calculations. Our general approach was to determine the size of a nutrient load then apply site-specific factors to estimate N & P losses from a farm.

While it might be argued that improvements on a farm rather than catchment scale are inadequate to achieve significant environmental benefit, we contend that a jigsaw (or catchment) cannot be completed without first handling individual pieces (or farms). Where a project such as NSF is voluntary and land is in private ownership, it is necessary to work at the level of individual farm enterprise. Collectively, our 187 on-ground works under NSF have delivered reductions more than double our targets for less export of N & P. Local farmers now have many completed examples of desirable works with which to raise the environmental performance of agriculture in the lower Hawkesbury Nepean catchment.

Three lessons:

1. Quantifying nutrient losses in runoff from farms need not be in the 'too hard' basket. With background information and site assessment, it is possible to make reasonable determinations of losses (that can then guide prioritisation and the assessment of investments) without resorting to expensive, medium-term research or monitoring programs.
2. Staff require training and expert information so that reasonable judgements on current and likely future nutrient exports can be made.
3. Among the most beneficial works were the capture and re-use of greenhouse drainage water, stock exclusion fencing where cattle spent a lot of time in waterways and upgrades to effluent management systems on long-established dairy farms.

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