DOES BEST MANAGEMENT PRACTICE ON DAIRY FARMS RESULT IN BETTER STREAM HEALTH?

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Abstract

The Best Practice Dairy Catchments study (2001-2011) has provided an invaluable data set describing water quality from five monitored catchments located in Waikato, Taranaki, Canterbury, Southland and the West Coast. While there have been some improvements in water quality resulting from increased stream fencing and greater use of irrigation for effluent disposal, N concentrations have increased as dairy farming has continued to intensify. However, trend analysis has shown that suspended sediment concentrations declined in all five streams, most likely in response to greater use of fences for stock exclusion. Biological assessments of aquatic invertebrates (as indicators of stream health) and stream habitat indicated improved stream health in four of the five catchments, most likely in response to the reduced sediment (and related pollutant) concentrations. Macroinvertebrate Community Index (MCI) scores improved in four of the five catchments, indicating the presence of a greater number of invertebrate species that are sensitive to organic pollution and general improvement in stream health. The pattern was not seen in the Southland sites, possibly due to on-going forestry operations in the upstream catchment and the use of tile drains. The provisional results suggest that actions leading to reduced loss of sediments from land (viz. stock exclusion) result in healthier and more diverse aquatic ecosystems. Other factors likely to affect stream health and habitat are the frequency of floods causing biological disturbance (as indicated by the FRE3 flood frequency statistic) and the degree of riparian shading (temperature, C inputs).

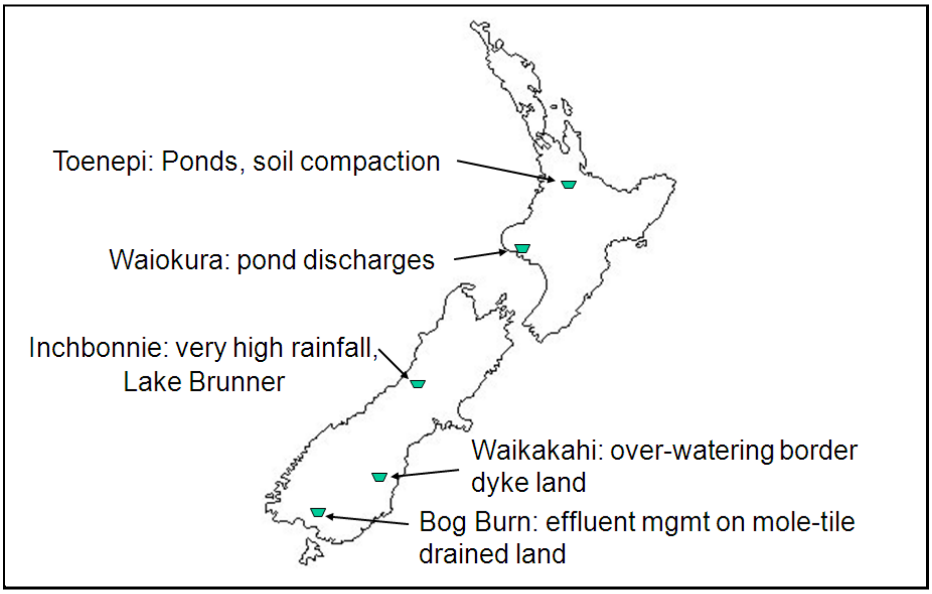

Fig. 1. Best practice dairy catchments for sustainable growth. Major contributing land uses affecting water quality at the start of the study are shown for each of the catchments.

Introduction

The Best Practice Dairy Catchments study (2001-2011) was established to:

(i) develop an understanding of the water quality of streams in five predominantly dairy-farming catchments in contrasting regions of New Zealand (Fig. 1),

(ii) derive best management practices (BMPs) based on the relevant land-water linkages, and

(iii) monitor changes in water quality as farmers adopt the BMPs (Wilcock et al. 2007; Monaghan et al. 2008).

The study has shown that although adoption of BMPs has been slow in many cases, there have been some definite improvements in water quality that can be directly attributed to better fencing out of cattle from stream margins (as specified in the Clean Streams Accord) and to a general move away from aerated lagoon treatment of FDE and discharge of treated effluent to waterways, to greater use of land irrigation methods. In particular, trend analysis of water quality data has shown significant ($p \leq 0.05$) decreases in suspended sediment (SS) concentration in all streams, as well as a general increase in water clarity as measured by black disc visibility, and some improvement in loss of faecal bacteria (*E. coli*). By contrast N and P trends have been variable, reflecting the expansion and intensification of dairy farming since 2001, and the effects of market forces (Table. 1).

