Colin J. Macgregor

# Qualitative methods offer insights into socio-economic and landuse: Influences on coastal environments


## Abstract

Nutrient concentrations (N, P and K) determine the extent to which surface water courses, and therefore coastal estuaries, are or may become eutrophic. The degree of eutrophication directly impacts on the biological health and even the geomorphic processes of such systems. Water quality testing easily identifies point sources of pollutants but when concerned with diffuse sources, such an approach yields little useful information.

Agriculture has been identified as a major diffuse polluter but the actual extent of its contribution and the reasons for its occurrence are not completely understood. If appropriate management strategies are to be developed to reduce its impact then we must understand the socio-economic circumstances that give rise to such pollution. Also crucial in management is the co-operation of farmers which implies we must understand the attitudes and values of farmers influencing the systems. Understanding present management regimes will also clarify the degree to which these practices are impacting on the environment as well as helping convince farmers of their roles and responsibilities. However, we must also acknowledge that change to more sustainable land management practices will bring impacts to the farmers themselves. These impacts may be minor or major depending upon individual circumstances. It follows therefore that it is important to identify those farmers who will be exposed to significant social and/or economic impacts as a result of conforming to current recommended practices (CRPs) and environmental legislation such as that associated with the EC's nitrate directive (Nitrate Vulnerable Zone).

This paper will discuss the value and use of interpretivist social science methods in natural resources management contexts generally but the Eden catchment in Scotland is a useful area to explore these in detail. Arable and livestock farming dominates landuse in the cathment and there is a history of diffuse pollution which is known to be impacting on the Eden estuary – an area regarded highly as a bird habitat. The catchment has also recently be designated a NVZ so farmers are already starting to think about what confirmation to more sustainable management practices will mean to their operations.

## Introduction

Coastal pollution as a result of nutrient over-enrichment (eutrophication) associated with nitrogen and phosphorous in particular is now regarded as one of the most significant problems associated with coastal ecosystems. In the worst cases such pollution results in harmful and nuisance algal blooms but there are also many other subtler food chain effects. This paper explores some of the most important socio-economic issues associated with terrestrial coastal pollution.

Water pollution is typically categorised according to its source. Point source pollution originates from sources such as pipes or ditches, from wastewater treatment plants or industrial discharges, which drain directly into rivers or the sea. Such sources are easily identified and very often investment in treatment technologies is all that is required to resolve the problems. Often however such investment will only take place where legislative requirements demand but the direct socio-economic impacts are usually constrained to those factory owners and/or local authorities responsible although the economic costs are inevitably passed on to the consumers of their services and/or products.

Diffuse sources of pollution emanate from sources that have no defined point of entry but typically result from rainwater running off the land and picking up pollutants along the way. Identifying and controlling such pollution is a more complex problem because it tends to be associated with land uses rather than easily identifiable operations. Perhaps the most notable land use type known to be responsible for diffuse pollution is agriculture. Historically, coastal eutrophication increased dramatically in the developed world during the 1950s and 1960s when the agricultural benefits of super-phosphate and nitrogen fertilisers were first developed and used with enthusiastic abundance (Boesch 2001). Other agricultural chemicals also affect coastal environments. For example, herbicides can stress saltmarsh diatoms and higher plants, which in turn can increase erosion (Mason *et al.* 2003).

While there has been some progress in reducing point sources of pollution, the same cannot be said of diffuse causes, particularly those associated with agriculture (Skinner *et al.* 1997). As a result, there has to date been very little clearly demonstrated success in terms of improvements in coastal water quality. There is now worldwide consensus that eutrophication, and by implication, the excessive use of fertilisers, must be reduced to some less harmful level (Boesch 2001). Excess nitrogen losses to the environment in particular are acknowledged as having serious environmental impacts. Responding to this, the European Union (EU) has introduced its nitrate directive. Under this directive Nitrate Vulnerable Zones (NVZ) have been and are being established throughout Europe. In essence, NVZs identify pollution sensitive areas (often river catchments) where stricter management controls over the use of fertilisers and organic manure are enforced in an effort to prevent nitrogen pollution.

While legislative initiatives have an important role to play, improvements in agricultural pollution will only occur with the cooperation of farmers. It follows that it is necessary to understand the socio-economic conditions that give rise to agricultural pollution before strategies can be developed to address the causes. We must also understand the attitudes and values of farmers influencing coastal systems. Their present management practices must also be understood in order to determine the degree to which their specific practices are actually impacting on the environment. All such information should help 'convince' farmers of their roles and responsibilities and so gain the support necessary for change to take place.

We must also acknowledge that change to more sustainable farm management practices will have direct socio-economic impacts on the farmers themselves and unlike point source polluters who can pass on the economic impacts to their consumers, no such option is available to farmers. This is because prices for agricultural commodities are either pre-set by the European Union (EU) or the supermarket supply chains with little regard to the costs of production. Of course, the economic impacts on farmers will vary depending upon individual circumstances so it follows that it is also important to identify those farmers who will be exposed to significant social and/or economic impacts as a result of conforming to the current recommended practices (CRPs) and environmental legislation such as that associated with NVZ status.

The research behind this paper is concerned with two central research questions. First, what are the socio-economic and farm land use/management practices most likely to cause eutrophication in coastal areas; and second, what types of farming are the greatest concern and who will suffer the most as a result of enforced environmental management?

