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Climate Change and Scottish Agriculture: An End to the Freedom to Farm?

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Abstract. As enshrined in the 2009 Climate Change Act, Scotland has one of the most ambitious and binding targets for greenhouse gas reductions in the world. By 2050 it has committed to reducing emissions by 80%, with an interim target of 42% by 2020. The agricultural sector is a significant source of emissions within Scotland and therefore has been set a specific target – to achieve a 1.3 mt reduction by 2020. The approach adopted within Scotland to achieve these targets can be defined as a Voluntary Environmental Programme involving actions focussed on extension and incentives. Improving the efficiency of the agricultural sector is seen as the primary way to reduce emissions, thereby placing little or no constraint on the development of farm businesses. Following the method for classifying policy actions developed by Pannell, the approach adopted is shown to be appropriate (with certain caveats) given the nature of the changes required and the impact on private firms and wider society. However, fundamental challenges are shown to exist in actually relying on this approach in practice. These relate to achieving the required levels of participation and the monitoring and measurement of the proposed changes to farming practices. The industry's response to the 2007–2008 food price spike bears witness to the fact that even if these challenges are overcome, any gains made are susceptible to changes in practice and land use driven by an improved market situation. For these reasons, the article concludes that tighter restrictions are likely to be placed on farms to ensure that the targets are met and these are likely to constrain the choices of land managers.

Introduction

Climate change is likely to be a major factor influencing agriculture over the next century, both directly and indirectly. In Scotland, the direct effects of climate change on agriculture are likely to be relatively benign, if not positive, with the exception of extreme weather events (Scottish Government, 2010a). However, the obligation to address climate change through the reduction of greenhouse gases from all sectors, including agriculture, may have a more important impact on the agricultural sector in Scotland. Over and above the United Kingdom's (UK) commitment under the

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Kyoto Protocol to reduce emissions by 12.5% below 1990 levels, Scotland has set a further ambitious target of emissions reductions by 80% by 2050.

Achieving these commitments raises a number of profound questions for Scotland and Scottish agriculture. These include the appropriate measures to put in place and the choice of policy instruments. Linked to this is the potential impact on the balance of power between the state and the farming sector in determining the use of land in Scotland and on the roles and responsibilities of both. A future challenge is whether or not Scotland can maintain and increase production in light of possible increases in food demand (as highlighted in the *Vision for Scottish Agriculture*, Scottish Government 2010c).

Research Questions and Methods

The main research questions addressed within this article are: whether or not the approaches adopted by the Scottish Government to achieve the set reductions in emissions from the agricultural sector are likely to succeed and; whether this will impinge on the ability of the farming sector to respond freely to market signals.

To address these questions a series of steps are followed. Initially a detailed review of the evolution of climate change policy in Scotland is undertaken. This is achieved through analysis of available policy-related documents, including: outputs from Government appointed stakeholder groups; Government consultation documents (including stakeholder responses); supporting documentation for the Climate Change (Scotland) Act itself (including proposed implementation strategies) and relevant ministerial speeches. A two-stage approach is then undertaken to evaluate the appropriateness of the policy options chosen in Scotland. The first stage, using a conceptual framework developed by Pannell (2008), considers whether or not the chosen approach is theoretically consistent with the aims of Government. Pannell's framework is chosen because its two-dimensional approach (based on assessing policy tools in light of the distribution of costs and benefits between the private firm and wider society) allows for policies to be simply assessed, whilst still being conceptually rigorous. The second stage considers whether or not the Scottish approach is likely to be successful in practice by evaluating the policy mechanisms against a series of criteria laid down in Borck and Coglianese (2009). The final stage of the analysis involves assessing the impact of alternative measures to control emissions from agriculture on farm businesses.

The article begins with a brief overview of the development of climate change policy in Scotland, including the views of the agricultural industry. It proceeds to assess more generally the appropriateness of these policies using the framework developed by Pannell (2008). Potential obstacles to achieving the policy goals through the use of a voluntary approach are then outlined. The article concludes with a discussion of alternative approaches that may have to be utilized and the possible implications for land managers.

