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Effects of intensive dairy and deer farms on streams and trout fisheries

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ABSTRACT

Many streams flowing through agricultural landscapes in New Zealand have poor water quality and biotic indicators. Loss of riparian zone function through vegetation removal and stock access cause changes. Farms where large numbers of cattle and red deer have access to streams result in degraded streams. Restoration of riparian zones and exclusion of stock from streams results in improvements but careful land management is also needed to ensure water quality and instream life is protected.

Keywords: streams; water quality; fish habitats; riparian zones.

INTRODUCTION

Intensive dairy and deer farming is widespread in several regions of New Zealand. Streams flowing through these areas contain fish habitats. Riparian-zone protection and sustainable land management practices are needed to protect these habitats.

The riparian zone is the land between the stream and the farmland. The way this area is managed has a significant effect on the extent to which intensive agriculture affects the stream. Careful land management outside the zone that takes into account soil properties is also needed. The soil must be managed so as ensure excessive amounts of soil (sediment), nutrients and bacteria are not released to streams and rivers.

Intensive dairy farming often results in increased nutrient loss, sediment discharge and faecal contamination of streams. This causes water-quality guidelines to be compromised - eg monitoring of 20 streams on the West Coast since 1977 revealed 77% exceeded guidelines for faecal contamination. In Bay of Plenty, streams bacteria derived from dairy farms contaminate estuaries so that contact recreation guidelines are exceeded (Deely *et al*., 1999 cited in Parkyn *et al.*, 2002).

Intensive red deer farming where deer have access to streams, causes soil loss, degradation of stream banks and contamination of water by sediment and pathogens. Bryne (2000) found that unfenced streams on a deer farm had extremely high faecal coliform levels and overall poor water quality, which severely inhibited instream faunal diversity. She concluded that loss in riparian vegetation contributed directly to high sediment loads and turbidity and unrestricted deer access resulted in a high level of riparian and instream disturbance.

TROUT FISHING AND TROUT HABITATS

Trout in New Zealand are legally defined as a sports fish with a significant economic and social value. There are about 190,000 licences sold annually, with an estimated 1.3 million trout or salmon fishing trips per year (Unwin & Brown, 1998).

Trout and salmon need suitable habitat to thrive. They must have rivers with adequate supplies of water of good quality - low nutrients and temperature, ideally with stony or gravelly beds and with good bank cover that provides shade. Increased suspended sediment, increased algal growth, and increased temperature, reduce growth rates and survival. Anglers and other people who come into contact with contaminated water risk being infected by pathogens derived from dairy cattle, causing serious illnesses (Poore, 2002).

MECHANISMS OF DEGRADATION

Streams which flow through pastoral lands, compared to streams in natural situations, such as in forests or native grasslands, have greater volumes of runoff, more intense storm flow, more suspended sediment, higher turbidity, lower water clarity and more nitrogen and phosphorus.

The increased runoff results in more eroded sediment, the increased fertility results in more sub- surface leaching losses, more fertilizer drift and the stock access to streams causes more faecal coliforms (FC) to be excreted into the water.

Where dairy cattle are allowed general access to streams, turbidity has been observed to increase from <10 to 50-250 NTUs in a hill country stream (Quinn *et al.*, 1998 cited in Parkyn *et al.*, 2002). At dairy cattle crossings, a 50% increase in suspended sediment and 400% increase in *E coli* have been observed (Davies–Colley *et al.*, 2001 cited in Parkyn *et al.*, 2002).

Dairy-shed effluent ponds are also significant sources of nutrients and faecal pollution. Recent studies, in the Bay of Plenty showed only 30-48% of discharges complied with required standards on first inspection (Pickles, 1999; Larsen, 2000 in Parkyn *et al.*, 2002). On the West Coast seven out of eight systems were causing significant adverse effects (Parkyn *et al.*, 2002). The use of ponds alone to treat effluent, followed by discharge to waterways, is no longer an acceptable practice and should be replaced by land application of effluent. However, in some situations this treatment system has severe limitations too, as discussed later.

Artificial drainage systems on farms increase runoff and reduce contact of water with soil and riparian zones where remediation could occur. Nutrients, sediments and FC concentrations are higher in drains than in normal streams. In some areas, waters from these drainage systems dominate the flow in small rural streams.

Shallow ground waters may also contribute to stream flows. Some can be contaminated with nitrate due to animal excretion at high stock densities (Monaghan *et al.*, 2000).