## Methodology

### *The Eden catchment and estuary*

The Eden catchment of Fife, Scotland makes an ideal case study site to investigate the socio-economic factors associated with adopting sustainable land management practices in an agricultural context. The catchment lies in eastern Scotland (Figure 1) and has two main rivers associated with it; the Eden River, which roughly dissects the catchment from west to east, and the Motray Water in the northern part of the catchment. Both these rivers drain into the Eden estuary at the village of Guardbridge.

The Eden catchment extends over an area of approximately 320 km$^2$ (TRPB 1994) the majority of which is drained by the River Eden (some 260 km$^2$). The Eden River itself rises in the Ochil Hills, not far from Loch Leven at around 220 meters above sea level but the majority of the catchment is low-lying and gently undulating.

The major land use in the catchment is arable farming and approximately 76 percent can be regarded as high quality agricultural land with very fertile soils or imperfectly drained brown forest and alluvial soil types (ECN 2002). The underlying geology comprises Devonian and a Carboniferous stratum, the former of which includes the most productive aquifer in Scotland, the Knox Pulpit formation (Robbins 1990). There is a small salmon run to the river and otters are also present (ECN 2002). Annual rainfall of the catchment varies from approximately 1,000 mm in the upper catchment to around 600 mm at the Eden estuary (TRPB 1994).

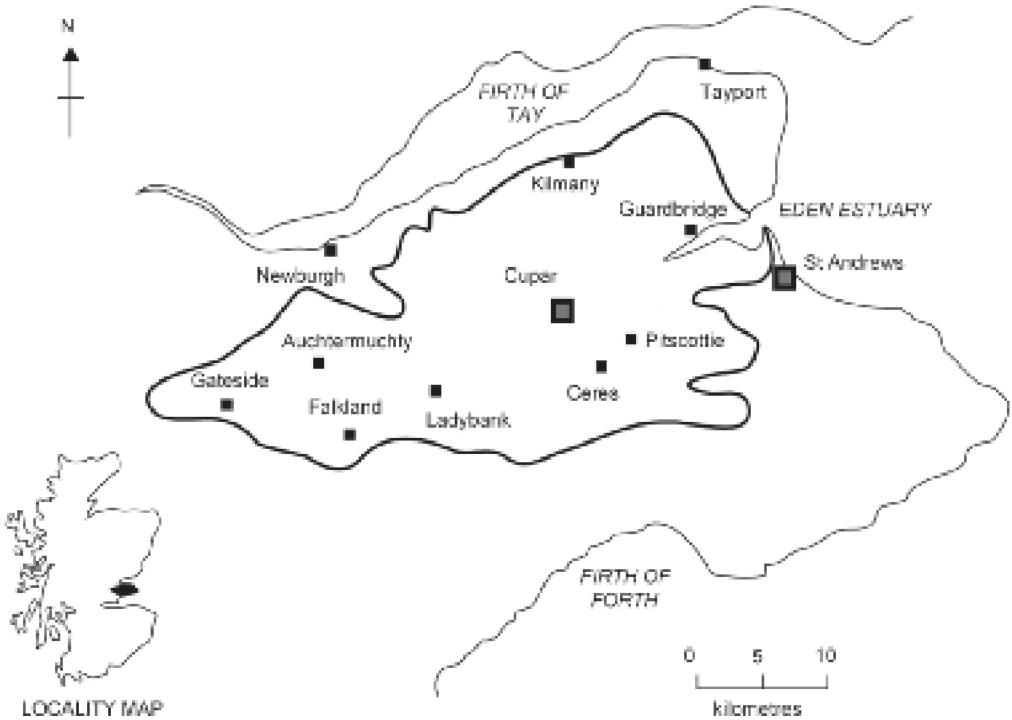


Figure 1. The Eden Catchment of Fife, Scotland

The Eden's estuary forms the Eden Estuary Local Nature Reserve, which is regarded as an important over-wintering site for wildfowl and waders (ECN 2002). Water is abstracted from groundwater, the river and its tributaries for irrigating crops (at present there is no licensing or restrictions on abstraction).

Although treated sewage is discharged to the rivers of the catchment from several small communities and from the town of Cupar (population 9,700), it is the effect of diffuse inputs from agriculture that is believed to be critical to river water quality and the ecological health of the estuary (SEPA 1996). Concern over the quality of drinking water from the Balmalcolm borehole led to a small area within the catchment (approx. 5 sq. kms.) just to the south of Ladybank, being designated a NVZ in 1996.

Despite some minor improvements in surface water quality in the catchment (the result of improvements to the various sewerage treatment plants in the 1980s), in January 2002 the Scottish Executive made it clear that the remainder of the Fife region, including the River Eden catchment, would also be designated a NVZ (Scottish Executive 2002). Later, in January 2003, the Action Programme measures under NVZ designation came into force (Scottish Executive 2003), making the timing of this research particularly relevant.

### *Qualitative methods in environmental social science contexts*

Mention social science methods to people not familiar with the various techniques and their initial thoughts are of questionnaires or perhaps telephone interviews. It is certainly true that a considerable amount of social science research is conducted using such methods and they certainly have some notable assets. For example, they allow a sample of the population to present their views and where the sample is sufficiently large and random, they can relatively accurately represent the views of a community as a whole. However, such methods are usually associated with positivist approaches and these tend to be constrained and limited by *a-priori* assumptions about the research questions (hypothesis testing). As such, they afford limited dynamic interaction and can only usually represent a snapshot in time. The alternative to positive approaches are interpretivist approaches. These usually rely on qualitative data and so offer the opportunity to explore the full range of issues associated with the research question/s. Data acquisition is developed bottom-up rather than top-down and while this can generate enormous quantities of data, there is a risk that some of it may be regarded as superfluous or even irrelevant to the research question/s. In short, positive quantitative approaches imply smaller data quantities derived from a larger sample of the population. Interpretivist qualitative approaches imply large amounts of data from a small population sample.