Evolution of Climate Change Policy in Scotland

Though concern over climate change and agriculture has a relatively long history within Scotland, a key milestone was the publication in March 2006 of *A Forward Strategy for Scottish Agriculture: Next Steps*. The Forward Strategy recommended that a stakeholder group be established to evaluate and monitor agriculture's response to climate change, through mitigation and adaptation (including the potential for related business opportunities).

In response, the Agricultural Climate Change Stakeholder group (ACCSG) was established in November 2006 and comprised a range of stakeholders, including those representing land managers, environmental organizations, government, NGOs and research institutes. A number of recommendations were made (ACCSG, 2008) providing useful insight into the perceived responsibilities of the key actors (government and industry). For policy, there was a call for better integration between separate policy themes (e.g. agriculture, biodiversity, flooding etc) and for lessons from other environmental incentive schemes and regulatory controls to be heeded. For industry, the group highlighted both a need for awareness of influences of climate change amongst farmers and land managers and also recognition of the need to contribute to mitigation. A wider role in raising awareness was highlighted for representative bodies from across the supply chain and the importance of collaboration stressed. There were also recommendations calling for improved knowledge transfer and further research (recognizing the huge uncertainties surrounding climate change). Given the nature of the challenge and composition of the group, it is unsurprising that support for a collaborative and voluntary approach to tackling climate change emerged.

From Recommendations to Policy

The ACCSG report began to identify responsibilities for tackling climate change. However, they were able to make recommendations based on a broad discussion of the relationship between agriculture and climate change unfettered by actual policy commitments. The extent of the challenge (as set by the Climate Change (Scotland) Act) was not known (although widely anticipated). Therefore the group did not have to deal with thorny questions such as the overall emissions reduction from agriculture and how the burden should be distributed between farmers and land managers and wider society.

The actual scale of the challenge emerged with the passing of the Climate Change (Scotland) Act of 2009, which set the target for Scotland of achieving an 80% reduction in greenhouse gas (GHG) emissions from 2006 levels by 2050 (with an interim target of 42% by 2020). Whilst the act sets the target for Scotland as a whole, it was clear from the outset that agriculture (and land use more widely) as a significant contributor to overall emissions would have to play its part in achieving the target. The *Climate Change Delivery Plan* (CCDP) (Scottish Government, 2009a) outlined in more detail how the reduction could to be achieved for Scotland as a whole and highlighted the need for four transformational outcomes to occur for there to be any real chance in achieving the target.[1] For agriculture and land use the transformational outcome was seen as:

> 'A comprehensive approach to ensure that carbon (including the cost of carbon) is fully factored into strategic and local decisions about rural land use through appropriate protection for Scotland's carbon rich soils; minimising emissions from agricultural and other land use businesses; encouraging the sequestration of carbon, for example through woodland planting; and the use of natural resources to generate renewable energy.'

More specifically the delivery plan noted that the share of the emissions from agriculture and agricultural land use could be reduced in 2020 from 2006 levels by 1.3 $MtCO_2e$.[2] According to NFUS calculations, this represented the equivalent of a fall of 10%, which was small in comparison to some sectors where the identified reductions reached 50% (NFUS, 2009). The relatively low percentage for agriculture probably reflects the high level of uncertainty surrounding emissions from agriculture and potential difficulties in securing reductions. In fact these challenges led the United Kingdom Climate Change Committee (UKCCC) when examining reductions for the UK as a whole to argue that targets for agriculture in the first implementation period might be inappropriate (UKCCC, 2008). Other key targets for land-use included increasing planting rates for trees to between 10 and 15 thousand hectares per year by 2015 (a major increase on the current levels of planting) and to sustain that rate thereafter to maintain the levels of carbon sequestered annually in trees and soils.

Within the CCDP support for a voluntary approach to achieving the targets was clearly in evidence: 'Short term action will focus on improved advice and services to land managers and opportunities for grant aid through the Scotland Rural Development Programme' (Scottish Government, 2009a, p20). Of course the Government was not oblivious to the challenges associated with such an approach and noted that 'The ability of increased advisory and communication activity, coupled with existing incentive structures, to realise the level of reductions required in avoidable emissions from the agriculture sector' was a significant risk to achieving the 42% target. Within the CCDP reference is also made to the fact that 'a key challenge for the land use sector is to achieve these targets while working within the global context of increasing demand for food.' This is a major issue and, as will be discussed later in the article, presents a real challenge to the success of a voluntary approach.

