Adapting Agri-Environment Schemes for Greenhouse Gas Mitigation – Observations from U.K. and U.S. Experience[1]

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Agri-environmental schemes have become an increasingly important part of the agricultural policy landscape on both sides of the Atlantic. Such schemes are typically designed to reduce negative externalities associated with agricultural activities, particularly environmental damage, and to enhance the supply of positive externalities or public goods, such as landscape amenities and the provision of wildlife habitat. Increasing concern about the potential impact of global warming from the accumulation of greenhouse gases (GHG) in the atmosphere raises the possibility of adding climate change objectives to the list of those already pursued through agri-environmental schemes. Although agriculture accounts for only 6% of global gross domestic product, the Intergovernmental Panel on Climate Change has estimated that it is responsible for roughly 14% of total GHG emissions (IPCC, 2007). That figure does not include any additional contribution of converting land from forest to agricultural uses. At the same time, since agriculture involves the management of living systems it has the potential to remove potentially harmful elements, particularly carbon, from the atmosphere. GHGs arise in different forms, not primarily as carbon dioxide, at many different stages in agricultural production processes and controlling emissions will require changes in specific agricultural practices across a large proportion of farmed land.

In the paper we review conceptual issues in the use of voluntary programmes to increase agriculture's contribution to GHG mitigation through changes in practices to reduce the sector's own GHG emissions, and through the adoption of carbon sequestration activities. We review basic issues involved in the design and implementation of such programmes (contract and mechanism design) and how climate change objectives might be addressed in schemes that have multiple environmental aims. We review the characteristics and operation of some agri-environmental schemes in the United Kingdom and the United States and how these might be adapted to promote GHG mitigation. The principal U.S. schemes discussed are the Conservation Reserve Program (CRP), which focuses on land retirement and the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP), which focus on improving environmental quality on land in agricultural production. The U.K. focus is on Entry Level Stewardship (ELS) which pays farmers for relatively minor changes in farm practices that have the potential to enhance environmental management over a substantial proportion of the agricultural area.

The challenges of GHG mitigation in agriculture

Smith *et al*. (2007) have reviewed the range of approaches that may be taken towards greenhouse gas mitigation in agriculture. Moran *et al*. (2011, p.99) comment on the challenges in identifying the most cost-effective measures for CHG due to: (a) the large number of potential mitigation measures, (b) the lack of relevant data, particularly on the costs of measures, and (c) the fact that the

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effectiveness of many measures depends on interaction with other measures. They develop short-lists of measures for crop/soils and livestock (mainly dairy and beef) that are relatively well-established and thought to have significant abatement potential. These are illustrated in Table 1. The authors also include the introduction of anaerobic digestion as a separate category.

Table 1a: Short-listed crops/ soils abatement measures

Using biological fixation to provide nitrogen inputs (clover)
Reduce nitrogen fertiliser
Improving land drainage
Avoiding nitrogen excess
Full allowance of manure nitrogen supply
Species introduction (including legumes
Improved timing of mineral fertiliser nitrogen application
Controlled release fertilisers
Nitrification inhibitors
Improved timing of slurry and poultry manure applications
Adopting systems less reliant on inputs (nutrients, pesticides, etc)
Plant varieties with improved nitrogen use efficiency
Separate slurry applications from fertiliser applications by several days
Reduced tillage/ no-till
Use composts, straw-based manures in preference to slurry

Table 1b: Short-listed livestock abatement measures (animal and nutrition management)

Increasing concentrate in the diet – dairy
Increasing maize silage in the diet – dairy
Propionate precursors – dairy
Probiotics – dairy
Ionophores – dairy
Bovine somatotrophin – dairy
Genetic improvement of production – dairy
Genetic improvement of fertility – dairy
Use of transgenic offspring – dairy
Increasing concentrate in the diet – beef
Propionate precursors – beef
Probiotics – beef
Ionophores – beef
Genetic improvement of production - beef

Table 1c: Short-listed livestock abatement measures (manure management)

Covering slurry tanks – dairy
Covering lagoons – dairy
Switch from anaerobic to aerobic tanks – dairy
Switch from anaerobic to aerobic lagoons – dairy
Covering slurry tanks – beef
Covering lagoons – beef
Switch from anaerobic to aerobic tanks – beef
Switch from anaerobic to aerobic lagoons – beef
Covering slurry tanks – pigs
Covering lagoons – pigs
Switch from anaerobic to aerobic tanks – pigs
Switch from anaerobic to aerobic lagoons – pigs

