

By Jane Fisher and Tom Barker



The changes in agriculture implicit in ZCB can be expected to have significant impacts on the ecological and chemical qualities of freshwaters because of increased nutrient flows from farmed land into water bodies, which always lie at the lowest points in the landscape. The main chemicals entering water bodies from their catchment (surrounding land that drains into the water body) are the plant nutrients nitrogen (N) and phosphorus (P). These nutrients enter lakes directly via overland flow and in streams, and fertilise the water (eutrophication) so that algae (planktonic and attached to surfaces) and plants (macrophytes) begin to make rapid growth.

The process of eutrophication is evident through a number of changes to the ecology of water bodies, including increases in phytoplankton and epiphytic algae at the expense of submerged macrophytes, reduced dissolved oxygen levels in deep water at the expense of fish, increased pH, and reduced light in the water column (Rast and Lee, 1983). These things lower the amenity, aesthetic and conservation value (Moss 1996). In a shallow lake, the macrophytes put on new growth, and may fill the water column, though some species usually disappear (James et al. 2005; Barker et al. 2008). As the eutrophication continues, the macrophytes may disappear entirely, changing the character of the lake into a turbid, often stagnant, pea soup dominated by phytoplankton (Scheffer et al. 1993). This causes wide-ranging changes in species of protists, plants and animals, and the water quality is poor, ugly, sometimes toxic, and expensive to clean (see Moss 2001).

In a deep lake, which has a lower proportion of its water in contact with the sediments, eutrophication can result in

blooms of toxic algae and deoxygenation of the deep water. Both of these degrade the habitat and adversely affect the survival of native fish, plants and crustaceans. In a river, where flowing water prevents the build up of nutrients in the water column, the effects are seen in the survival of plants, invertebrates and fish, and often in the estuary and shallow sea of the river's mouth.

An increase in arable land will thus lead to a change in the rate of export of nutrients and toxins to aquatic ecosystems. Nutrient pollution from both chemical and natural fertilisers has accelerated with the intensification of modern agriculture. The increase in arable agriculture, in contrast to keeping land under permanent pasture, is also likely to increase soil instability, thus increasing the suspended sediment load to lakes and rivers, and is also associated with an increase in P, which travels with soil particles. Conversely, a reduction in pasture and intensive animal units will probably lead to a reduction in point source loading of P, which is an important source of nutrient pollution. Additionally, more arable agriculture frequently is associated with enhanced use of pesticides, which also migrate to surface and groundwaters and are toxic to freshwater organisms as well as humans. Together, these changes have strong potential impacts on freshwater ecosystems and biodiversity, and may impair water quality if not managed sensitively.

In summary, more arable agriculture may lead to:

- More eutrophication and consequent ecosystem degradation;
- Enhanced sedimentation rates;
- Increases in toxins from pesticides;
- Loss of native species.

Less area to pasture is likely to lead to:

- Less eutrophication due to phosphorus;
- Less pollution from complex organic matter such as slurry and therefore fewer instances of high BOD (Biological Oxygen Demand – a major factor in the health of aquatic organisms) in receiving waters;
- Less poaching (by hooves) at waters edges, and damage to riparian vegetation;
- Loss of low grassland swards and poached wet fields and their associated flora and fauna (including BAP (Biodiversity Action Plan) species such as lapwing).

Waters in catchments dominated by pasture tend to have low N:P ratios, while those in arable areas tend towards high N:P ratios depending on the amount of nitrogenous fertilisers applied (Arbuckle and Downing, 2001). The geographical variation in P and N loading is especially marked in Britain, where livestock dominate the steeper slopes and higher altitudes, which also receive greater annual precipitation. Such areas are vulnerable to erosion and loss of soil particles with associated P, and leachate from manure that is relatively P-rich (Arbuckle and Downing, 2001). Total loss of N and P in runoff (i.e. to water bodies) can be greatest in arable landscapes, where the soil contains a low proportion of binding organic matter and usually is bare for part of the year (Johnes 1996).

Soluble forms of key nutrients are particularly easily transported, and will have to be carefully managed in a ZCB scenario. Nitrate (NO_3) is more concentrated in groundwater, as it is highly soluble and can be transported at depths below that intercepted by plants (Horne and Goldman, 1994). Ammonia (NH_3) and P adhere to clay particles, and are transported to lakes via mass-movement or in sediment-laden surface waters, as well as in dissolved forms (NH_4 and PO_4). Geographical variations in geology and soil type are the main influences on the balance between surface and ground water drainage, and can be a guide to mitigation measures. Clay-rich soils are relatively impermeable, and result in greater surface run-off (Sonzogni, 1980) and associated sediment-attached P loss. More porous soils allow greater vertical movement (leaching) of water in the soil horizons, or even as ground water, which favours the transport of dissolved N, rather than P (Kolenbrander, 1972). These tendencies have been noted in the field where Mcclay et al (2001) found that groundwater nitrate increased under arable land-use. For these reasons, controls on additions of fertilisers and means of reducing leaching and intercepting runoff will be critically important for ZCB. This is all the more important today when the total amount of global nitrogen fixed by anthropogenic activity now exceeds that by all natural processes combined (Vitousek 1994).

Estuarine and coastal waters tend to be nitrogen limited and therefore are vulnerable to eutrophication from increased arable agriculture. Eutrophication in coastal waters in particular can cause toxic 'red-tides' from dinoflagellates, which are toxic to fish and shellfish, are damaging to fish stocks and threaten marine and human health.

Recommendations

- Maintain and extend conservation buffer strips alongside hedgerows to allow predators of crop pests to flourish and provide seed and cover for birds;
- Maintain and extend riparian buffer strips and wetlands to intercept nutrient pollution, promote denitrification of N-rich runoff and intercept toxins;
- Ensure year-round ground cover of arable land, for instance by leaving winter stubble, to reduce soil erosion and provide winter feeding for birds;
- Consider soil health and sustainability by reapplying organic matter, including crop and animal waste in preference to inorganic fertilisers;
- Reinstate hedgerows to aid soil protection and biodiversity, including abundance of crop pest predators;
- Promote pasture and low-intensity cattle or sheep grazing on marginal land, including uplands and wetlands, where grazing for conservation can maintain bird nesting and foraging sites, and rare flora and insect communities, and also provide free-range, rare-breed meat and dairy products.

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