In practice, the voluntary approach mooted in the CCDP took the form of the Farming for a Better Climate (FFBC) initiative and the use of options available in the Scottish Rural Development Programme (SRDP) and other support for renewable energy initiatives. As described by the Scottish Government, 'FFBC is a targeted communication strategy designed to encourage farmers to adopt efficiency measures that reduce emissions, and help them adapt to climate change while at the same time having an overall positive impact on business performance'. In addition, an innovative approach was taken through extending the monitor farm concept which had been successfully used in Scotland for helping farmers develop the commercial side of their businesses (ADAS, 2008).

Since the passing of the Climate Change (Scotland) Act further work has been undertaken developing policies relating to both mitigation and adaptation. These were published in 2010 and 2011 (Scottish Government, 2010a, 2011). In particular, the targets set in the Climate Change Delivery Plan were replaced in 2011 by the more detailed Report on Proposals and Policies (RPP) (Scottish Government, 2011). The RPP revised the possible emissions reductions from current and proposed policies in agriculture down from 1.3 $MtCO_2e$ to 0.9$MtCO_2e$. Overall the RPP estimated that current policies were able to deliver a 38% reduction in emissions by 2020, 4% below the target of 42%. The RPP also extended the range of potential options to reduce carbon but re-iterated the approach of the Scottish Government.

> 'The key challenge in this sector is to contribute towards climate change targets while ensuring that Scottish agriculture remains productive and competitive. The Scottish Government's approach is to begin by seeking the maximum uptake of voluntary actions which both reduce avoidable emissions (those that arise from inefficient use of fertilisers and other resources rather than from the fermentation of feeds in the guts of animals) and improve farm performance' (Scottish Government, 2011).

Overall in Scotland, the carrot is clearly more in evidence than the stick with a focus on win–win opportunities and with few constraints being imposed on land managers.

Industry Support

Unsurprisingly, a voluntary approach to achieving environmental goals is often favoured by industry as it is seen as preferable to the implementation of costly regulation (Borck and Coglianese 2009; MacLeod et al., 2009). Through the policy consultation process these views were expressed strongly and consistently by the main farmer and land manager organisations (National Farmers Union of Scotland, NFUS, and the Scottish Rural Property and Business Association, SRPBA). Analysis of consultation responses highlights that they recognized the responsibilities of their members in helping tackle climate change, but clearly support a voluntary incentivised approach.

> 'Farmers and other land managers also need to contribute to the mitigation of climate change. This may require wider adoption of current best management practices, such as nutrient budgeting and energy efficiency but, given appropriate policy support, more significant adjustment to the nature of agricultural land management could be achieved to provide 'win-win' outcomes' (NFUS, 2008).

> 'The SRPBA is hopeful that the Climate Change (Scotland) Act will not impose further regulations on land managers but will ensure that targets are met by creating positive incentives for them to reduce greenhouse gas emissions' (SRPBA, 2009).

In addition to the non-regulatory approach they strongly support the choice of measures that may improve business performance as well as cutting emissions:

> 'And it is the next step in delivering further efficiencies on which we are now focussed. Much of what can and should be done will be measures which, regardless of their beneficial environmental effects, will first and foremost, make business sense to our primary producers' (NFUS et al., 2010).

> 'For example, if land managers are told that they can contribute to reducing greenhouse gas emissions by practising precision farming when applying fertilisers, which would also reduce their overall costs, they will be more likely to take up this measure than if the message is conveyed in a purely "mitigate climate change" manner' (SRPBA, 2009).

However, within the consultation responses some areas of potential conflict between government and industry begin to emerge, particularly concerning afforestation plans.

> 'NFU Scotland doubts very much whether this approach to tackling climate change will achieve anything positive. It is naive in the extreme to think that simply planting more trees on mainly agricultural land, to lock up carbon, will make a significant contribution in addressing what is a global and complex problem' (NFUS, 2009).

The closeness between the approach of the government and the industry is seen clearly in the speech given by the cabinet secretary to the NFUS AGM in 2009.

> 'I will defend the Scottish livestock sector to the hilt, because we owe it to the world to produce food. But at the same time, we have a responsibility to be as efficient as possible, including in greenhouse gas terms. The research clearly shows that you'll make more money too. So it's in the planet's interest, but it's in your interest as well' (Lochhead, 2010).