Source: Moran et al. (2011)

Based on these lists of measures Moran *et al*. generate a marginal abatement cost curve for GHG abatement in U.K. agriculture. They conclude that current emissions of GHGs could be reduced by 12% at negative cost, raising the obvious question of why this has not already occurred; there are, of course, many possible reasons. There is considerable heterogeneity amongst agricultural sub-sectors, regions and farms. Much of the information available at this stage on GHG mitigation derives from technical research studies meaning that measures are often untested at the farm level and there may well be differences between the technical analysis and what is possible to achieve in practice. Inevitably too, performance will depend on the skills and abilities of the individual farmers who implement the measures. The analysis is based on the immediate on-farm impacts on GHG emissions, without consideration of potential side effects both positive and negative. These may be significant, such as the co-benefits in increased productivity or improved water quality. Ideally, measures should be assessed on a lifecycle basis but this was not possible in the Moran *et al*. study. There are also questions of wider adjustments following adoption. Thus, for instance there may be rebound effects in that measures that reduce intensity of production in one location might lead to increases and offsetting GHG emissions elsewhere, either within or beyond the UK (see the paper by Blandford, Gaasland and Vårdal in this session for a discussion of changes in the intensity of agricultural emissions under GHG emission reduction policies in Norway). Finally, the position will change over time as information on the measures improves and as further research identifies and refines alternative technologies and approaches.

Despite the challenges, there is clearly scope for change in agricultural practices to mitigate GHG emissions even though there is no single or simple approach. Measures to reduce GHGs can be adopted in many different ways with different impacts in different circumstances, some at low cost. The achievement of substantial reductions will require changes to agricultural systems across a substantial proportion of the land area but in different ways in different contexts. Individual farmers are likely to have far better information on the least cost options for their particular farm than a government agency. This clearly represents a substantial challenge for the introduction of policy measures to encourage GHG abatement.

The requirements for GHG mitigation policy incentives

There is limited information available to set up a system through which individual farmers are incentivised to reduce the impact of their production practices on emissions. Franks and Hadingham (2012) draw attention to difficulties in identifying the most polluting firms due to the lack of agreement on the relevant functional unit against which to standardise emissions. They also note the

challenge of setting emissions targets given temporal variability in yields and hence in emissions associated with factors outside the farmer's control. Indeed, at this stage it may be difficult for government even to set feasible aggregate targets for GHG mitigation in agriculture. However, if GHG mitigation is to be adopted as an objective, either on the basis of a national reduction decision or as the result of the adoption of an international agreement, policy needs to develop on the basis of the limited information that is available. The best should not be the enemy of the good. Any policy measure should promote learning by doing both in terms of testing alternative approaches towards mitigation and revealing information about the costs of on-farm implementation.

Uncertainty on the impact of particular changes in farm activities on emissions in particular contexts and the difficulty of measuring and monitoring emissions from specific sites mean that the most feasible policy approach is likely to be one in which payments are made to farmers to induce changes to their agricultural production systems and management based on the costs that these changes impose on the farm business (see the paper by Boisvert and Blandford in this session). The multiplicity of options within different agricultural systems in different contexts suggests that the government agent will have very limited information on the options and costs faced by individual farmers. Farmers will have better information on the farm level costs of introducing mitigation measures, although they may have limited knowledge of current emissions and there will be a need to disseminate information on mitigation options and their impacts. The design of a scheme will need to address this problem of asymmetric information. Further, it seems unlikely that implementation costs will vary systematically spatially so that there is little basis for addressing the problem through spatial targeting, unless spatial differences in implementation costs can be revealed voluntarily by the implementers (farmers). We may note though that, in contrast to agri-environment benefits more generally, the value of GHG abatement does not vary spatially. This suggests that there is little justification for decentralising decision-making in schemes to the local level. It is likely to be easier to compare the potential value of benefits that can be generated from changes in farm activities on a standard basis given the single quantifiable objective of reducing GHG emissions in terms of CO_2 equivalents, although this simplification will be limited to the extent that GHG mitigation is considered to generate co-benefits in the form of other ecosystem services that should be taken into account. Many existing agri-environmental schemes focus on a range of ecosystem services so it will be necessary to adapt the design of such schemes if GHG mitigation is also to be taken into account.[3]

The nature of the mitigation options available and the likely scale of the emissions reductions that will be required to meet domestic or international targets, suggest that a large proportion of agricultural activity will need to be affected. Thus a scheme should be available to, potentially, all farmers. However, in order to be feasible farmer involvement in the scheme would need to be encouraged at relatively low transactions costs, probably by remote (on-line) application and approval. The cost of monitoring compliance is also an issue. Technology can also help here, for example, through remote sensing of changes in land use practices.