Table 1. Summary of water quality trends in BPDC streams. Arrows indicate significant ($p \leq 0.05$) upward or downward trends. NST is either no significant trend or a zero trend slope.

Catchment	TN	NO_X-N	FRP	TP	*E. coli*	SS	Black disc
Toenepi	NST	NST	NST	NST	NST	↓	↑
Waiokura	↓	↓	NST	NST	↓	↓	↑
Waikakahi	↑	↑	NST	NST	↓	↓	↑
Bog Burn	↑	↑	NST	NST	↑	↓	NST
Inchbonnie	↓	↓	↓	↓	NST	↓	↑

While much emphasis has focused on concentrations and loads of water quality variables (N and P forms, SS and *E. coli*) there is also an interest in how dairy farming affects stream ecosystems, and the benefits of applying best practice. To address that issue, biological assessments were conducted in the Toenepi, Waiokura, Waikakahi and Bog Burn streams in winter and late summer of 2002, and in the Inchbonnie streams during August 2005 and March 2006. Previous to that, four seasonal surveys were conducted in Toenepi Stream during 1995-97. In this paper we discuss recent work linking on-farm actions with water quality and stream health (as determined by biological assessments).

Methods

Trend analysis was carried out using water quality data from the five-catchment monitoring programme, using the non-parametric seasonal Kendall trend test (Hirsch and Slack, 1984).

Assessments of stream habitat, periphyton type (Biggs 2000) and benthic invertebrate diversity were made in summer (February 2011) at three sites (50 m reaches) for each stream, and compared with other streams in the region. Water clarity (black disc), conductivity, DO, pH and temperature were measured *in situ* as physico-chemical descriptors of habitat. Invertebrate collection followed protocols used by regional councils in their respective regions. These were typically composite kick-net samples from riffles and/or runs. Macroinvertebrate samples were collected as timed kick samples with a D-net (500 µm mesh catch bag) and preserved with isopropyl alcohol prior to identification and enumeration, as per Wilcock *et al.* (2009). The 2011 Waikakahi survey followed the methodology described by Meredith et al. (2003). Taranaki Regional Council have included sites on Waiokura Stream in their routine biological monitoring programme and allowed the data to be included in this study.

There are a number of metrics that can be applied to biological survey data to classify stream conditions. In this paper we have focused on the Macroinvertebrate Community Index (MCI) (Stark 1993) and its derivative, the semi-quantitative MCI (SQMCI). These metrics indicate levels of organic enrichment in stony streams by assigning individual invertebrates with given sensitivity scores (1-10). Sensitive species have a high score (e.g. 10 for some mayflies), whereas species that are tolerant of harsh conditions have low scores (e.g. 1 for worms and 2 for some midge larvae). An overall score is calculated from presence-absence data in the case of the MCI, or a five-point scale of coded abundances (SQMCI). An interpretation of MCI and SQMCI scores is given in Table 2. The study is expected to finish in 2013 when sufficient data has been gathered to define relationships between changes in water quality and biotic condition.

Table 2. Interpretation of Macroinvertebrate Community Index (MCI) and Semi-Quantitative MCI (SQMCI) index values from Boothroyd & Stark (2000) (Quality class A) and Stark & Maxted (2007) (Quality class B).

Quality Class A	Quality Class B	MCI	SQMCI
Clean water	Excellent	>120	>6.00
Doubtful quality	Good	100-119	5-5.99
Probable moderate pollution	Fair	80-99	4.00-4.99
Probable severe pollution	Poor	<80	<4.00

Results and Discussion

All streams except Bog Burn showed an increased MCI score, indicating improved habitat conditions (Fig. 2). It is notable that the upstream forestry reference site of Bog Burn (Taringatura) was clear-felled during the period between 2002 and 2011, which may have also affected results in the study downstream reach (Fig. 3).