Lochhead's assertion is supported by Scottish Government estimates, which suggest that by achieving the greater efficiencies that 'Farming for a Better Climate' encourages, farmers and other land managers could save up to an estimated £464 million between 2011 and 2022.

To date, the development of climate change policy within Scotland appears to place few constraints on the agricultural sector's freedom to farm beyond current environmental restrictions (for example, those included within the cross-compliance regulations) and the need to follow best practice. Whether or not this *laissez-faire* approach can be maintained will depend upon its effectiveness in achieving the set targets. Using a framework developed by Pannell (2008), the next section briefly considers whether or not the chosen policy mechanisms (extension and incentives) are appropriate. This is followed by a more detailed examination of some of the practical hurdles associated with the use of a voluntary approach.

Choice of Policy Options

Pannell notes that there are a number of policy options available to achieve changes in management of privately owned land. He also notes that existing agri-environmental programmes from around the world use a range of mechanisms to encourage change, including education, awareness raising, technology transfer, research and development, regulation, subsidies, and other economic instruments (Pannell, 2008). As highlighted in Table 1, he categorizes the mechanisms into five types defined as positive and negative incentives, extension, technology development and no action.

Having defined the possible options available, Pannell proceeds to derive a simple but useful framework for assessing the most appropriate situations for use of the different policy options. This involves dividing the policy space in terms of the impact of the action on private (the individual firm) and public (being everyone else) net benefits (returns minus costs). This is highlighted in Figure 1.

For example, Pannell argues that where actions produce positive private and public net benefits as shown in area A (which may be classified as win–win situations) then extension is the appropriate mechanism. Alternatively, where an action may lead to a reduction in profitability of the firm (negative net benefits) but will produce more than compensating public net benefits (triangle C), positive incentives should be used.

Table 1. Alternative policy mechanisms for seeking changes in management of private land.

Category	Specific Policy Mechanisms Included
Positive incentives	Financial or regulatory instruments[a] to encourage change.
Negative incentives	Financial or regulatory instruments[a] to inhibit change.
Extension	Technology transfer, education, communication, demonstrations, support for community network.
Technology development	Development of improved land management options, such as through strategic R&D, participatory R&D with landholders, or provision of infrastructure to support a new management option.
No action	Informed inaction.

Note: [a] Financial or regulatory instruments include polluter-pays mechanisms (command-and-control, pollution tax, offsets), beneficiary pays mechanisms (subsidies, conservation auctions and tenders), and mechanisms that can work in either way, depending on how they are implemented (define and enforce property rights, such as through tradable permits).
Source: Pannell, 2008.

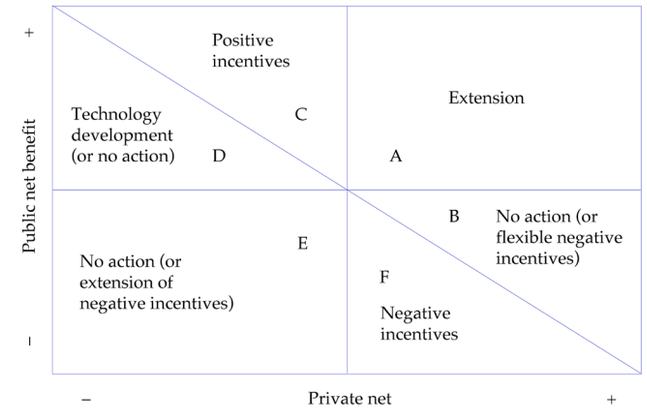

Figure 1. Suggested classes of policy tools for different levels of public and private benefits.
Source: Pannell, 2008.