Finally, information and technologies available to address GHG mitigation are likely to alter as new research is undertaken and different measures are tested on farm. In this respect, a policy should be flexible and adaptive so as to be able to incorporate new information. However, there is a trade-off between flexibility to respond to changes over time and the security that an environmental contract can offer to farmers who invest and make changes to their farming systems. This is a particular problem where significant long-term investments are required to reduce emissions or to generate carbon sequestration. Short term contracts will discourage farmers from making major changes and possible uncertainty may encourage them to look for higher payment levels if they are to be induced to change existing practices.

Any policy will need to be supported by substantial investment in technology transfer and extension services to translate the research and explain the alternative land uses and management practices to

[3] In contrast to GHG mitigation, efficient implementation of schemes that pursue multiple environmental objectives may require decentralised decision making.

farmers. Some voluntary initiatives are being developed along these lines, such as that promoted by a group of organisations in the UK (Greenhouse Gas Action Plan, 2011), but it is very likely that greater incentives and compulsion will be required, coupled with public investment in research, development and extension.

We may thus look for certain characteristics in an implementation programme:

- Payments for the introduction of changes in activities that mitigate GHG emissions
- The use of a mechanism to address problems of information asymmetry
- Integration with the provision of other ecosystem services
- Coverage across a large proportion of the farmed area
- Low transactions costs per farmer enrolled
- Potential to accumulate information and implement adaptive management.

Adapting the agri-environment approach

There has been considerable activity in the development of agri-environmental programmes. We focus on a limited set of examples – specifically conservation programmes in the United States and the Entry Level Stewardship (ELS) in England to examine what is involved in adapting such programmes to address GHG mitigation.

U.S. Conservation Programmes

Since their introduction in the 1985 Farm Act a range of resource conservation programmes has been adopted in the United States. The most relevant for our purpose are the Conservation Reserve Program (CRP), which focuses on land retirement to achieve a range of environmental objectives, and the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP) which promote the adoption of environmentally-friendly practices on land that remains in agricultural production.

The CRP uses competitive bidding; in which producers specify the payment they would be willing to accept to retire particular parcels of land from production. The bids are judged against an Environmental Benefits Index (EBI) with acceptance or rejection based on an assessment of benefits relative to costs. The EBI has evolved over time. The current version includes aspects relating to wildlife habitat, water quality, soil erosion and air quality. The latter includes a minor element for carbon sequestration, so the possibility of introducing climate change criteria already appears to have been accepted.

EQIP and CSP provide producers with technical and financial assistance for implementing and managing a range of conservation practices on land in agricultural production. The scope of EQIP is very broad with virtually any farm, type of agricultural land, and a wide range of practices being potentially eligible. The adoption of improved practices for managing water resources (e.g., irrigation systems and livestock drinking systems) and the management of livestock waste have typically accounted for roughly two thirds of the total spent on the programme (Johansson, 2006). The CSP has a much narrower focus – targeting the maintenance or adoption of practices that contribute to an enhancement of environmental quality beyond the level of practices funded through EQIP. Animal waste storage or treatment facilities are not funded under the CSP. Applicants identify a list of activities they are prepared to undertake, based on information provided by the funding agency to address priorities identified at the State or watershed level. While not competitive to the same extent as the CRP (there is no bidding process) both schemes evaluate whether to provide funding for specific practices on the basis of an EBI approach. Producers submit proposals which provide information on potential environmental performance and benefits and costs, thereby reducing information asymmetry. New practices are funded on a cost sharing basis, which means that farmers judge there to be additional benefits associated with these in terms of cost reduction or increased production efficiency and higher profitability. A number of the practices currently identified under

EQIP, e.g., improved handling and management of animal waste or conversion to no-till cultivation can contribute to reducing GHG emissions and/or carbon sequestration.