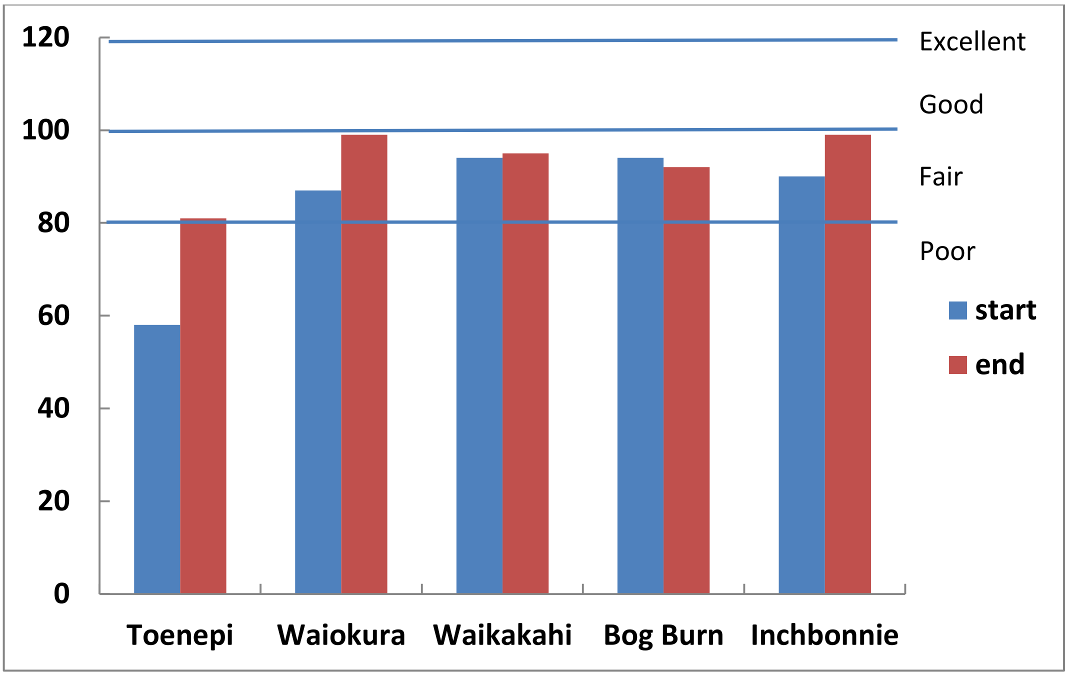

Fig. 2. Macroinverebrate community index (MCI) scores at the beginning (1995 for Toenepi; 2002 for Waiokura, Waikakahi and Bog Burn; and 2005 for Inchbonnie) and end (2011) of the present study period. Horizontal lines refer to water quality classes for quality class B (Table 2).

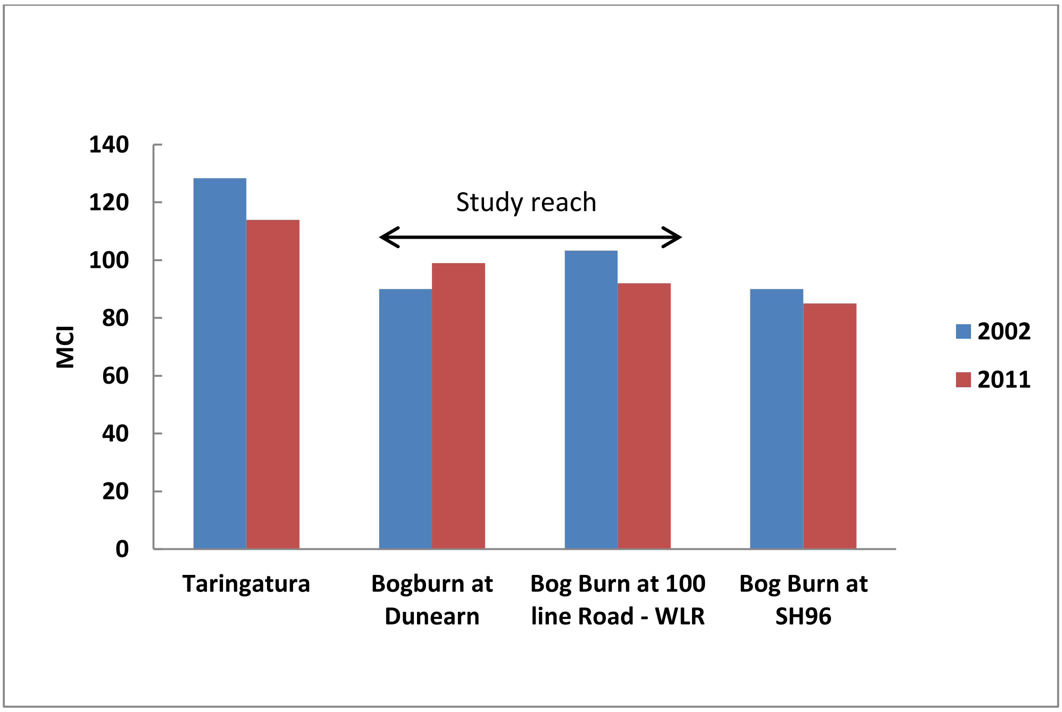

Fig. 3. Bog Burn MCI scores at the start (2002) and end (2011) of the present study, showing the effects of clear-felling upstream of the reference site.