Pannell also provides useful insight into a question raised by Bork and Coglianese. That is if actions are truly win–win why have firms not already exploited them? (Borck and Coglianese, 2009). Recent analysis highlights a number of such actions that could be implemented in the UK (MacLeod et al., 2010) and understanding why they have not been adopted is crucial to assessing whether they really are viable options. Pannell provides part of the answer by raising the concept of learning costs and notes that 'even though private net benefits from land-use change are positive… there may still be costs and impediments to learning that must be overcome, resulting in lags to adoption'. Though he notes that in reality extension may shorten, but not eliminate, the lags to adoption.[3]

Pannell's framework suggests that (depending on the initial allocation of property rights) the extension approach adopted by the Scottish Government is appropriate for the 'win–win' options and that where the reduction in private net benefit for each tonne of CO_2 equivalent is less than the social cost of carbon (Moran et al., 2010) positive incentive approaches promoted by the Scottish Government may be appropriate. His approach also supports the idea that where the private cost is greater than the social benefit (area D in Figure 1), then development of new technologies (supported by R&D) may be appropriate. However, the choice of the right policy mechanism is neither necessary nor sufficient for actual achievement of the policy goal as becomes clear in the next section.

Will the Voluntary Approach Deliver?

Following Krarup (2001), the Scottish Government's policy towards climate change within the agricultural sector may be seen as a form of voluntary environmental programme (VEP). There is a growing literature on the relative effectiveness and efficiency of achieving environmental goals through voluntary environmental programmes as opposed to other approaches (for example, Brouhle et al., 2004; Gunningham and Sinclairi, 2002; Borck and Coglianese, 2009) and this provides insights into the likelihood of success of the policy.

Prakash and Potoski (cited in Borck and Coglianese, 2009) highlight that the effectiveness of the voluntary approach can be represented by the following simple formula:

> Effectiveness = Number of Participants × Average effect per participant + Spillover effects

Therefore, in the context of this article, effectiveness depends upon the level of participation by farmers and land managers, the direct effect of participation on emissions and any knock-on effects associated with participation. Issues surrounding each of these components are examined in the following sections. It soon becomes apparent that although the formula looks relatively simple, populating it presents serious challenges.

Participation

The first challenge to ensuring sufficient participation is the fact that agriculture is dominated by small businesses (there are upwards of 50 000 holdings in Scotland, although around 20 000 may be considered significant producers). Therefore, unlike other sectors where there are a few large players, a voluntary approach in agriculture means that a large number of individuals with their own attitudes and motivations have to volunteer to take part. The scale of the task was highlighted in the CCDP where estimates were produced that uptake would have to be in the region of 90% to achieve the required reduction of 1.3mt by 2020 (Scottish Government, 2009b).

There is an extensive literature relating to the uptake of voluntary agri-environmental schemes within the UK (for example, see Morris and Potter, 1995; Wilson, 1996; Wilson and Hart, 2001; Burton et al., 2008; Burton and Paragahawewa, 2011). This literature highlights that a range of factors encourage or hinder uptake of voluntary schemes including age, education, size of business, social capital, cultural issues, etc. Whilst this literature does provide insights into the decision-making process, it should be noted that signing up to a voluntary agri-environment scheme is not necessarily the same as undertaking activities that mitigate climate change. This is because agri-environment schemes usually involve some trade-off between adoption of the measure and production (in return for a payment). Many of the measures being proposed in Scotland may be seen more in the light of adoption of new technologies (Lindner, 1987; Feder and Umali, 1993; Mathijs, 2003) although many of the factors that drive technology adoption are similar to those that drive adoption of voluntary agri-environment schemes. In general, a key finding is that even if adoption provides financial benefits to a farm, a range of other social and cultural factors will actually determine whether a measure is adopted.

One important area highlighted in the literature on adoption (either of new technologies or environmental measures) relates to the attitudes and values of land managers and this is equally likely to be an issue for measures relating to climate change. It is clear from the earlier sections that the representative bodies recognize the responsibility of the agricultural sector to play its part, but is that the case for the rank and file? Barnes and Toma (forthcoming) note that there is a surprisingly small literature on farmer attitudes towards climate change and that which exists has been either at the generic or conceptual level (for example, Adger et al., 2007; Howden et al., 2007; Iglesias et al., 2007) or, where the work has been more applied, the focus has been on more vulnerable regions (Maddison, 2007; Gbetibouo, 2009; Gwimbi, 2009; Mertz et al., 2009). As might be expected, in the studies which have been conducted in developed countries, a variety of attitudes emerge, ranging from scepticism in the US (Harrington and Lu, 2002) to mixed perceptions in the UK in the 1990s (Holloway and Ilbery, 1996) and to a more recent acknowledgement of the importance of climate change in the UK (Farming Futures, 2008). In relation to Scotland, Barnes and Toma surveyed close to 600 dairy farmers in 2009 and found that only 50% perceive climate change as a problem for their business. This lack of concern might simply reflect the perceived wisdom that the impacts of climate change on Scotland itself may actually be relatively benign, but does highlight that there could be significant challenges to getting farmers to adopt mitigation measures.