Entry Level Stewardship in England

The ELS in England is a whole farm scheme intended to draw a large proportion of farmers into more active environmental management. It currently covers over half the farmed land in England: 56% of the utilised agricultural area is in ELS, 67% under some form of agri-environment scheme (Natural England, 2012). Participants select simple management practices from a wide range of options for which they are awarded points per unit of activity, such as for hedge, ditch or wall management, buffer strips and over-wintered stubbles or areas left for birds. In order to enter the scheme, they are generally required to achieve a total equivalent to 30 points per hectare for the farm as a whole. Points are set per unit of activity according to the estimated income foregone or the costs of undertaking the activities in line with EU rules relating to payments for agri-environment schemes. Any farmer achieving the overall target can enter the scheme. The choice of environmental management option is thus left to the farmer and will inevitably reflect options that meet the farmer's own objectives. Further, the fixed number of points required for entry to the scheme and fixed payment mean that there is no incentive to undertake environmental management beyond the minimum. By 2007, ELS participation had effectively allocated, inter alia, some £35 million to hedgerow management and £25 million to management of intensive grassland (Hodge and Reader, 2010). More recently the government has encouraged applicants to concentrate on priority objectives in terms of sets of options defined for particular environmental improvements within defined localities.

Comparing the approaches

U.S. and U.K. schemes represent different approaches to the provision of environmental services. U.S. schemes include elements that aim to promote efficiency and competition in funding. Government collects information on proposed land management changes, the estimated environmental benefits and the level of payment required for adoption. Benefits are assessed by means of an Environmental Benefits Index (EBI) drawing on information provided by producers and spatially differentiated information on the local circumstances in which the land is located. This enables producers' offers to participate in programmes to be ranked and selected, subject to constraints on available funding. Information is provided in advance on what factors are to be taken into account, so that producers are able to assess whether their offers are likely to be successful. The EBI (elements included and the weights attached to them) can be designed to encourage producers with the potential to supply particular environmental services to apply. The structure of the EBI can be varied through time to reflect changing priorities. Table 2 shows the factors and point scores assigned in the 2011 sign-up for the CRP. Of the maximum possible point score (excluding the scoring for costs) of 400 points, 240 are unambiguously allocated to negative externalities of crop production (lower water and air quality and increased soil erosion), 110 are unambiguously allocated to promoting the supply of public goods (wildlife habitat and carbon sequestration). The remaining 50 points (enduring benefits) apply to increasing the probability of securing continued reduction in externalities and an enhanced supply of public goods beyond the period of enrolment in the programme.

The weightings attached to each of the factors, both the total points allocated to a particular characteristic (e.g., contribution to wildlife habitat, category N1, versus enhancement of water quality N2) and the allocation of points within these characteristics (e.g. aspects of the contribution to wildlife habitat within N1) reflect a particular set of preferences for the range of possible outcomes. Most of the characteristics that are rated are based on scientific judgments, although science may offer only limited guidance as to how those should be weighted. Some of the preferences for characteristics are based on an absolute threshold, i.e., no points are awarded unless a particular characteristic is present or a threshold value for that characteristic is met (e.g., N2a). Other factors (e.g., N1a) are continuous over a given range. For those variables it is possible to determine implied trade-offs among

characteristics at the margin. This is not possible for the discontinuously rated factors. Even in the former case, the interpretation of marginal valuations among factors is not straightforward due to differences in metrics. In this context, the scaling of individual factors is critical (e.g., the construction of the indices used for leaching and sedimentation in N2) and the factors themselves may not be comparable. For example, it would be difficult to determine what a marginal change in the measure of cover benefits (N1a) relative to a marginal change in the erodability index (N3) across land parcels would actually mean in terms of overall environmental quality.[4]

Despite these limitations, the index approach used in the EBI for the CRP seems to hold considerable promise for developing a structured approach to designing a payment scheme to enhance the supply of environmental goods (including carbon sequestration) and to reduce the supply of environmental bads (including GHG emissions from agriculture) (Cattaneo *et al*., 2006). In particular, it has the following advantages:

1. There is an explicit identification of the environmental factors that are valued by policymakers and the relative weights that are placed on them.
2. The factors are known to producers in advance, such that they are in a position to judge whether it would be worthwhile for them to seek to participate in the programme.
3. A competitive bidding process provides an opportunity for taxpayers to get the best value for money in terms of improving environmental quality – producers will place bids that are in line with private costs of meeting the contract requirements and these may be below the social costs or benefits involved.