The approach adopted in this type of research lies somewhere between these two. Commonly known as the General Inductive Method (GIM), the approach is typically used where there are specific research objectives as is the case in this study (this research had a number of specific research objectives). Such research objectives imply a deductive methodology however, as the name suggests, the inductive component is regarded very highly and by allowing the data to influence the outcomes the issues that are important to the informants are not lost.

Most researchers using the GIM collect data from interviews and since there are specific research objectives and questions, it is important to exercise some control over the interview process. This ensures the interviews stay on the subject of concern, otherwise considerable time can be spent discussing and ultimately examining issues that have little relation to the main aims of the research.

Following interviews, the inductive process essentially involves a series of steps that include close readings of transcribed interviews and coding sections of the text according to dominant themes or categories. These categories may also be linked with other categories in various ways such as a network, a hierarchy, or perhaps causal sequences.

### *Establishment of the Agricultural End Users (AEU) group*

While this paper is restricted to reviewing the findings associated with the two research questions stated above there are other research questions which demand more continuous input from the informants. It was therefore decided that a group of farmers would have to be identified that would be prepared to remain in the project until the end of 2005 (Agricultural End Users (AEU) group).

There are approximately 127 individual farms in the Eden catchment[1]. Although true statistical representation is both difficult and unnecessary in interpretivist research of this kind, it was nevertheless acknowledged that it would be useful if the membership of the AEU group was generally representative of the whole farm population. It was considered that an AEU group of approximately 30 informants fell within realistic expectations for the project.

Identifying farmers to make up the AEU group involved a stratified sampling procedure, which considered the location of the farms, the type of farms and the size of farms. Most farmers identify themselves in British Telecom's *Yellow Pages* © and the various localities of the catchment can be mapped according to telephone prefix codes. Initial meetings with farmers enabled the stratification to take place.

Two interview times were agreed upon. The first of these explored attitudes and management practices. Questions first centred on developing a farm profile. Then environmental deterioration, river and estuary quality, general farm management, nutrient management, the Eden as a Nitrate Vulnerable Zone (NVZ), set-aside and buffer strips, governmental financial support, and a range of other 'progressive' farm management issues were explored. The second interview was used to gather more detailed farm data in order to allow an estimate of nutrient balance to be made for the farms (a nutrient budget).

*Nutrient Budgeting*

The Nutrient Budget (NB) is a management tool that can help land users, particularly farmers, account for the flow of nutrients (nitrogen (N), phosphorous (P), and potassium (K)) through the farm system, thereby identifying losses which can allow management decisions to be made that may reduce losses to a minimum (Sheaves 1999). Figure 2 summarises how nutrient inputs, outputs and losses typically occur on farms.

Figure 2 demonstrates that nutrient inputs enter the farm system in three ways; two are natural (deposition and mineralisation) and affect all land uses but the third, which is of most concern in terms of potential surpluses, is directly related to farming. Its sources are typically mineral fertilisers, concentrated feedstuffs, roughage (e.g. straw) and seeds or seedlings. Farmyard manure (FYM) and/or slurry can also be a major input when imported to the farm. Outputs take the form of agricultural produce of various kinds. However, the farm is generally inefficient at converting nutrients within the inputs to outputs as produce – this is particularly true of nitrogen, mainly because of its diffuse nature when in the environment. Phosphorus and potassium losses can also generate serious consequences when excessive amounts find their way to the wider environment but these two will not be discussed further in this paper because data analysis associated with them is still continuing.

Losses of nitrogen occur in many areas of the farming process but according to Bergius *et al.* (2002) there are four that are particularly noteworthy. The first two processes account for most of the nitrogen lost in the cycle. These are:

[1] The median farm size of farms involved in this study was 192 ha. There is approximately 24,320 ha of farmland within the catchment, therefore, 24320/192 = 126.66.

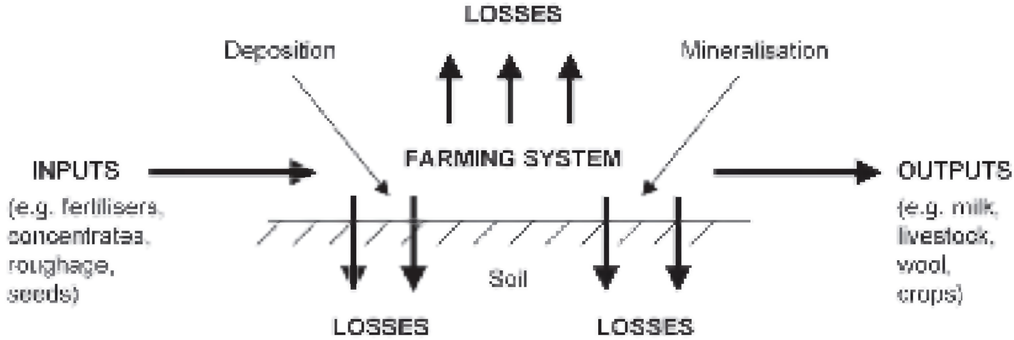


Figure 2. Nutrient flows within a typical farm enterprise (adapted from Sheaves 1999)

1. Denitrification – bacteria change nitrate in the soil to atmospheric nitrogen which joins the atmosphere.
2. Volatilisation – turns urea fertlilsers and manures on the soil surface into gases that also join the atmosphere.

