Ten years of dairy catchment monitoring in New Zealand: what has it taught us?

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There has been a dramatic growth of pastoral dairy farming in New Zealand in the last 20 years with 515,000 hectares of sheep/beef farms converted to dairy farming and a 17% increase in the stocking rate (Quinn et al. 2009). World dairy commodity prices and cost-efficient farming have driven the expansion and intensification of dairying in New Zealand. Whilst this change in land use and land use intensity has been an important driver of economic growth, communities have also recognised the potential risks to the health of soil and water resources (Wilcock et al. 2007). Pastoral dairy farming is carried out where there are net runoff losses i.e. where rainfall+irrigation water inputs exceed evapotranspiration. Coupled with high loadings of nutrient forms (N and P) and faecal matter to land, this generates relatively large export coefficients of nutrients and faecal microorganisms, with significant impacts on receiving water concentrations and loads.

Concern about poor water quality and the long-term environmental sustainability of dairy farming led to the New Zealand dairy industry initiating a monitoring study of five predominantly dairy farming catchments: two in established dairying areas of the North Island (Toenepi and Waiokura), and three in South Island areas where dairy farming is relatively new (Waikakahi, Bog Burn and Inchbonnie) (Wilcock et al. 2007). The study has entailed continuous measurement of flow at catchment outlets, and monthly monitoring of water quality supplemented by surveys identifying key inputs to streams. Stream water has been analysed for pH, conductivity, temperature, water clarity (black disc), turbidity, dissolved oxygen, suspended solids, *E. coli*, nitrate plus nitrite N, ammonia N, total N, filterable reactive P and total P. Loads and specific yields have been calculated for selected water quality variables. Averaged data from farm surveys carried out every 2-3 years were used to derive model farms for each catchment. This information was used in turn to identify cost-effective management practices that could minimise the transfer of potential stream pollutants from land to water. These surveys gathered data on farm productivity levels, feed purchased and sold, stock and effluent management systems, soil management, fertiliser use and the extent of stream fencing to exclude stock access (Table 1).

Table 1 Characteristics of monitored dairy catchments and streams.

	Toenepi	Waiokura	Waikakahi	Bog Burn	Inchbonnie
Area (km^2)	15.8	20.9	41.0	24.8	6.0
Rainfall (mm yr^{-1})	1160	1250	520	900	4830
Topography	Flat-rolling	Flat	Flat	Flat	Flat
Stocking rate (cow ha^{-1})	3.2	3.2	3.6	2.9	2.0
Fertiliser input (kg ha^{-1} yr^{-1})					
N	54	135	161	93	178
P	36	38	28	34	50
Irrigation (mm yr^{-1})	0	0	800	0	0
Streamflow (L s^{-1})					
Range	0-7000	69-7260	33-3700	8-12100	11-21400
Mean	216	432	589	289	360
Median	64	363	568	136	95

An analysis of trends (Table 2) shows improved water clarity (also turbidity and SS) for most catchments, and a mixture of increasing and decreasing trends for TN, TP and *E. coli* concentrations. Overall, loads of N and P have stayed much the same over 10 years for all five catchments, but SS loads have, on average, decreased by 50%. The main exception is the Bog Burn catchment, where loads have trended upwards for N, P and SS as production has increased.

Table 2 Trend analysis of dairy catchment water quality data using Seasonal Kendall test on flow-adjusted concentrations (significant trends are for $P \leq 0.05$). NS = not significant.

Catchment	TN g m^{-3} yr^{-1}	TP g m^{-3} yr^{-1}	*E. coli* (100 ml) $^{-1}$ yr^{-1}	Black disc clarity m yr^{-1}
Toenepi Mar 1995-Mar 2011	NS	NS	NS	Increasing 0.04 ± 0.02
Waiokura May 2001-Mar 2011	NS	NS	Decreasing 100 ± 25	Increasing 0.03 ± 0.01
Waikakahi Sep 1995-Mar 2011	Increasing 0.06 ± 0.01	NS	Decreasing 15 ± 5	Increasing 0.06 ± 0.02
Bog Burn May 2001-Sep 2010	Increasing 0.04 ± 0.01	NS	Increasing 44 ± 20	NS
Inchbonnie Jun 2004-Feb 2011	Decreasing 0.08 ± 0.02	Decreasing 0.01	NS	Increasing 0.10 ± 0.02

Improved stock exclusion from riparian areas and greater use of land application for re-utilising farm dairy effluent (FDE) are major reasons for decreasing SS and *E. coli* inputs to streams. This is offset by ongoing intensification of land use with increasing loss of N to waterways in the three South island catchments. BMPs have been identified for each catchment and are being implemented to reduce these losses, e.g. deferred irrigation of FDE, optimal use of fertilisers, stock management, improved irrigation efficiency, and their efficacy will be discussed. The monitoring programme has successfully detected improvements in water quality in response to farming changes and adoption of BMPs. It has also allowed us to relate changes in water quality variable concentrations to farm productivity as well as to mitigation practices (i.e. double-bottom line accounting), thereby incorporating environmentally sound practices into farm management systems that are economically practical.

The slow rate of change of farmer behaviour and climatic cycles of different duration have required that monitoring be carried out over at least 20 years to distinguish between improvements due to adoption of BMPs, and changes caused by climate. Monitoring at the catchment level has enabled effects due to a single, dominant land use to be examined in isolation from other land use effects.

References

Quinn, J.M.; Wilcock, R.J.; Monaghan, R.M.; McDowell, R.W. and Journeaux, P. (2009) Grassland farming and water quality in New Zealand. *Tearmann: Irish Journal of Agri-Environmental Research* **7**, 69-88.

Wilcock, R.J.; Monaghan, R.M.; Thorrold, B.S.; Meredith, A.S.; Betteridge, K. and Duncan, M.J. (2007) Land-water interactions in five contrasting dairying watersheds: Issues and solutions. *Land Use and Water Resources Research* **7**, 2.1–2.10.

Wilcock, R.J.; Nash, D.; Schmidt, J. Larned, S.T.; Rivers, M.R. and Feehan, P. (2010) Inputs of Nutrients and Fecal Bacteria to Freshwaters from Irrigated Agriculture: Case studies in Australia and New Zealand. *Environmental Management* Online: DOI 10.1007/s00267-011-9644-1.