In contrast, there are a number of disadvantages:

1. The way that the index is constructed (factors included, the way these are measured and the points allocated to them) may not produce the most desirable or efficient outcome in terms of enhanced environmental quality. In short, the EBI may be poorly constructed.
2. There may be learning by doing over time or implicit collusion among producers such that bids tend to converge around the maximum rental rate that the policymakers are prepared to offer under the programme. This is deterred by the relative complexity of the EBI making it difficult to know what the maximum rate will be in any specific circumstance.
3. The use of the index may involve relatively high transactions costs in terms of the preparation of bids by producers, evaluation of the bids by policymakers, and monitoring of compliance under contracts.

One additional weakness of the U.S. approach in the context of working lands programmes is that the full cost of adoption of practices is not covered. Cost shares are typically 50 per cent. This means that practices which could generate a high social return, but do not generate a private return may not be popular with farmers. There are certainly cases where private returns can be generated from environmental practices, for example, the conversion of relatively low productivity cropland to other uses or the adoption of low-input production methods (e.g., no-till cultivation). The installation of biogas facilities may also qualify if the resulting energy can be used on-farm or sold to the power grid. Afforestation may generate private returns if forest products can be harvested and sold. However, there is likely to be a range of practice changes that will involve lower profits (e.g., conversion from intensive to extensive livestock production), such that a cost-sharing approach is unlikely to be viable.

The ELS does not contain a competitive element and provides less direction in terms of the choice of practices. The numbers of points awarded for options are the same in all areas. Any landholder willing to sign up to sufficient environmental management measures is entitled to join. This creates an issue of adverse selection and is unlikely to be efficient in that the composition of the environmental management options arising will substantially be a reflection of what farmers are

[4] The construction of an EBI can become complex if there are potential trades-off between practice changes in terms of objectives. Thus, for example, an increase in emissions efficiency (lower emissions per unit of agricultural output) through the intensification of production could be in conflict with other aims that require extensification (e.g., wildlife habitat protection).

willing to do, either minimizing the cost or perhaps reflecting their personal preferences for the environment. There is no reason to believe that this should reflect the pattern of environmental benefits that would maximize the social return to the expenditure committed to the scheme. But on the other hand, it may be seen as being fair; all farmers are effectively given a right to receive payment for the delivery of ecosystems services, or at least for undertaking management options that are expected to deliver such services. Farmers are eligible whatever the counterfactual. There have been concerns that under other environmental schemes, the most conservation-oriented farmers who have protected the wildlife and landscape features on their farms have effectively been ineligible to participate because they already have high environmental standards and so have been unable to demonstrate the additionality that they can deliver. In contrast, farmers who have caused damage to the environment by intensifying their production have had more scope to demonstrate potential environmental gains. The current approach allows all farmers an opportunity to gain income from the scheme and brings a large proportion of agricultural land under a higher standard of environmental management. Arguably, the ELS encourages farmers to give more thought to environmental issues and to consider incorporating more substantial changes into their farming systems. It might be suggested that these qualities are suited to the current stage in the introduction of measures for the mitigation of GHGs where there is uncertainty as to the best measures to be adopted and a need to involve a large proportion of farmers in managing their land so as to reduce GHG emissions.

An issue that arises in the context of an ELS-type scheme is whether points should be allocated to mitigation management options on the basis of the on-farm cost of introducing measures, as is the case under the European Rural Development Regulation, or whether they should be allocated in relation to the expected environmental benefits to be gained from GHG mitigation. In principle, payment for the provision for environmental services should seek to equal the minimum cost of provision, such as might be achieved in an open competitive procurement process. However in this context, where the government has very limited information on costs, where there is likely to be substantial variation in cost levels between farms and where farmers have the choice as to which environmental service they opt to provide, there are arguments that the level of points should be based on the value of the environmental good generated rather than on the cost of its provision, at least in the short term. Assuming that farmers will choose combinations of options that give sufficient points for them to enter the scheme at minimum cost, where points are allocated on the basis of estimated costs, their selections reveal little information about the cost-effectiveness of GHG mitigation. However, if the points were awarded on the basis of the expected benefits from reductions in GHG per unit of activity, farmers would have an incentive to select management options that achieved mitigation at minimum cost, even though with a fixed level of payment, the scheme will still be subject to adverse selection. In contrast to other environmental benefits generated from agri-environment schemes, the value of GHG mitigation is independent of the location at which emissions are generated. Thus analysis of the options selected could provide information on the relative costs of the alternative mitigation measures and this information, in conjunction with an improving understanding of the actual emissions mitigated by various management options and the development of technology and knowledge about alternative methods for GHG mitigation can lead to improvements in policy design over time.