Both of these are a serious concern; volatilisation produces ammonia which contributes to the greenhouse effect and acid rain, and while losses of this kind can vary considerably, they can still be significant. For example, Sheaves (1999: 5) notes that 'it is estimated that overall on an average dairy farm 100 kg of N/ha per year are lost this way from manure alone'. Fertliser use and the ageing and dying parts of plants can add considerably to this figure. As a general rule we can assume that the higher the nitrate content of the soil, the greater is the risk of evaporation.

All losses of nitrogen are environmentally undesirable but for this study it is terrestrial losses associated with the remaining two forms of loss that are of most concern because it is these that directly impact on the coastal system. These are:

3. Runoff – water carries nitrogen from fertlisers, manure and soil into rivers and streams.
4. Leaching – water carries nitrates deep into the soil profile where plants can no longer access them. This ultimately creates a groundwater quality problem.

In simple terms, nitrogen not lost to the atmosphere or incorporated in the outputs of the farm finds its way to streams and/or groundwater and ultimately to the Eden estuary. While some of this lost nitrogen enters the underlying aquifer much still comes to the surface or the estuary by way of springs and seeps. In terms of nutrient budgeting one must also note that much of the nitrogen lost to the atmosphere by way of (1) and (2) effectively returns to the land indirectly by way of deposition.

There are essentially two methods of conducting whole-farm nutrient budgets. The field-by-field method (e.g. AgResearch 2002) examines inputs, outputs and surpluses for all fields in the farm and then combines these to produce a whole-farm result. The advantage of this method is that it allows the farm manager to consider and target changes in management for individual fields. Clearly this method is particularly suited to individual farmers. However, a more immediate and less 'data-hungry' method is the farm-gate method (Lanyon and Beegle 1989). This method is useful when one is concerned with catchment-scale analyses involving a number of farming enterprises. Consequently, it is the second method that was adopted for this study.

Data variables required for farm-gate nutrient budget estimates include the following:

- The area of land farmed – this must be broken down into crops, vegetables, pastures and non-production areas.
- Livestock on the farm – this accounts for all animals on the farm for the year under consideration. Animal numbers are multiplied by their respective livestock units (LU) value to determine an overall carrying load. Manure and urea deposition can then be estimated from these. Stock weight gains over the year must also be accounted for as outputs.
- Milk production – total for the year.
- Wool production – total for the year.
- Livestock feeds – this takes account of all imported feed-stuffs of any kind. The N P and K values of the different feeds must also be noted.
- Roughage – any hay, silage or straw that is either imported or exported from the farm.
- Crops and seeds – seeds and/or plant seedlings brought onto the farm and their weight and N P K content must be identified. Likewise, in terms of outputs, all yields from crops must be noted along with their respective N P and K contents.
- Organic manure – for a farm-gate analysis the only details that necessarily must be recorded is FYM and/or slurry that is either imported or exported from or to the farm. Different types of organic manure have differing levels of N P and K (e.g. chicken manure compared with bovine) so this must be considered where necessary.
- Fertilisers – all mineral fertilisers used on the farm must be accounted for with clear statements about their respective N P and K concentrations.
- Legumes – all legume crops fix nitrogen into the soil from the atmosphere so the type of legume and the number of hectares of production must be considered.
- Deposition – precipitation deposits nitrogen directly to the farm. An estimate for the total over the year must be included.
- Mineralisation – again, an estimate of the generation of nitrogen as a result of mineralisation must be included.

Data associated with the above was collected during interviews with the farm managers. This usually took up to 3 hours each (sometimes involving more than one visit) although for farmers who maintained high quality records, the time necessary was considerably less.

At the time of compiling this paper, 33 farms were involved in the study and the median farm size for these was 192 hectares. As mentioned above, the sample was stratified according to farm size, farm type and locality within the Eden catchment. While the distribution of farm types within the sample cannot be considered statistically representative, the stratification is nevertheless approximately proportional to the whole farm population of the catchment. Since farming in the Fife area has above national average production levels and there is multigenerational participation, the selected farms are representative of the type of operation that will continue farming for the foreseeable future.

## Results

### *Findings from initial interviews*

None of the informants felt responsible for any negative environmental impacts either on or off the farm although twelve farmers did express some concern over nutrient exportation to rivers. About a third also said that soil erosion was a potential problem and there were other soil-related concerns mentioned including sub-soil compaction, structure decline and wind erosion.

Not surprisingly, the terrestrial environment was regarded as being slightly more important than the river or marine environment. Personal investments in the terrestrial environment (e.g. shooting interests) seem the likely cause of this slight bias. Productivity and marketing were the primary motivators for ensuring environmental integrity while lack of funds, together with government associated bureaucracy, were the main negative reasons that make continued environmental management difficult.

The health of the Eden estuary was not mentioned by any of the farmers in their responses about water quality despite the fact that this issue was specifically mentioned in a number of questions. More than a third of farmers thought that nitrates were a concern in rivers but further comments suggest this is perceived to be a diminishing problem. When asked about improving river and estuary quality, themes centred on present nutrient management regimes, denial (i.e. 'we're not responsible'), reconciliation (i.e. 'we'll adjust as we have to') and concern about possible future legislative or quality assurance scenarios.

Fences and hedgerows help prevent runoff which helps avoid river pollution and eutrophication (Unwin 2001). Even though most farmers were aware of this, more than half said that they had increased the size of their fields in recent years. While some suggested that this is more likely to occur on arable only farms because it is assumed they can benefit from the removal of fences and hedgerows, there was actually no evidence here to suggest that cereal producers were any more likely to take out fences than the livestock producers.

