Agricultural environmental management; case studies from theory to practice

A. Frost*, S. Stewart**, D. Kerr**, J. MacDonald*** and B. D'Arcy***

* Soil and Water, Scotland, 4 Bayswell Road, Dunbar, EH42 1AB, Scotland
** Scottish Agricultural College, West Mains Road, Edinburgh, EH9 3JG, Scotland
*** Scottish Environment Protection Agency, 7 Whitefriars Crescent, Perth, PH2 0PA, Scotland

Abstract Six farms were examined, each from a different sector of Scottish agriculture. Surveys were carried out to identify both diffuse pollution risks and options for habitat conservation and enhancement. Financial data were also gathered to determine the current sources of farm income, both from sale of produce and from grants. Whole farm plans were produced aimed at bringing about reductions in diffuse pollution to water, soil and air and also habitat improvements. The assembled information was used to devise a possible agri-environment grant scheme to aid the implementation of the whole farm plans.

Keywords Agriculture; best management practice; diffuse pollution; farm management contracts; grants

Introduction
Agriculture in Scotland, as elsewhere in the EU, is very heavily supported by direct subsidies from government. In 2001, direct subsidies totalled £441 million, a large sum when set against a total income from farming of £273 million (SEERAD, 2002). Net overall farm income averaged just £6,000 per farm for the year 2000/2001, despite the average farmer receiving £26,600 in subsidies. Only 7% of the grant aid was specifically directed to agri-environment schemes. The rest was production support although an additional £30 million was directed to a livestock extensification scheme.

This project examined ways in which agricultural support might be targeted to achieve better results. Six farms were selected in different representative sectors of Scottish agriculture. Surveys were carried out of diffuse pollution risks and of opportunities for habitat conservation or enhancement. Financial data were also gathered by examination of the farm accounts. Costed proposals were produced for each farm to address the various issues identified. These data were then used to examine how such proposals might be supported by a new grant scheme.

The farms
Details of the farms are contained in Table 1.

The land class quoted is that from the national land classification system (MLURI, 1991). It ranges from class 1, the best land, to class 7, land of little agricultural value.

The hill sheep farm carried 1,575 breeding ewes and, in summer only, 70 suckler cows. It had no arable land and neither hay nor silage were produced.

The upland stock farm carried 400 breeding ewes and 45 suckler cows. Almost all the farm was in a grass arable rotation with hay, silage, turnips and barley being produced. Half of the barley was sold off the farm for malting with the rest of the produce being consumed on the farm by the stock.

The lowland stock and arable farm carried 1,000 breeding ewes and 75 suckler cows. One third of the farm was in permanent grass with the rest in a grass arable rotation. Crops
included wheat, oats, barley and silage. The wheat and oats were sold off the farm with other crops being retained for use by the stock.

The dairy farm had 100 milking cows and their replacement heifers. In addition, 200 hill ewes were wintered on the farm. None of the land was arable although it had been in the past. Silage was produced. Considerable quantities of additional feed were brought in.

The lowland general arable farm had no outside grazed stock but did fatten 150 store cattle indoors. Almost all the land was in arable cropping, the best in a rotation including winter wheat, winter barley, spring barley, potatoes and set aside. The poorer land was in continuous winter wheat. Yields were generally high.

The intensive arable farm with vegetables had no stock. Cropping comprised spring barley, winter wheat, potatoes, broccoli, spinach (grown for seed), leeks and shopping swedes. One area was in continuous spring barley with another in continuous winter wheat. The rest was in an arable rotation with the cereals, vegetables and potatoes. There were also 17 hectares of set aside.

The surveys

Surveys were conducted to identify risks of diffuse pollution from each farm and to devise control measures. Habitat surveys were also carried out to assess opportunities to preserve existing biodiversity or to create or enhance habitats where biodiversity has been affected adversely by farming activity. Data was also gathered from the farmers’ accounts on the breakdown of their income between sales of produce and subsidy. Subsidies were split between production support and agri-environmental payments.

Diffuse pollution risks and amelioration measures

Only risks associated with water pollution are considered in this paper although the whole study was wider. Diffuse pollution risks identified fell into six main areas. These included the following:

• Fertilisers and manures. On each farm, a full nutrient budget (including nutrients in brought in animal feedstuff) was carried out. The results of these are given below in Figure 1.

In each case, as soil phosphorus levels were already adequate, it was recommended that phosphate fertiliser inputs be reduced until a balance between inputs and offtakes was achieved. In the case of the dairy farm, achieving balance by reducing fertiliser inputs was not possible as most of the brought in phosphate was in the form of animal food.