At the same time, the scheme needs to take account of the potential to deliver other types of ecosystem services. In the CRP, these are allowed for explicitly by means of the weightings in the Environmental Benefits Index. In the ELS, they can be reflected in the points awarded for the adoption of specific management options.

Selecting a policy approach

The choice of what type of agri-environment model to adopt in the shorter term depends on objectives and circumstances. The degree of devolution of decision-making with regard to objectives and the allocation of funds depends on the degree of spatial variability in the preferences for alternative environmental outcomes and potentially preferences for agri-environmental benefits over other types of collective good. Given a mix of environmental attributes across farms and locations, it would not

be feasible (or efficient in terms or outcomes) to provide a single undifferentiated payment to farmers for supplying categories of attributes. Payments would need to be spatially differentiated to reflect differences in the ability of farmers to supply those attributes.

The current county-based approach used for agri-environmental programmes in Norway provides the potential for some degree of spatial targeting (Huso, 2010). As noted above, values of GHG mitigation are the same across all areas, but this does not apply to other ecosystem services. We assume that at this stage, farmers will be offered payments to encourage them to divert land or introduce measure to mitigate GHG emissions. Payments may be made for land to be diverted to agro-forestry or maintained as high carbon wetlands in addition to payments for achieving other environmental objectives.[5] The diversion payment might cover the establishment costs for forest plantings and compensation for net income foregone over the life of the planting, either through a series of fixed annual payments or a lump sum based on a discounted stream of future income.[6] If cost were the only consideration, diversion payments would be targeted to regions where the opportunity costs of agro-forestry are low and where the sequestration potential from forestry is high. However, since there are multiple environmental objectives, the determination of how to allocate diversion payments based on the use an EBI would seem to be more appropriate. The EBI has more general applicability since it can also be used to identify where payments for other environmental services should be directed, even if the allocation of contracts to individual farmers is not done on the basis of an EBI.

More generally, in the European case, the public good component of schemes would have to be expanded beyond the enhancement of wildlife habitat under the CRP to include other aspects of landscape amenities. This factor is already reflected at the local level in many European agri-environment schemes. Different weightings would need to be developed for other factors. For example, in the EBI for the CRP very little weight is given to carbon sequestration, whereas this would be a much more significant element in an EBI that had the promotion of carbon sequestration as a primary goal.

It is an open question as to whether a bidding process should be used. This has a number of advantages and disadvantages as outlined above. A major reason for using that approach in the US has been to try to achieve the maximum environmental effects given a constraint on the area that can be enrolled in the scheme, and the amount of available funding. Policymakers in the EU may not face the same imperatives, especially where agri-environment schemes continue to be regarded as a means of re-allocating CAP expenditure subsequent to the decoupling and potential reduction of Pillar 1 payments and in Norway there appears to be a general acceptance of the principal of providing substantial support to agriculture. In the European case, the EBI might be used to provide transparency in the determination of fixed payments to particular parcels of land that are brought under the environmental programme. An ELS approach based on points and not requiring competitive bidding may have some attractions in this context. It would have significant advantages in terms of transparency and efficiency in comparison to other alternatives, such as the use of cross-compliance in direct payments that are targeted primarily to income support.

In practice, a policy will be likely to involve some combination of different tiers, as is already the case in both the US and UK. If, as seems likely, the objective will be to engage the majority of land managers in GHG mitigation in some way or other, then it will be necessary to develop an easily

[5] Investments in some mitigation activities that are not directly linked to the use of land, such as the use of methane digesters for animal waste, could also be targeted through the use of incentive payments. Cost sharing is used as the primary approach for promoting investments that improve environmental quality in the United States, for example, in the Environmental Quality Incentives Program (EQIP).

