Abstract

Climate change mitigation for agriculture: water quality benefits and costs

R Wilcock, S Elliott, N Hudson, S Parkyn, J Quinn

National Institute of Water & Atmospheric Research, P.O. Box 11-115, Hamilton, New Zealand

New Zealand is unique in that half of its national greenhouse gas (GHG) inventory derives from agriculture--predominantly as methane (CH_4) and nitrous oxide (N_2O), in a 2:1 ratio. The remaining GHG emissions predominantly comprise carbon dioxide (CO_2) deriving from energy and industry sources. Proposed strategies to mitigate emissions of CH_4 and N_2O from pastoral agriculture in New Zealand are:

(1) utilising extensive and riparian afforestation of pasture to achieve CO_2 uptake (carbon sequestration);

(2) management of nitrogen through budgeting and/or the use of nitrification inhibitors, and minimising soil anoxia to reduce N_2O emissions; and

(3) utilisation of alternative waste treatment technologies to minimise emissions of CH_4.

These mitigation measures have associated co-benefits and co-costs (disadvantages) for rivers, streams and lakes because they affect land use, runoff loads, and receiving water and habitat quality.

Extensive afforestation results in lower specific yields (exports) of nitrogen (N), phosphorus (P), suspended sediment (SS) and faecal matter and also has benefits for stream habitat quality by improving stream temperature, dissolved oxygen and pH regimes through greater shading, and the supply of woody debris and terrestrial food resources. Riparian afforestation does not achieve the same reductions in exports as extensive afforestation but can achieve reductions in concentrations of N, P, SS and faecal organisms. Extensive afforestation of pasture leads to reduced water yields and stream flows. Both afforestation measures produce intermittent disturbances to waterways during forestry operations (logging and thinning), resulting in sediment release from channel re-stabilisation and localised flooding, including formation of debris dams at culverts.

Soil and fertiliser management benefits aquatic ecosystems by reducing N exports but the use of nitrification inhibitors, viz. dicyandiamide (DCD), to achieve this may under some circumstances impair wetland function to intercept and remove nitrate from drainage water, or even add to the overall N loading to waterways. DCD is water soluble and degrades rapidly in warm soil conditions. The recommended application rate of 10 kg DCD/ha corresponds to 6 kg N/ha and may be exceeded in warm climates.

Of the N_2O produced by agricultural systems, approximately 30% is emitted from indirect sources, which are waterways draining agriculture. It is important therefore to focus strategies for managing N inputs to agricultural systems generally to reduce inputs to wetlands and streams where these might be reduced to N_2O.

Waste management options include utilising the CH_4 resource produced in farm waste treatment ponds as a source of energy, with conversion to CO_2 via combustion achieving a 21-fold reduction in GHG emissions. Both of these have co-benefits for waterways as a result of reduced loadings.

A conceptual model derived showing the linkages between key land management practices for greenhouse gas mitigation and key waterway values and ecosystem attributes is derived to aid resource managers making decisions affecting waterways and atmospheric GHG emissions.

**Correspondence:* r.wilcock@niwa.co.nz

Water Science and Technology 2008, 58(11): 2093–2099. doi: 10.2166/wst.2008.906.