The analysis has thus far concentrated on the government/agricultural sector relationship. However, other drivers are pushing farmers towards taking actions to reduce emissions. This is particularly evident with recent actions by the major supermarkets within the UK (Smith et al., 2010). Marks and Spencer, for example, are aiming to make all their activities carbon neutral as well as helping their suppliers cut their emissions (known as Plan A). Whilst supermarkets may be undertaking these voluntary actions to maintain a commercial advantage, there is likely to be a more direct business imperative for farms to cut emissions. Therefore, it is not much of a leap to see carbon management simply as an extension of the current farm assurance schemes in operation across the UK. Adoption of these quality assurance schemes became virtually mandatory as supermarkets became increasingly concerned about traceability in the face of a number of high profile food scares. Their dominant role in the food supply chain is well recognized (Burt and Sparks, 2003) and, therefore, they have the ability to exert significant pressure on their suppliers.

The combination of the fact that the government is focusing on 'win–wins' and providing incentives, the support for the approach by industry bodies, the raised awareness by many farmers of the issues surrounding climate change and the push from the major retailers can therefore be seen as factors that could encourage the

wide-scale participation that is required. However, as the next section highlights, other challenges still have to be overcome.

Impacts of Participation

A fundamental constraint on the effectiveness of the voluntary approach is the level of uncertainty as to the actual impact of participation. This may be viewed in terms of monitoring and measurement. First, although farmers and landowners may sign up to the agreement it is actually very difficult to monitor practices precisely (although record keeping for pesticides and fertilizer applications are already required under existing schemes, ADAS (2009) note that verification will require an auditing process and therefore will be expensive). However, even if farms fully comply, there is a very high level of uncertainty surrounding the actual (rather than assumed) relationship between management activities and the associated emissions (for example, altering the timing of the spreading of fertiliser). As Renwick et al. (2002) highlight in the context of carbon sequestration, this is in part due to the challenges of measuring the actual emissions coming from the land (or livestock). Further complications occur because of the relative crudeness of the current approach taken to measure emissions (known as the inventory) at the country level. This crudeness means that the inventory is unable to accurately assess the current emissions at the level of the individual farm, and is also insensitive to many of the management options promoted to reduce carbon. This hardly provides confidence for those tasked with cutting their emissions and whilst significant resources are being put towards improving the UK inventory there will still inevitably be major gaps in our understanding.

Differentiating between reductions that have occurred as a result of participation rather than simply by the effects of other drivers is also a challenge when assessing the effectiveness of voluntary schemes (Borck and Coglianese, 2009). On the surface, this may not appear to matter as it is the overall reduction in emissions that count for Scotland. However, failure to identify the cause of the reduction may increase the risk of not achieving the set targets. For example, there has been a marked reduction in GHG emissions in Scotland since 1990, due largely to structural changes within agriculture (significant declines in livestock numbers and declining crop areas). Therefore if this trend continues after the introduction of the measures promoted by the Scottish Government, it may be tempting to attribute the gains made to the policy rather than the structural changes. The problem is that if the structural decline is reversed, as happened so dramatically in the case for wheat production in 2007–2008, then part of the assumed gains from the voluntary approach will be lost. Therefore it is important to differentiate the impact of structural changes in agriculture from those arising due to uptake of the voluntary measures.

Spillovers and Knock-on Effects

In the literature, spillover effects are defined as the potential impact of the VEP on other firms (Borck and Coglianese, 2009). That is, if other firms adopt similar practices to those within the VEP (for example to ensure they do not cede some advantage to competitive firms) then the impact of the VEP may be greater than simply the sum of the actions of those signed up to it. This particular spillover effect may not be

that significant in the context of individual farms (but may be for the major retailers), however there are other spillover or knock-on effects that may be of importance.