[6] This would satisfy the conditions for inclusion of environmental payments in the so-called 'green box' category of support under the Agreement on Agriculture in the WTO. Note, however, that the high level of protection provided to Norwegian agriculture would increase the magnitude of these payments since presumably they would be linked to domestic prices for agricultural products rather than world prices.

accessible scheme with low transactions costs. At this stage, efficiency may be a lower priority than engagement and fairness. Over time, regulation and efficiency may become higher priorities. But some aspects of GHG mitigation and sequestration will require longer term commitments if they are to be effective. The sequestration of carbon, especially in soils, needs to be secured in the very long term, in principle in perpetuity. If the carbon is lost at the end of the environmental contract, then clearly the benefits of the policy are effectively lost. In this context, land management will need to be set for the long term through a more formal arrangement. The CRP approach may offer a suitable policy model for this element with multicriteria evaluations of bids, competitive pricing and potential to lock in commitment through a covenant or easement that is binding on the land, rather than simply a contract with the owner or else through transfers of land ownership to an entity that is committed to long term protection, such as a trust or government body. Along similar lines, we note that the Wetland Reserve Program in the US includes both permanent and 30-year easements as options to secure long term commitment. The CRP has provisions to allow certain economic uses of land placed under the programme (e.g., routine grazing) so economic uses (e.g., harvesting of forest products for approved purposes) could also be allowed on forest land devoted to carbon sequestration under long-term easements.

We raise one further issue that warrants further consideration. Some approaches to GHG mitigation may be better addressed by farmers collectively rather than individually. An obvious example here is the introduction of relatively large scale anaerobic digestion plants. Thus provision should be made for the introduction of collective agreements that allocate funding amongst a group of farmers according to their contribution. This requires some element of institutional development to allocate, monitor and enforce the internal arrangements. Franks (2010) suggests Dutch environmental co-operatives as a potential model.

Conclusions

In the early stages of the introduction of pollution control measures, where in effect a particular type of environmental impact comes to be recognized as a form of pollution requiring government intervention, this is generally first approached through voluntary measures. This process is illustrated in the introduction of controls over nitrogen pollution in Europe, first introduced by voluntary nitrate sensitive areas subsequently regulated in Nitrate Vulnerable Zones, or in the control of straw burning, first under a voluntary code of practice and subsequently banned. This reflects a lack of information as to the full implications of the pollution, the best methods of abatement in specific circumstances and an insufficient wider social consensus to be willing or able to make more fundamental changes to property rights. Policies to mitigate GHG emissions would seem to be in this early stage. A programme of measures for GHG mitigation is likely to require some combination of a basic low level scheme to engage with a majority of farmers alongside a more targeted scheme requiring long term land management commitments. The ELS or EQIP offer a model for the former and the CRP a model for the latter. In the longer term it may be possible to establish more flexible approaches, potentially establishing system of off-setting or a market for GHG emission entitlements. At the same time, government may raise the required standard of environmental management by establishing a duty to undertake or not undertake certain specific types of management practice. These are amongst the many issues that require further consideration.

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Table 2. Summary of factors and point scores in the 2011 EBI for the U.S. Conservation Reserve Program

Factor	Characteristics	Point score
N1 Wildlife		Max = 100
N1a Cover benefits	Different planting mixtures rated in terms of benefits to wildlife	0-50
N2a Enhancement	Specific practices judged to enhance wildlife habitat, e.g., establishment of pollinator habitat	0, 5, 20
N3a Priority zones	Locations designated as high priority for wildlife improvement	0 or 30
N2 Water quality		Max = 100
N2a Location	Locations designated as high priority for water quality improvement	0 or 30
N2b Groundwater	Leaching index weighted by population using the groundwater	0-25
N3c Surface water	Sedimentation index weighted by population using the surface water	0-45
N3 Erosion	Erodability index	Max = 100
N4 Enduring Benefits	Likelihood that practices will remain in place after the contract period, e.g., conversion of land to woodland	Max = 50
N5 Air Quality	From reduction in wind erosion	Max = 50
N5a Wind erosion impacts	Potential for wind erosion damage weighted by population potentially affected	0-25
N5b Wind erosion soils	Particular soils that are highly erodible	0 or 5
N5c Air quality zones	Location in zone not meeting standards	0 or 5
N5d Carbon sequestration	Weighted average of carbon sequestration from certain practices	3-10
N6 Cost	Cost of environmental benefits per dollar of expenditure	Max = ?
N6a Cost	Point value determined after sign-up based on actual offer data – weights offers with low rental rates more highly	
N6b Offers below maximum payment rate	Points for percentage that offer is below maximum rate	0-25

Source: Based on FSA, USDA (2011).