More than two-thirds of the farmers interviewed use a combination of animal waste and mineral fertiliser on their farms. When asked about management practices that are likely to cause nutrient exportation, the most important themes to emerge were applying excessive nutrients, the rain (including 'bad luck', which is associated with application followed by rain), applying manure to frozen ground, poor timing of applications and inappropriate manure and/or slurry storage. The implication here is that it is the livestock farms that are more likely to indulge in inappropriate practices.

Nearly all the farmers have their soils regularly tested for pH, phosphorous (P) and potassium (K), however, the frequency of testing varies considerably from almost monthly to periods greater than 5 years. Less than a third of the farmers that make up the AEU group test within recommended frequencies (i.e. every 2-3 years). Most farmers keep records of nutrient use and tests but only about half have records dating back more than 10 years, suggesting perhaps that it is only relatively recently that most have been monitoring consistently.

All farmers interviewed were aware that the Eden was being designated a NVZ in 2003 and just about all of the requirements associated with that legislation were mentioned collectively. However, individual's understanding of the requirements and implications varied widely. Most were aware of the closed seasons for nutrient applications and about a third new there would be restrictions on quantities. Storage requirements (silage and slurry) and record keeping were also mentioned by about a third of those interviewed. In terms of perceived impacts, nearly half the farmers thought NVZ status would affect their management practices in some way. Again, comments suggest it will be livestock producers more than cereals producers that will be hardest hit – storage was their biggest concern. Trading dung for straw with cereals producers may provide possible solutions to some livestock producer's storage capacity concerns.

Under the EU's Common Agricultural Policy (CAP) cereal farmers can receive annual payments (approximately £241.20/ha) for the area of land under cereal production so long as they 'set-aside' 10% of their cereal producing land upon which no production of any kind can take place (Moore, Allen and Innocent 2003). Not surprisingly, nearly all the farmers in the group had established some set-aside – usually the minimum required by the Agriculture Area Payments Scheme (AAPS) and all said they had established it to qualify for support under the scheme. Farmers clearly see more benefits associated with set-aside than there are costs. The only concern of any significance is the fact that these areas must be mown in accordance with the provisions of the scheme. Weeds and vermin may also be a minor issue.

The AAPS is by far the most common source of government funding support accessed by the farmers interviewed but this scheme effectively supports production of certain commodities. Other funding schemes of an environmental stewardship-type nature were mentioned but these were not nearly so popular e.g. four farmers were accessing the Countryside Premium Scheme (CPS), two the Rural Stewardship Scheme (RSS) and two the Woodland Grant Scheme (WGS). Views regarding accessing government funding varied. The AAPS was so widespread that most did not even acknowledge that it was funding support. But apart from the AAPS, many expressed apathy or even contempt for other funding schemes such as the RSS or CPS. For example, there were these comments: 'I don't want the commitment', 'I'm not interested', 'It's all too complicated' and 'It's too competitive'. Many also said they 'didn't know what was available' or they 'hadn't got round to it'.

When asked about possible changes in funding allocation under the CAP, nearly all were against such changes. Many also made comments to the effect, 'I'm a producer – not an environmental manager', suggesting perhaps that CAP reforms may bring cultural as well as economic and social impacts. About half the concerns were associated with the geographic distribution of funds and many felt they might be discriminated against on the basis of location. There was also concern about eligibility and the bureaucracy that they thought would inevitably be involved in applying for funds.

Buffer strips (non-production land along field margins) can enhance farm wildlife and help prevent run-off (Leeds-Harrison *et al.* 1996). Half the farmers interviewed said they had established buffer strips and four main reasons were given: to make the spraying of pesticides and herbicides easier, wildlife benefits, access to government funding and to help prevent erosion. Comments suggest there are probably more potential costs to the farmer associated with buffer strips than there are benefits; for example, loss of productive land, potential weeds and pests, fence establishment and maintenance (where there are stock). However, being able to avoid the spray regulations associated with Local Environment Risk Assessment for Pesticides (LERAPs) was regarded so highly that all felt these relatively minor costs were worth enduring.

Developing sustainable farming operations is clearly the way to ensure economic, social and environmental benefits. According to the NGO Linking Environment And Farming (LEAF) *Integrated Farm Management* (IFM) is a whole farm philosophy that provides 'the basis for efficient and profitable production which is economically viable and environmentally responsible…IFM integrates beneficial natural processes into modern farming practices using advanced technology. It aims to minimise environmental risks while conserving, enhancing and recreating that which is of environmental importance' (LEAF 2001). Less than half of the 30 farmers interviewed said they had heard of the integrated farming philosophy but it was clear from the descriptions of those that said they had that only a very few had anything but a very rudimentary understanding of what is implied; for example, 'sustainability' was never mentioned in their responses.

Precision farming involves utilising soil testing, computer and GPS technology to help improve the effectiveness of fertiliser distribution. The technology has the potential to reduce fertiliser costs and minimise wastage. In contrast to integrated farming, more than two-thirds of the farmers understood quite well what was implied by the technology and it turned out that two members of the group had already been experimenting with it.

The contrasting findings between integrated farming and precision farming perhaps demonstrate well how innovative methods will be adopted if it is perceived there are 'true' economic benefits; in this case, cost savings associated with reduced fertiliser use.