A number, though not all, of the actions are aimed at improving efficiency on farms. Others, for example, improving animal health, will also indirectly improve efficiency. If farms simply maintained their existing level of production, then a saving in emissions could be realised. However, economic theory suggests that increased efficiency means lower costs and lower costs lead to increases in production (a form of Jevons' paradox).[4] In this situation the overall impact on emissions will depend upon whether or not the output boosting impact offsets the GHG saving effects. This is the difficulty of having national targets and targets based on production as opposed to consumption (SEI, 2009). Improved efficiency will help reduce overall global emissions associated with food production, but may actually lead to increased emissions within an individual country. Of course, the increased efficiency leading to increased production and increased emissions argument should not be reversed to lead to a call to farm inefficiently and save the planet.

Reversibility

Even if the above challenges are surmounted, there is the possibility that any gains achieved in the short term are lost in the longer term if firms are able to revert to previous practices without fear of punishment or, in the case of agriculture, change production (i.e. move from crop to livestock, grass to crops) in response to markets.

Therefore whilst the voluntary approach appears to have attractions due to the imposition of few constraints on the agriculture sector, this section has highlighted the practical constraints to using such an approach. It should be acknowledged that a number of these challenges, especially in relation to measurement and monitoring, are as relevant to other possible approaches as to the voluntary one (ADAS, 2009). This said the evidence appears to support Morgenstern and Pizer who argue that 'it is hard to argue for voluntary programs where there is a clear desire for major changes in behaviour' (in Borck and Coglianese, 2009).

It is clear that the Scottish Government have also maintained the right to change direction: 'The Scottish Government will work hard to represent the best interests of Scottish agriculture during the CAP negotiations. Attaining a high uptake of FFBC voluntary measures without resorting to regulation remains the priority. However, a mandatory regime may be necessary if insufficient progress is achieved by the sector' (Scottish Government, 2011).

It may though be, in this particular case, that the relatively low target for agriculture (under 10% reduction by 2020 from 2006 levels) means that even with these difficulties, the target may be achievable with little impact on farm businesses. For example, it is estimated that a 4% reduction had already occurred by the end of 2007 (NFUS et al., 2010). However, the next section argues if the market situation improves for agriculture in Scotland, it will be much harder to achieve reductions without resorting to policy mechanisms placing greater constraint on farm businesses.

Market Forces versus Climate Change?

Over the last 20 years or so there has been a sustained period of low prices for agricultural products within the UK, with only the occasional respite. As noted earlier,

in Scotland this coupled with other factors such as reform of the CAP and productivity gains in the dairy industry has led to a marked decline in livestock numbers and also crop areas. In addition, there has been a trend towards reduced applications of artificial fertiliser onto grassland (Defra, 2009). These changes have meant that significant reductions in emissions from agriculture have occurred (estimated at 20% since 1990 by the NFUS; NFUS, 2010). Although the term post-productivism has engendered much debate (for example, see Ilbery and Bowler, 1998; Evans et al., 2002; Mather et al., 2006; Wilson, 2007; Ward et al., 2008) it is reasonable to argue that uptake of agri-environmental schemes, increased diversification and pluriactivity has seen agriculture move away from a focus purely on commodity production. As returns from commodity production fell and support to agriculture became increasingly questioned, farming and landowner organizations began to embrace their new role and promote their members more strongly as 'guardians of the countryside' (for example, see NFU, 1998). It can be argued that these factors have made it easier for governments to encourage uptake of schemes to protect the environment. That is, there has been less conflict between the financial goals of the farm business and the wider goals of society.

However, as has been highlighted above, after many years of struggling to produce profits, the industry sees a brighter future as a number of institutions (including the OECD) are predicting a sustained period of higher agricultural commodity prices. This is due to the often quoted combination of factors including rising world population, increased affluence in China, and the production impacts of climate change in some regions of the world.

The response to the recent high prices of 2007–2008 highlights how policies that protect the environment can soon disappear when other pressures emerge. In Scotland, wheat production increased by around 17%, set-aside was removed across the EU and concern was raised about farmers' continued participation in agri-environmental schemes (*Observer*, 2008). As noted by the then head of policy at the Council for the Protection for Rural England, 'The problem is that the mindset of farmers will switch back to production, and it will become increasingly difficult to persuade them of the value of environmental intervention' (*Observer*, 2008). This might especially be the case for climate change where the main environmental effects are seen as spatially (other countries) and temporally (future generations) removed from the activities of the business.