SYMPTOMS OF DEGRADED STREAMS

Intensive agriculture causes physical changes to streams too, such as: reduced shade, increased algae, increased temperature, reduced organic matter, stream straightening, increased gradients, reduced length, and increased flow variability. These physical changes, as well as chemical changes, reduce water quality, and contribute to higher stream temperatures.

Such changes affect fish and macroinvertebrates. Mayflies and stoneflies require cool water to survive. Trout need temperatures to be less than 19ºC for growth (Elliott, 1994). Small, unshaded, low and mid altitude streams frequently exceed 20ºC in summer when air temperatures also exceed 20ºC in all parts of NZ.

Increased suspended sediment reduces clarity, which reduces the ability of fish to find food. It abrades biota generally, smothers substrate, affects habitat and food resources for fish and macroinvertebrates and silt deposition leads to a change in macroinvertebrate communities, from pollution-intolerant to pollution-tolerant species. Shaw & Richardson (2001) found that pulses of fine, suspended sediment caused an increase in invertebrate drift, and a decrease in family richness. It also caused a reduction in trout growth.

WATER QUALITY IN NEW ZEALAND

Monitoring in Southland in 2001 showed 33% of sites had poor ecosystem health (Environment Southland, 2001). Mostly, these were in smaller streams. The loss of well-vegetated margins was considered to be the major factor involved.

Case study: the Orauea River, Western Southland

The larger rivers in Southland are at present less affected than small- to medium-sized streams. The fluctuating flows in the larger rivers, which have a high proportion of their flow derived from undeveloped land areas, maintain a low periphyton biomass, but smaller streams, with a higher proportion of their catchment in developed land, develop extensive periphyton blooms. In the summer of 2002-2003, the Orauea River was one of the worst affected. During the 2002 winter, large areas of the catchment were used for off farm grazing on forage crops. This produced runoff with a high concentration of suspended sediment, containing pathogens and nutrients. In the spring and early summer, extensive cultivation on hills, combined with heavy localised rainfall events, resulted in fine sediment being discharged to the river. This sediment settled in the river margins, reducing the area suitable for macroinvertebrate production significantly. In December, most of the bed of the stream downstream of the affected sub-catchments was smothered with fine sediment. By mid-January, riffle areas, where the velocity was high, were clear of sediment and periphyton but other areas were blanketed. After sustained low flows at the end of January, long filaments of brown algae covered the low velocity areas of the stream, and filamentous green algae was found in the higher-velocity areas.

The situation elsewhere in New Zealand is similar. Regional Council reports show, on the West Coast, there were poor invertebrate communities in streams affected by dairy discharges. In Wellington, 11 of 15 forest sites were good, but only three of 17 rural streams were considered good. In Taranaki, there is a gradual decrease in quality in 32 sites from bush to coast. In the Waikato, 198 sites were sampled and half of those in developed catchments were moderately or severely degraded (Parkyn *et al*., 2002).

In an attempt to reduce sediment runoff from deer pastures in Northern Southland Environment Southland and the Waiau Trust constructed sediment treatment ponds on a small stream which red deer had access to. Measurement of sediment runoff by collection in the ponds indicates that many tonnes of sediment are lost from these pastures annually.

On another small stream near Te Anau, water samples were collected where deer were present. Water samples were also collected from the stream to provide background conditions. Where the deer had access, the water had a turbidity measurement of 280, and 3200 faecal coliforms/ 100ml. The unaffected water had a turbidity of 0.4 and FC of 71/100ml.

Riparian-zone management to restore ecological function

Riparian management is a useful tool to mitigate adverse effects of agriculture on streams. Riparian zones filter contaminants and sediment from overland flow.

Good land management practises are required to complement the riparian zone. There is a need to avoid overstocking, as excessive losses of N from urine patches may occur (Monaghan *et al.*, 2000). Avoidance of soil compaction, the retirement of steep land, protection of wetlands, diversion of road and track runoff away from streams and careful management of fertiliser applications is also necessary.

To avoid adverse effects, streams should be fenced on both sides to allow the growth of a mixture of vegetation. Stock crossings must use well-designed culverts and bridges, which do not affect fish passage. Runoff from the crossings and the tracks leading to them needs to be diverted away from streams. The management of the land must have regard for soil types so that soil processes can utilise fertiliser and effluent that is applied so that excessive amounts do not bypass the soil and enter streams. Stocking densities, stock management and fertiliser application rates need to be related to the ability of the soil to fully contain the production system on the farm, and not let excessive amounts of nutrients “escape”.