Farm Waste Management Plans (FWMP) can be developed for farmers with the intention of providing them with strategies to minimise the risk of diffuse pollution from their farms. When prepared properly, they should address at least four areas of concern: minimising dirty water around steadings, better nutrient use, risk assessment for manure and slurry and the management of water margins (SAC 2002). More than a third of the farmers in the AEU group said they had prepared a FWMP. However, further questions exploring these plans suggested that the vast majority were brief statements concerning the disposal of farm waste e.g. plastic containers, tyres etc. In fact, the responses here indicated that most farmers, in thinking of their FWMP, were actually referring to very minimal statements demanded by product quality assurance rather than comprehensive strategic waste management plans.

Further discussion associated with these interviews will follow after the section attending to nutrient budgeting.

*Findings from the nutrient budgets*

At the time of writing this paper, 30 farms had supplied full datasets for the NBs. These included 4 dairy or intensive livestock farms, 16 mixed farms and 10 arable only farms. The total area comprising these farms is 8,832 ha which is equal to approximately 34 % of the farming area of the catchment. NBs were calculated for the year that started at the beginning of November 2001 and ended at the end of October 2002. While it is extremely difficult to estimate how much of the surplus was lost to the atmosphere, results suggest that farming in the area is making a very significant contribution to nitrogen pollution at the estuary. As Table 1 shows, all the farms in this sample were showing N surpluses to a greater or lesser degree. This finding is particularly significant in light of the fact that all farmers interviewed were unconvinced that they were responsible for any pollution to the system.

For management purposes, it is useful to know what the spatial distribution of farms having the greatest pollution impact on the catchment. With respect to nitrogen use, the NB delivers two notable findings. First, as discussed above, it estimates the nitrogen surplus/deficit for each farm. By expressing this in kgN/ha it offers a way of comparing surpluses between farms. However, it should be noted that comparing farms in this way can be misleading since every farm must be regarded as being unique (the true value of NBs lies in their capacity to monitor individual farms from one year to the next). Also useful is the level of efficiency i.e. what proportion of the N from inputs is converted to output products. Table 1 displays the findings of these

Table 1. Nitrogen Surpluses from Thirty Eden Catchment Farms

| **Farm Ref.** | **Surplus Nitrogen (kgN/ha)** | ***Nitrogen* Efficiency (%)** | **Farm Ref.** | **Surplus Nitrogen (kgN/ha)** | ***Nitrogen* Efficiency (%)** |
|---|---|---|---|---|---|
| 1 | 116.52 | 21 | 16 | 55.54 | 63 |
| 2 | 74.15 | 65 | 17 | 120.28 | 36 |
| 3 | 118.35 | 51 | 18 | 110.88 | 20 |
| 4 | 60.77 | 71 | 19 | 115.68 | 41 |
| 5 | 78.63 | 58 | 20 | 83.22 | 48 |
| 6 | 316.31 | 13 | 21 | 116.46 | 36 |
| 7 | 1460.94 | 28 | 22 | 50.54 | 73 |
| 8 | 370.05 | 17 | 23 | 120.28 | 36 |
| 9 | 76.66 | 52 | 24 | 159.31 | 28 |
| 10 | 50.78 | 68 | 25 | 54.36 | 72 |
| 11 | 97.44 | 27 | 26 | 48.3 | 69 |
| 12 | 138.31 | 37 | 27 | 263.01 | 30 |
| 13 | 111.67 | 44 | 28 | 82.65 | 49 |
| 14 | 105.91 | 62 | 29 | 45.5 | 82 |
| 15 | 58.26 | 56 | 30 | 83.61 | 66 |

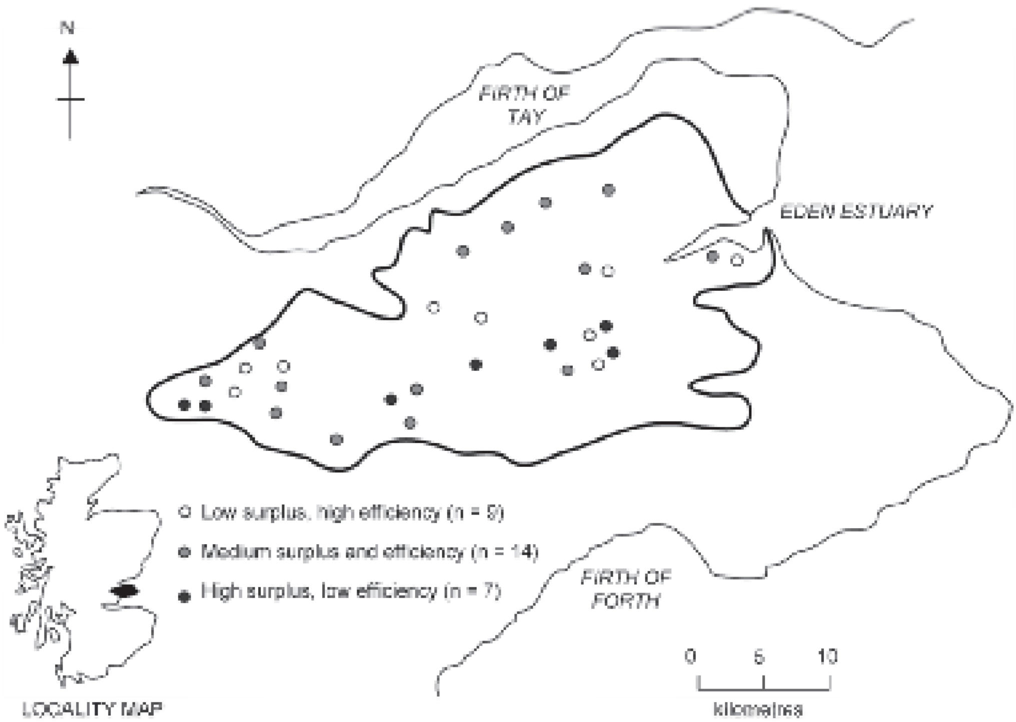


Figure 3. Spatial distribution of farms with estimates of their relative nitrogen pollution impacts

two results while Figure 3 displays the approximate location of the farms with completed NBs[2].

