The position of dairy farming amidst N-sensitive ecosystems

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Abstract

The Water Framework Directive (WFD) requires adjustments in Dutch land use. A modelling study was carried out to find out how a specific N concentration in water can be achieved through a combination of land use and farm management. The study indicates that farms with a high production level per ha, may only have a future if they recycle N efficiently. Even then they should be surrounded by a substantial amount of conserved or rehabilitated natural areas.

Keywords: ammonia, dairy farming, eutrophication, land use, nature, nitrate

Background and objectives

According to the EU WFD (Anonymous, 2000) member states must promote the ecological quality of waters bodies and hence take measures to reduce the concentration of various compounds among which nitrogen (N). A good ecological quality may require a N concentration < 5 ppm N. Agriculture is the major source of N. As targets of the WFD refer to the spatial scale of river basins, the cumulative effect of all farms together as well as surrounding non-agricultural land use must be considered. However, farming in general and intensive dairy farming in particular is the dominant form of land use in many parts of the Netherlands. Adjustments of the dairy industry may thus be needed.

The N load from farms into the environment equates the product of input inefficiency and input level, implying that even efficient systems can be environmentally questionable whenever their intensity i.e. input level is high. Conversely, low input systems are not 'clean' by definition. The N efficiency of a livestock farm can be increased by avoiding luxury protein consumption, thus reducing manure production, and abating N losses associated with manure recycling (Schröder, 2005). Existing variation justifies to treat the (in)efficiency level together with production intensity as variables rather than as fixed points of departure. Production intensity also determines evapotranspiration and thus the precipitation surplus from agricultural land, being the other determinant of the N concentration.

Natural areas can have a diluting effect on the ultimate N concentration. However, their diluting effect becomes disproportionally smaller the larger the relative share of agriculture, as ammonia immissions from agriculture into natural areas wear off their diluting effect. Land use and production intensity further interact as a targeted regional milk quota can be produced on either a large number of extensively managed hectares leaving relatively little room for undisturbed nature but yet fostering farmland nature, or on a small number of intensively managed hectares poor in wild life themselves but amidst saved 'undisturbed' nature. These feedbacks require a regional analysis of the combined effects of land use and management within farm boundaries on milk production, on nature and on water quality. The present study explores how much non-agricultural land is needed as a function of the targeted N concentration in receiving water bodies and the characteristics of farming and nature, through a modelling approach.

Materials and methods

In our approach we adopted only two types of land use: 'nature' and 'dairy farming'. We combined simple models of the water balance and N flows of both types of land use. In-farm N fluxes and conversion efficiencies and consequent N loads into soil and air were based on Schröder *et al.* (2003). Precipitation surplus (PS, mm) in agriculture was described as a function of crop N yield (NY, kg N per ha.yr) according to PS = *MIN* (450; 450 –

1.33 * (NY – 200)) for NY < 275 and PS = 350 for NY > 275). N load to the soil under nature was set equal to the product of volatilized ammonia-N per ha agriculture and the land use fraction agriculture, reflecting our simplification that all ammonia-N volatilized from agriculture was supposedly deposited within regional boundaries. Assumed precipitation surplus in natural areas was fixed at either 200 (pine forest) or 300 mm (reed) reflecting the differences of rainfall interception in leaf canopies (Bouten *et al.*, 1992; Roth & Mellert, 2004). We assumed that in agriculture on average 50% of the soil N surplus denitrified, whereas in natural areas we allowed this value to range from 75% (reed) to 25% (pine forest) (Schröder *et al.*, 2005). Variables and parameter settings are presented in Table 1.

Table 1. Variables and parameter settings in scenario studies.

Land fraction	Variable		Low	High
Water	Targeted N concentration		1 ppm	12 ppm
Farm	Milk production		9,000 l per ha.yr	13,000 l per ha.yr
	Dietary protein		15% in DM	20% in DM
	Manure management quality	Gaseous N losses from housing and stores	30% of the TAN* excreted	20% of the TAN* excreted
		Gaseous N losses from land spreading	50% of the TAN* applied	10% of the TAN* applied
		Mineral soil-N recovered by crops	50-70%	60-80%
			Wet: 'reed like'	Dry: 'pine forest like'
Nature	'Nature' of nature	Precipitation surplus	300	200
		Fraction of N soil surplus which is denitrified	75%	25%