Nitrate leaching from dairy farms is typically greater than from other types of farms, and is inevitable with intensive farming operations (DeKlein *et al*., 2000). It can be controlled to acceptable levels, so that groundwater concentrations are not elevated beyond background levels, by careful management of soils and pasture. Ideally, the use of nutrient budgets (e.g., OVERSEER™– a computer programme devised by AgResearch), in conjunction with soil test information, is the best available tool for evaluating nutrient use efficiency on individual NZ farms.

Phosphorus losses pose a risk to most surface waters since this is usually the limiting nutrient. Phosphorus losses can be greater from soils where dairy effluent is sprayed (Condron *et al*., 2002). Reduced irrigation rates may be needed where this is occurring.

Artificial drains are designed to take water rapidly from the soil profile to avoid saturation and reduced plant growth. However, water in fertile soils contains elevated concentrations of dissolved nutrients. The drainage systems facilitate the loss of fine sediment, bacteria and some nutrients, notably phosphorus, which is attached to sediment particles, to streams.

Mechanisms to reduce the loss of nutrients from farms into waterways

Wetlands are advocated as a mechanism to trap and utilise these contaminants but careful construction and maintenance of these is needed. Nguyen *et al*. (2002) found seepage wetlands reduced nitrate loss provided flows were low, but increased ammonia, dissolved organic nitrogen and particulate nitrogen in outflows. Matheson *et al*. (2002) found there was removal of nitrate in riparian zones mainly by denitrification, rather than plant uptake. They recognised, however, that there are a number of pathways for nitrate removal and active management of the riparian zone may be needed to optimise this process.

In addition to riparian zones, environments in drainage ditches can reduce the transport of contaminants from pastures to waterways. Nguyen *et al*. (2002) found that ammonia and phosphorus was removed from a mixture applied to a drainage ditch as it flowed along the ditch. Sedimentation, and incorporation into plant and bacterial tissues were the purported methods of attenuation. Faecal bacteria derived from cow faeces were removed from water in drainage ditches. Slow water flows and high plant biomass was needed in the ditches for this to be effective.

The disposal of dairy-shed effluent to land can also lead to stream pollution. Problems with the non-uniform distribution of the effluent from current irrigation systems, and application of effluent onto land where the depth of application exceeds the soil moisture deficit, especially where mole and tile drains exist in heavier soils, are causing serious difficulties at the moment (Monaghan *et al*., 2002). In addition long term application of effluent may adversely affect pasture quality and animal health. Storage of effluent in anaerobic/aerobic ponds so it can be applied during drier times of the year appears necessary to avoid direct drainage of effluent from soils with mole and tile drains. Horne *et al*. (2002), reported reduction or elimination of pathogenic organisms from the effluent drainage using this system too.

Winter grazing/feedlots

Winter grazing on brassica crops is a problem on heavy or sloping soils (Monaghan et al. 2002). Soil compaction results in reduced infiltration, which in turn leads to increased runoff to surface water.

Surface water runoff to streams from bare soil carries silt, nutrients, and organic wastes to watercourses. To reduce adverse effects, the crops should be on flat land of an appropriate soil type with a generous riparian zone isolating the crop from any stream. Winter grazing paddocks could ideally be sited one paddock away from any stream, thus ensuring a large grass “buffer” paddock”exists. “Back-fencing” the grazing herd would allow soil infiltration rates to recover following grazing, thus reducing the volumes of surface runoff generated.

Ideally a well-designed feedpad, well away from any stream, which collects effluent for later disposal, is required to ensure soils, streams and water quality is protected. Such systems can increase pasture production, significantly reduce nitrate loss and can be cost effective (DeKlein *et al*., 2000).

CONCLUSIONS

Riparian zone protection and management is a basic requirement for the protection and restoration of water quality in intensively farmed catchments. There is abundant evidence that intensive dairy and deer farming is unsustainable unless riparian protection is implemented and maintained. In addition, careful land management of soils, fertiliser and effluent is required to ensure that transport of contaminants from farmed land to streams does not occur.

The livestock industry and regulatory authorities have a responsibility to undertake further research. Results of this research must be applied to the industry to ensure its economic viability is secured and its environmental effects are reduced to levels where increases in nutrients, sediments and pathogens are not elevated in streams and rivers in, or downstream of, intensive farming areas.

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