The increases in MCI scores are compared with the decreases in mean SS concentrations for the same periods that were derived from trend analysis of monitoring data (Fig. 4).

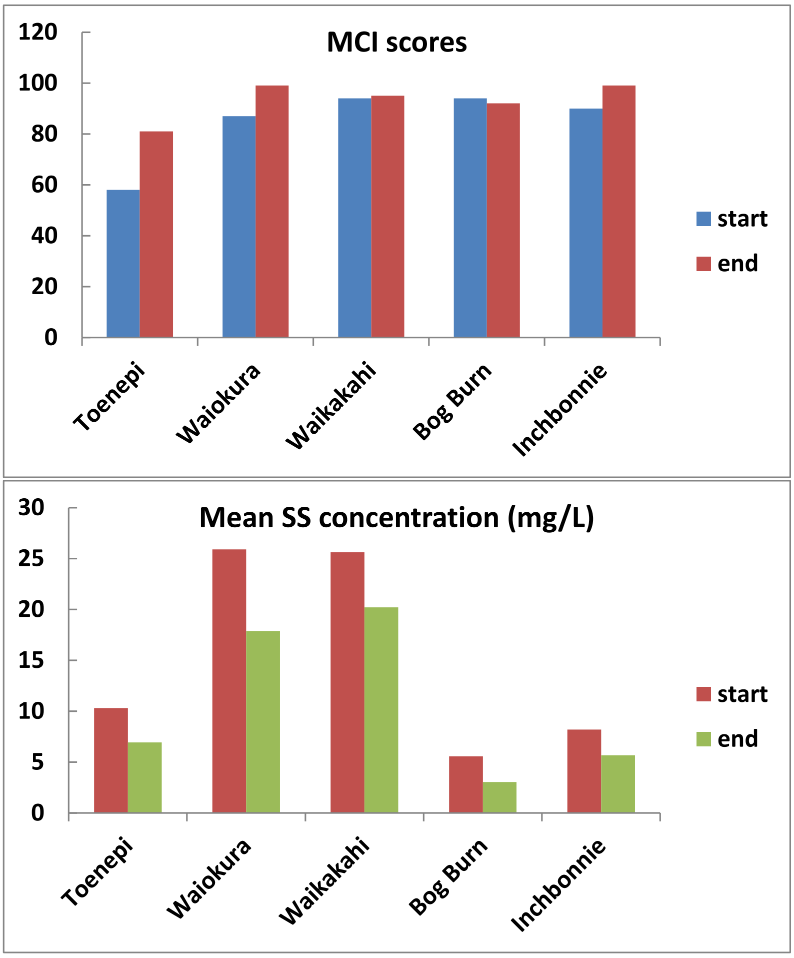

Fig. 4 Changes in suspended sediment concentration and MCI scores over the same monitoring periods.

It is highly likely that improvements in stream fencing in all study streams, from about 50% in 2001 to at least 80% in 2011, are the major cause of reduced sediment loss and, hence, SS concentrations (McDowell & Wilcock 2007; Wilcock et al. 2009). Livestock seek out water, succulent forage, and shade in riparian areas, leading to trampling and overgrazing of streambanks, soil erosion, loss of streambank stability, declining water quality, and drier, hotter conditions. These changes have reduced habitat for riparian plant species, cold-water fish, and wildlife, thereby causing many native species to decline in number or go locally extinct. Such modifications can lead to large-scale changes in adjacent and downstream ecosystems (Belsky et al. 1999; Richards et al. 2006). Hence, we are reasonably confident that reduction in stock access to stream banks in the BPDC streams has resulted in less sediment lost from stream banks and contributed to healthier streams.

We are aware that other factors will contribute to the improved MCI scores, such as climatic effects on flow disturbance events (floods that remove periphyton and "reset" plant growth in river channels), as well as nutrient (viz. N and P) concentrations that cause increased organic enrichment and thereby affect stream ecosystem structure. The reduction in organic loading to some streams resulting from fewer direct discharges of treated FDE as more farmers use irrigation methods may also have some effect on our observations and will be taken into account with other potentially causative factors at the completion of the study. Nonetheless, we are confident that the reduction in SS concentrations resulting from increased stock exclusion has had a significant, albeit small in some cases, effect of improving the quality of stream ecosystems in the BPDC streams.

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