The circular symbols on the map (Figure 3) represent the nitrogen impact from each farm in the catchment. The symbology has been designed to take account of both efficiency and the amount of N per hectare when deriving estimates of impact. For the purpose of display, these have been summarised as: Low surplus, high efficiency (farms with < 100 kgN/ha and > 60 % efficient); Medium surplus and efficiency (farms between 100 and 150 kgN/ha and 30 to 60 % efficient); and, High surplus, low efficiency (farms > 150 kgN/ha and < 30 % efficient).

A review of figure 3 suggests little if any catchment-wide spatial pattern in the distribution of the higher and/or lower agricultural polluters although it could be suggested that there would appear to more higher polluters along the course of the Eden, which runs east to west in the southern part of the catchment. The Motray Water also runs east to west but it is located in the northern part of the catchment, and it would seem that the four farms occupying this area are medium polluters only. There is some water quality evidence (TRPB 1994) to confirm that the Eden has more higher

[2] Confidentiality demands that the exact details of the farms' locations and references cannot be displayed.

polluters than the Motray but with limited cases in the sample, this comment must be treated with some caution. Of more interest perhaps is the relationship between farm type and pollution. Table 2 displays the median surpluses for the different farm types along with their respective median N efficiency levels.

Table 2: Median Nitrogen Surpluses and Efficiencies for 30 Eden Catchment Farms

| Farm type | Surplus Nitrogen (kgN/ha) | Nitrogen Efficiency (%) |
|---|---|---|
| Arable (crops) only (n = 10) | 75.4 | 61.5 |
| Open mixed farming (n = 16) | 113.7 | 42.5 |
| Dairy / intensive livestock (n = 4) | 343.2 | 18.5 |

What is apparent from Table 2 is that the arable farms generated the least N surplus while the dairy and intensive livestock producers produced the most. In fact, the four farms described here as dairy/intensive livestock producers contributed more than 21% of the total N from all thirty farms. In contrast, the arable producers contributed less than 14% despite the fact there were 10 of them in this category. There is a spatial component to this also; rainfall is heavier in the west of the catchment and it is here that most of the dairy farming in the catchment is carried out (higher rainfall produces the richer pastures necessary for milk production). The Tay River Purification Board (TRPB 1994) also observed higher nitrogen concentrations in the Eden in the west compared with the east (approximately 10.5 mg/l and 7.5 mg/l, respectively). All this confirms what was found in the interviews: that the intensive livestock producers and dairy farms are most likely responsible for diffuse agricultural pollution. They will also feel the impact of NVZ legislation the most.

## Conclusions

The fact that none of the farmers interviewed in this study felt they were responsible for river and estuary pollution suggests there is a clear need to demonstrate that farming does produce nutrient surpluses. The findings from the NBs will be disseminated back to the farmers taking part in this study to gauge their reactions and to see if their views and intended management practices change as a result.

Nutrient budgeting is gathering increasing interest in the farming community in Europe. It is a simple but effective way of showing nutrient usage and loss on farms, however, its use in the farming community is not widespread. For example, only one farmer here had had a nutrient budget completed for his farm and this was only because the Scottish Agricultural College (SAC) had done it free of charge as part of a research study. Government farming agencies may need to consider more aggressively promoting the potential benefits of nutrient budgeting (cost savings associated with reduced mineral fertliser use) as part of whole farm management. By way of contrast, we can consider New Zealand's approach to this. The NZ Ministry of Agriculture and Forestry (MAF) has developed a quite sophisticated but fairly user-friendly nutrient budget software package which they will provide free to any farmer requesting it. Perhaps a similar strategy for NVZ designated areas would be appropriate in the UK. and in other EU States.

The farmers interviewed evidently do not readily perceive a connection with their farm management practices and the environment of the coastal zone. Basically, they continue to blame point sources for pollution to rivers and the estuary. The question associated with integrated farming also demonstrates that most lack what could be described as a 'systems thinking paradigm' about their farms and their place in the wider environment. They tend to focus only on what occurs within the boundaries of their farms; this is not to say that they lack concern for the environment but its value seems strongly associated with production motivations. What occurs off the farm seems over-looked or ignored partly at least because there is little incentive to minimise off-site impacts. In light of this it would appear that a legislative approach to encouraging sound environmental management might be the only serious way of ensuring compliance with sustainable practices. The responses of the farmers to the regulations associated with LERAPS regulations perhaps demonstrates well how restrictions can produce positive results – in short, most farmers find it so much trouble to manage pesticide and fertliser spraying close to water coursers that it is simply easier to install buffers. Importantly, few seem particularly troubled by the loss of production land and in some cases, strips were made wide enough (20 meters instead of the required 10 under LERAPS) so that they could continue to obtain an income from the land as set-aside.

One could question whether the current regulations associated with NVZ status go far enough. Arable producers certainly seemed the least concerned about restrictions over the quantity of fertlisers – all claimed they use less that that permissible under the prescribed limits. Certainly, given the results form the NBs, it seems these producers have less to be concerned about than others. Nevertheless, even this group is producing surpluses and it is clear from SEPA's continuing water quality tests of the Eden that a diffuse pollution problem still exists. Again, more widespread use of nutrient budgeting would help clarify what quantities of nutrients are escaping from which farms.