Table 2 shows estimates of the nitrogen leached from fields in each farm. All six farms were below the limit of 12 mgN/l (50 mg NO₃/l) set by the EU Nitrates Directive. This limit however is a very arbitrary figure and environmental damage can certainly be caused at lower levels than 12 mg/l. Although contributing a high loading of nitrates, the dairy farm complied with the directive because of the dilution caused by the wet climate resulting in a high excess winter rainfall.

There were also issues arising from spreading of manures and slurries, particularly on

| Table 1 |
|----------|----------|-----------|
| Farm type                        | Area (ha) | Tenure   | Land class |
| Hill sheep                         | 750       | Tenant   | 5 and 6    |
| Upland stock                       | 170       | Owner    | 3, 4, 5 and 6 |
| Lowland stock and arable           | 306       | Tenant   | 3 and 4    |
| Dairy                              | 60        | Owner    | 3 and 4    |
| Lowland general arable             | 190       | Owner    | 2 and 3    |
| Intensive arable with vegetables   | 196       | Owner    | 1 and 2    |
the dairy farm, the upland stock farm and on the lowland stock and arable farm. On each, storage and land-use restraints required spreading during winter periods when the ground was frequently frozen or saturated.

- **Pesticides related risks.** In-field risks were generally addressed by the use of unsprayed water margins. On the intensive arable farm, leaching of residues to groundwater was probably an issue on the sandy raised beach soils. This was addressed by carefully targeting pesticide usage to reduce it to a minimum. Risks associated with pesticide handling in the farmyard were addressed by specifying “Biobeds” (Torstensson and de Pilar Castillo, 1997). Sheep dip was not used on any farm.

- **Farmyard run-off.** This pollution risk was assessed and considered to be significant in several cases. All grossly contaminated run-off should go to a slurry store but lightly contaminated impermeable surfaces always remain. If run-off from these areas also goes to the slurry store, slurry becomes very diluted with rainwater and the risk of pollution during spreading is generally increased. In such cases, a pond and wetland treatment system along the lines of an urban drainage detention pond (CIRIA, 2000) was specified. A typical design appears below in Figure 2.

- **Soil erosion.** Low rates of soil erosion were observed on several farms. In no case was the rate of soil loss sufficiently high to affect the long term productivity of the land even in a time scale of centuries. However, on three farms (upland stock, lowland stock and arable and general arable) there was a significant impact on surface water. In each case, wide buffer strips between the arable fields and the water were specified and in two cases where the soil erodibility was known to be particularly high, additional permanent

---

**Figure 1** Excess of inputs over offtakes

**Table 2**

<table>
<thead>
<tr>
<th>Farm type</th>
<th>Leached N (kg/ha)</th>
<th>Leachate concentration mg N/l</th>
<th>E.C. limit mg N/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hill sheep (fertilised grass)</td>
<td>6</td>
<td>1.6</td>
<td>12</td>
</tr>
<tr>
<td>Upland stock (fertilised grass)</td>
<td>14</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Lowland stock and arable (fertilised grass)</td>
<td>10</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Dairy (silage land)</td>
<td>57</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>General arable (overall average)</td>
<td>19</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Intensive arable (overall average)</td>
<td>13</td>
<td>5</td>
<td>12</td>
</tr>
</tbody>
</table>

Downloaded from https://iwaponline.com/wst/article-pdf/49/3/71/420682/71.pdf by guest
grassed filter strips in water gathering hollows were specified. In one case (the lowland stock and arable farm), further measures such as some type of conservation tillage might have been suggested had not the farmer already been employing a rotation with long grass leys which effectively reduced the potentially high soil losses.

- Water margin buffers. In most cases, fenced water margin buffer strips of at least 2 metres width on flat land and up to 20 metres in steep “at risk” situations were specified. On semi-natural hill land, such water margins were thought to be neither necessary nor appropriate.

- Irrigation water abstraction. Scottish regulations currently impose very little control on abstraction of surface water by farmers for irrigation. One farm (the intensive arable farm with vegetables) did so and another (the general arable farm) planned to do so soon. In each case, it was proposed that the pond to treat farmyard run-off be enlarged to serve the dual purpose of a farmyard water treatment system and a storage reservoir to allow winter flows in the rivers to be used for summer irrigation of crops. The resulting pond would be far larger than the water treatment needs required but would work all the better for that.