* *TAN = total ammonia-N*

Results and discussion

Acknowledging that 1) N and water fluxes may cross regional boundaries, 2) in real life there are more forms of land use than just dairy farming and nature, and 3) ecological quality is not merely determined by N nor is it just needed in receiving water bodies, our explorations yet reveal that there are numerous pathways to similar destinations in terms of milk production, nature and environmental quality. Obviously, the need for non-agricultural land use increases the stricter the targeted N concentration (Figure 1A). Our analysis shows that non-agricultural land use could be considerably smaller to attain a specific N concentration, if the dietary protein content would be reduced from the common 20% to 15%, or if manure management would be adjusted to ambitious but attainable levels (Bannink *et al.*, 2005; Schröder, 2005). Figure 1B shows that the type of nature has a considerable effect on the need for non-agricultural land use. The diluting effect of 'pine forest'-like nature is smaller than that of 'reed'-like nature. More agricultural land use would be possible with lower levels of milk production per unit area. Note that the regional milk production is slightly larger with many low productive hectares than with fewer high productive hectares. This is due to the disproportional rise in ammonia emission into natural areas when the fraction of agricultural land use increases (Figure 1C).

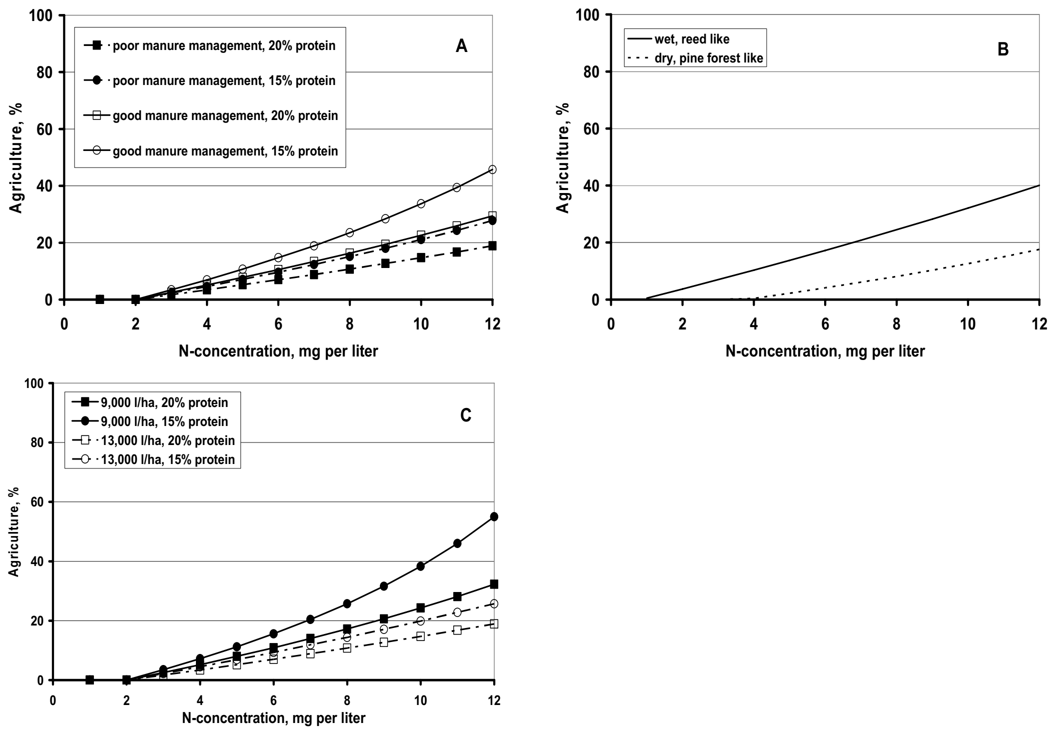

Figure 1. *Allowable fraction of agricultural land use, as affected by the targeted N concentration and (A) manure management and dietary protein content, (B) the type of nature, and (C) milk quota per ha agriculture and dietary protein content (in each graph the non-varied factors were fixed at intermediate levels).*

Conclusions

The WFD does not necessarily put an end to intensive dairy farms provided that these farms drastically improve the use efficiency of N, and save or rehabilitate sufficient hectares for nature through permanent set-aside. Arbitrary but legitimate choices concerning ones definition of nature (i.e. farmland nature *vs.* saved wilderness), appear to determine whether regional targets of milk production and water quality should be achieved by a small number of hectares with intensive farms or by a large number of hectares with extensified farms.

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