Livestock producers certainly do have some concerns with NVZ status. Their biggest concerns are those associated with the storage of silage and slurry. Many recognise that if they wish to maintain their herd sizes they may have to up-grade their tanks and pits. Most will also have to curb the quantities of fertilisers/farmyard manure they use. While most would probably qualify for a 40 percent grant to help improve their storage infrastructure, they maintain that there is no way to finance the remaining 60 percent; they comment, 'with commodity prices being so low, where am I to get the rest of the money?' Trading dung or slurry for straw with arable farmers seems like it may offer part of the solution in at least some cases but unfortunately, in an NVZ context, the farmyard manure rich farmers may have some difficulty identifying local arable producers willing to take part in such exchanges. One arable farmer in this study had already opted out of such an arrangement he had with a neighbour because of perceived possible NVZ conflicts. Exchanges of this kind may be possible wider afield, i.e. with arable farmers outside NVZs but even if this is possible the expense of transportation is likely to make it prohibitive.

This study did not set out to examine the social impact of CAP reforms but it is clear from comments received that the subsidies associated with it and environmental management are intertwined. For example, there is a strong dependence on income support generated through the AAPS scheme. The average arable or mixed farm in this study grew approximately 120 hectares of AAPS qualifying grains (typically wheat, barley and oil seed rape). This represents an annual income of about £29,000. If CAP reforms result in the loss of this it will surely have knock-on effects that will impact on the farmer's capacity to carry out or experiment with environmentally sensitive practices. Given the farmer's rather luke-warm attitudes towards alternate funding schemes, the shift from a production emphasis to one of environmental stewardship demanded by NVZ status and CAP reforms will certainly not be an easy one. Consequently, it may be some time before there are observable improvements in the quality of river and estuarine water.

## References


Bergius, S., Parkes, P. and Stankevicius, R. 2002. Investigation of Carbon and Nitrogen Cycles in Pig Farming, Socrates European Common Curriculum (05 85 00) Spring semester 2002, Den Kongelige Veterinaer og Landbohojskole, Copenhagen.

Boesh, D. 2001. Agriculture and Coastal Eutrophication, [On-line], Available: http: //ca.umces.edu/ian/commonground/reports.htm [5 October 2001].

Agresearch 2002. Overseer User Manual: nutrient budget programs, Ministry of Agriculture and Forestry, New Zealand.

ECN (Environmental Change Network) 2002. ECN Freshwater Sites – River Eden, Fife Region, Scotland, [On-line], Available: http: //www.ecn.ac.uk/sites/eden2.html [19 April 2002].

Lanyon, L. and Beegle, D. 1989. The role of on-farm nutrient balance assessments in an integrated approach to nutrient management, Journal of Soil and Water Conservation **44**: 164-168.

LEAF (Linking Environment And Farming) 2001. What is Integrated Farm Management? [On-line], Available: http: //www.leafuk.org/LEAF/organisation/ifm.asp [15 June 2002].

Leeds-Harrison, P., Quinton, J., Walker, M., Harrison, K., Tyrrel, S., Morris, J. and Harrod, T., 1996. Buffer Zones in Headwater Catchments. Report on MAFF/English Nature Buffer Zone Project CSA 2285. Cranfield University, Silsoe, UK.

Mason, C., Underwood, G., Baker, N., Davey, P., Davidson, I., Hanlon, A., Long, S., Oxborough, K., Paterson, D. and Watson, A. 2003. The role of herbicides in the erosion of salt marshes in eastern England, Environmental Pollution **122**: 41-49.

Moore, Allen and Innocent 2003. A Guide to IACS and other Agricultural Subsidy Payments for 2003, [On-line], Available: http: //www.mooreallen.co.uk/agriculture/information-extra1.htm [10 June 2003].

Robbins, N. 1990. Hydrogeology in Scotland. London: HMSO for the British Geological Survey.

SAC (Scottish Agricultural College) 2002. The 4-point Plan: Straight forward guidance for livestock farmers to minimise pollution and benefit your business, [On-line], Available: http: //www.sac.ac.uk/corporate/publications.asp [7 July 2002].

Skinner, J.A., Lewis, K.A., Bardon, K.S., Tucker, P., Catt, J.A. and Chambers, B.J. 1997. An overview of the environmental impact of agriculture in the U.K. Journal of Environmental Management **50**: 111-128.

Scottish executive 2002. Fife farmers prepare to discuss NVZs. News Release: SE237/2002, [On-line], Available: http: //www.scotland.gov.uk/pages/news/2002/01/SE5237.aspx [28 January 2002].

Scottish executive 2003. Guidelines for Farmers in Nitrate Vulnerable Zones. The Scottish Executive.

SEPA (Scottish Environmental Protection Agency) 1996. State of the Environment Report 1996, SEPA Corporate Office, Stirling, Scotland.

Sheaves, J. 1999. FWAG's Nutrient Budget Handbook (unpublished), Farming and Wildlife Advisory Group, Prince of Wales Road, Dorchester, UK.

TRPB (Tay River Purification Board) 1994. A Catchment Study of the River Eden, Fife. Technical

Report TRPB 1/94. Tay River Purification Board, Fife.
UNWIN, R. 2001. 'New Initiatives to Control Soil Erosion in England', pages 426-430 in D. E. Stott, R. H. Mohtar and G. C. Steinhardt (eds). 2001. Sustaining the Global Farm. Selected papers from the 10th International Soil Conservation Organisation Meeting, May 24-29, 1999 at Purdue University.