**Habitat conservation and enhancement**

A variety of opportunities were identified to conserve or enhance habitat. On most farms these were drawn from the following options:

- grass margins and hedges round fields,
- conservation headlands where arable crops received low or zero rates of agro-chemicals,
- strips of unharvested crops for winter feed for birds,
- management of grazing fields and hay/silage crops for ground nesting birds and other wildlife,
- management of wetland, woodland, moorland and species rich grassland,
- creation of new habitats.
Some of the diffuse pollution measures, particularly the water margins and some of the soil conservation measures, served also to enhance biodiversity.

On the hill sheep farm, current stocking rates were considered to be too high and to be damaging the semi-natural habitats, particularly the heather moorland. It was proposed that sheep numbers be reduced.

Farm accounts
The current source of income to the six farms and their current state of financial health are shown in Table 3. The figures are the mean of three years, 1998, 1999 and 2000.

The profits (or losses) quoted above are the figures before the personal drawing of the farmer from the business. It can be seen that only the upland stock farm was making an adequate profit on the farming business. The profits of all the others were either very low or were making a loss on the farming side of the business. It is interesting to note that the upland stock farm was amongst the most traditional of the farming systems and that this farm contained a remarkably great degree of natural biodiversity. Whilst this does not prove that environmentally friendly farming is always profitable farming, it does prove that it can be so.

Costed proposals
The proposed actions on each farm were split into those aimed at reducing diffuse pollution and those aimed at habitat conservation or enhancement. The data is presented in Table 4.

These annual payments are compared with the current grant aid to each farm in Table 5.

All the proposed measures, both those aimed at controlling diffuse pollution and those aimed at habitat conservation and enhancement, could be brought about for an annual payment to each farmer averaging 31% of the current grant aid in addition to a capital payment averaging out at £26,000 per farm.

The dairy farm was judged to be environmentally unsustainable. Application of a range of best management practice measures would not be adequate. There were two reasons for this. Firstly, because two thirds of the phosphorus input was in the form of animal feed, it was impossible to balance the phosphorus budget without reducing feed inputs. This would force a reduction in cow numbers, making the farm unviable. Secondly, the farming system required much of the slurry to be spread in winter as in summer the land is all used for grazing or silage production. As the soils are at or above field capacity for at least seven months in each year, slurry has to be spread on saturated or frozen land causing pollution problems.

Our suggestion for this farm is that the farmer, who is at normal retirement age, be assisted by a retirement scheme to leave the industry and, as a condition of this, restrictions be placed on future use of the land. Appropriate future uses might include amalgamation with a neighbouring farm to create a larger unit or the establishment of a suckler cow herd with some arable cropping to produce winter feed for the cattle.

Similar problems are likely to arise on other dairy farms with no other enterprise and on other intensive livestock units such as pig farms. The presence of a significant proportion of

### Table 3

<table>
<thead>
<tr>
<th>Farm type</th>
<th>Sales</th>
<th>Grants</th>
<th>Farming profit</th>
<th>Total profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hill sheep</td>
<td>£49,000</td>
<td>£60,000</td>
<td>(£14,000) loss</td>
<td>(£9,000) loss</td>
</tr>
<tr>
<td>Upland stock</td>
<td>£53,000</td>
<td>£34,000</td>
<td>£27,000</td>
<td>£31,000</td>
</tr>
<tr>
<td>Lowland stock and arable</td>
<td>£116,000</td>
<td>£52,000</td>
<td>£5,000</td>
<td>£7,000</td>
</tr>
<tr>
<td>Dairy</td>
<td>£124,000</td>
<td>£2,000</td>
<td>£12,000</td>
<td>£13,000</td>
</tr>
<tr>
<td>Arable</td>
<td>£121,000</td>
<td>£42,000</td>
<td>(£8,000) loss</td>
<td>£19,000</td>
</tr>
<tr>
<td>Intensive arable</td>
<td>£224,000</td>
<td>£30,000</td>
<td>(£70,000) loss</td>
<td>(£40,000) loss</td>
</tr>
</tbody>
</table>
arable land on the farm, either producing feed for the stock or crop for sale would greatly reduce problems by providing an outlet for the slurry and manure.

**Grant proposals**

Currently 93% of the grants being paid to Scottish farmers support production, not agri-environmental measures. As control of pollution and habitat conservation or enhancement are clearly in the public interest whilst increased production is not necessarily so, the balance seems undesirable. In these six farms at least, an increase in the proportion of the total grant aid going to agri-environmental support from 7% to 31% would achieve most of the objectives which might be desired. As Table 3 clearly demonstrates, additional support beyond that required to realise pollution and habitat objectives will still be needed if the farms are to continue in business.

It is proposed to examine what features any enhanced agri-environmental scheme might have. One possible scheme is set out and its merits and potential problems discussed.

**Basic requirements**

Any scheme should be an all encompassing whole farm plan taking account of habitats and wildlife, farming practices, waste minimisation, pollution control and sustainable use of soil and water. Schemes should have the following attributes.

- Schemes, or at least the basic diffuse pollution control parts of them, should be open to all farmers.
- There should be continuity of funding over an extended period (decades).
- There should be regular assessment of the performance of grant funded actions.
- Measures should be regularly adjusted in the light of assessment and of advances in knowledge.
- There should be an individual local contact adviser.

**Table 4**

<table>
<thead>
<tr>
<th>Farm type</th>
<th>Diffuse pollution control</th>
<th>Habitat measures</th>
<th>Annual total $</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capital</td>
<td>Annual</td>
<td>Capital</td>
</tr>
<tr>
<td>Hill sheep</td>
<td>£4,800</td>
<td>£400</td>
<td>£7,500</td>
</tr>
<tr>
<td>Upland stock</td>
<td>£14,400</td>
<td>£2,300</td>
<td>£8,500</td>
</tr>
<tr>
<td>Lowland stock and arable</td>
<td>£7,000</td>
<td>£2,400</td>
<td>£25,900</td>
</tr>
<tr>
<td>Dairy3</td>
<td>£35,600</td>
<td>£500</td>
<td>£10,500</td>
</tr>
<tr>
<td>General arable</td>
<td>£11,700</td>
<td>£1,500</td>
<td>£13,300</td>
</tr>
<tr>
<td>Intensive arable with vegetables</td>
<td>£7,800</td>
<td>£1,800</td>
<td>£9,500</td>
</tr>
</tbody>
</table>

1. Includes capital payment spread over five years
2. Mostly compensation for stock removal
3. Does not address all issues satisfactorily, particularly nutrient imbalances

**Table 5**

<table>
<thead>
<tr>
<th>Farm type</th>
<th>Current total grant payment (year 2000)</th>
<th>Current agri-environment grant payment (year 2000)</th>
<th>Proposed annual payment, not including capital payment</th>
<th>% of current total grant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hill sheep</td>
<td>£57,900</td>
<td>£14,900</td>
<td>£33,800</td>
<td>58%</td>
</tr>
<tr>
<td>Upland stock</td>
<td>£33,700</td>
<td>£4,200</td>
<td>£7,800</td>
<td>23%</td>
</tr>
<tr>
<td>Lowland stock and arable</td>
<td>£60,800</td>
<td>£0</td>
<td>£8,900</td>
<td>15%</td>
</tr>
<tr>
<td>Dairy</td>
<td>£2,900</td>
<td>£0</td>
<td>£1,800</td>
<td>62%</td>
</tr>
<tr>
<td>General arable</td>
<td>£39,100</td>
<td>£0</td>
<td>£5,800</td>
<td>15%</td>
</tr>
<tr>
<td>Intensive arable with vegetables</td>
<td>£23,600</td>
<td>£800</td>
<td>£9,100</td>
<td>39%</td>
</tr>
</tbody>
</table>
• There should be proper scientific monitoring of schemes feeding back to farmers and policy makers.
• There should be local flexibility in goals and methods both at regional and single holding level.
• There should be payment for continuation of past good practice as well as for amending past poor practice.
• Payments should be for positive actions, not for refraining from carrying out negative actions.
• Training for farmers should form an important part of any scheme.
• A manual of Best Management Practices with details of cost, performance, design etc. will be essential.
• Farmers must take a full active part both in drawing up and in implementing schemes.

Proposals
The grant scheme described below aims to address the above issues. It is by no means a complete set of proposals but might be viewed as a starting point from which fuller proposals would be devised. The assumption is made that funding would come from a reduction in the current production based subsidies, transferring increasing amounts of money into the unified agri-environment scheme. Ultimately all support might be provided through this single three tier scheme.

Throughout, the objectives of any measures would primarily be set by the grant giving body but the methods of achieving those objectives would primarily be set by the farmer, in discussion with his adviser. This method of working is aimed at encouraging maximum farmer initiative and will tend to bring about the development in practice of new and innovative environmental improvement options. Whilst environmentalists may know what needs doing, farmers frequently know how to do it.

The initial “bronze” level of the scheme would be open to all farmers and would not involve any competitive element. It aims at diffuse pollution control and, as such, requires to be universal. It would not be compulsory but would be an essential starting point for any state financial support, including the production subsidies whilst they remained. It might be expected that almost all farmers would participate at this level.

Bronze level (mainly diffuse pollution control)
A farm unit and area based payment, scaled by land type, with a flat rate per farm plus a payment per hectare.

Requires:  Diffuse pollution audit, including nutrient budget and waste minimisation,
Habitat audit and archaeological report,
Training for farmer (including basic biodiversity and standards of good farming practice),
Regular ongoing training,
Compliance with agreed plan drawn up by farmer and local adviser,
Accurate record keeping of fertiliser and pesticide use and of farm waste management,
Additional capital payments where capital items needed,
Reduction of stock numbers on semi-natural land to environmentally sustainable levels,
Standard of good farming practice adhered to including compliance with codes of practice (environmental codes of practice, animal welfare codes, farm assurance scheme codes, etc.).
Agreed access provision for public where appropriate,
Regular assessment (2 years initially then 5).
The “silver” level is broadly similar to some existing schemes such as the Rural Stewardship Scheme.

**Silver level (habitat conservation/enhancement)**
Action based payment (i.e. each item done gets payment)
Requires: All bronze items,
Agreed programme of habitat preservation/enhancement actions with targets set by farmer and adviser together taking into account local priorities and farmer’s interests,
Additional training in appropriate areas, frequently by farm visits to selected farms with good practice,
Regular assessment.
The “gold” level is aimed at special case farmers, either with the interest and ability to go further or those with very special habitats. Major parts aim to tap the undoubted practical conservation expertise in parts of the farming community and make it available to all. Only a few farmers might be expected to participate.

**Gold level (additional habitat enhancement)**
Action based payment.
Requires: All silver items,
Additional habitat audit by specialist in particular field,
Further training by specialist (may be government environmental agencies, universities, etc.),
Agreed programme set by farmer with assistance as needed and agreed by specialist,
More extensive management and creation of habitats,
Acceptance of role as “model farm” with teaching role for farmer to visiting groups of silver level farmers (additional payment for time),
Option to participate in writing relevant sections of best practice manual (additional payment),
Option to act as part time local farm habitat adviser (additional payment).

The outline grant scheme set out above has the following advantages.
The Bronze part, mainly covering diffuse pollution control, is open to all and because it is the key to all grant aid, will have fairly universal uptake. Payments in this part of the scheme are not action based, that is the farmer is not being paid to address any particular diffuse pollution problem but to farm in a way which minimises such problems. This addresses to some extent the “polluter pays” principle. Farmers currently causing little diffuse pollution will receive as much money as those currently running “dirty” enterprises. As the good farmers will have little additional to do, they will be rewarded for past good practice.

All sections of the scheme have strong farmer training aspects, something which has been missing in the past. The scheme also aims to draw on the practical expertise which exists in the farming community and to disseminate this knowledge. Too many codes of practice produced by government agencies in the past have been very short on practical detail. For example, The Environment Agency in England recently produced a booklet on best farming practice (Environment Agency, 2001). This is an excellent booklet as far as it goes but is woefully short on practical detail. In a section on “Establishing Crops” it recommends “Non-inversion tillage” but detail of how to do it is limited to three short sentences. If only it was so simple! Unless the manuals contain the information needed to produce the
desired change in methods of farming, they are unlikely to be used. A range of single topic practical booklets is likely to be used more than general all encompassing texts. If advisory publications are to be used, they must be useful practical guides.

The proposed scheme contains the provision for a single adviser to work in a geographical area with farmers in the scheme. The adviser would gain experience of the relevant measures for the area, would get to know which farmers had what expertise to pass on, would be in a position to organise training visits to “model farms” for scheme participants and would simplify access to the scheme. If each adviser covered sixty farms, the cost might be £850 per farm. This is about 3% of the total value of subsidies going to farming.

Conclusions
Current agricultural grant schemes cost large sums of money but produce little environmental gain. In the case of the six study farms, switching about 30% of the current grants to agri-environment schemes would produce large benefits.

A scheme is proposed with the following main features.
• Payment to farmers to adopt an agreed scheme of environmentally friendly farming practices with a flat rate payment per farm plus an area based payment weighted depending on the nature of the land. Participation in this part of the scheme, aimed mainly at diffuse pollution control, would be necessary for access to any other grant aid.
• Additional payments for a range of habitat conservation or enhancement measures, with payments being made for each action undertaken.
• A significant training element including tapping of existing expertise in the farming community, with payments to able farmers to facilitate this.
• The appointment of area advisers, each with responsibility for about 60 farms in one area.
• The provision of a retirement scheme for farmers unable to meet the diffuse pollution reduction requirements with conditions attached to future land use.

Acknowledgements
The authors wish to acknowledge the help of the six farmers, the project steering group and many others who gave their assistance. The financial support of SEPA is also acknowledged.

References