This brings us back to the fundamental question as to whether Scottish farmers can both take advantage of opportunities to boost production in the face of higher prices arising from the global supply and demand situation and achieve severe (relative to other countries) targets for the reduction of emissions. Of course, Scotland is not alone in the challenge of trying to achieve this balance. For example, the situation is even more acute in New Zealand, where even though the overall emission reduction targets are significantly less than Scotland, agriculture forms both a major part of those emissions and also of the economy (MAF NZ, 2010). There are clear moral dilemmas that arise if policies to reduce emissions prevent production from increasing. Whilst it may be argued that the hunger problems facing the world currently are a question of distribution rather than overall production, higher prices signal shortages. Therefore, do we prevent farmers from increasing production today and alleviating these shortages at the possible expense of future generations? Given the worldwide response to the food price crisis of 2007–2008 (including such actions as export bans), it would seem likely that for politicians the voices of those alive now will outweigh those of the future.

A Need for Alternative Approaches

If the climate change targets are to remain in place in Scotland, alternative approaches may be required in the future both to secure any gains that have already been made (thus far mainly through structural change) and to make further reductions in the light of increased demand for agricultural products. There is an extensive literature on the relative advantages and disadvantages of the various approaches to achieving environmental improvements described by Pannell and outlined in Table 1 (for example, see Hatch (2005); Hahn, 1989; Wu and Babcock, 1999). Here some are briefly discussed in terms of the constraints they will place on agriculture.

If we consider area D in Figure 1, we have a situation where the public benefit is outweighed by the private cost of implementation and Pannell suggests technology development as a possible action in this situation. Work undertaken to develop Marginal Abatement Cost Curves (MACC) for the UK Climate Change Committee (MacLeod et al., 2010) highlighted a range of options that could reduce emissions but currently were too expensive to implement (that is their cost per tonne of carbon saved was significantly above the estimated social cost of carbon). Significant research effort across many countries (the Global Research Alliance, for example) is investigating a range of ways of reducing emissions whilst increasing production and if these yield practical results could reduce the costs of new technologies. In addition, increased profitability may lead to the industry being able to invest in technological solutions that can significantly reduce emissions. The new technology route like the VEP offers the promise that it would allow agriculture to achieve its commitments with the minimum of disruption to the business. However, as with a VEP there are uncertainties over practical application and adoption of new technologies and it cannot be relied on to deliver specific targets.

Within other parts of the European economy tradable permits have been implemented as a way of reducing emissions (European Trading Scheme, ETS). The cap and trade approach potentially gives greater control for the Government in terms of achieving its targets (by setting the cap on overall emissions levels, whilst the tradable nature of the permits potentially enables these targets to be met in the most efficient way (US EPA, 2010). A potential advantage is that it still allows flexibility for firms to respond to price signals emanating from changes in supply and demand. For example, if wheat prices rise due to changes in market conditions making production more profitable, then wheat farmers would be able to buy permits from other farmers (and potentially other sectors if the scheme were economy wide) and increase production in response. Also the fact that the permits can be traded will encourage farms to adopt new methods that reduce emissions. However, the fundamental issue is that if trade is restricted to within agriculture the industry overall will be constrained and limited in its ability to produce. If it is economy-wide then there is the potential for agricultural activities to decrease markedly if other sectors buy permits from agriculture, though the advantage is that at least they will be compensated for this decline. In addition, significant problems exist in terms of implementing such a scheme at the farm level. These relate to the sheer number of farms, and the measurement and monitoring of emissions at the farm level (i.e. similar to the voluntary approach). It is perhaps not surprising that Australia abandoned plans

to include agriculture in an emissions trading scheme and that New Zealand has done so only at the level of the processing industry (MAF NZ, 2010).

Command-and-control measures (for example, Nitrate Vulnerable Zones (NVZs) or cross-compliance regulations)[5] potentially place more restriction on the actions of farms. The blanket approach of NVZs has always been unpopular (hence the initial recommendation from the ACCSG, that lessons should be learnt from existing regulations). Although focussing on the English situation, a review of alternative approaches by ADAS examines a number of regulatory options to reduce emissions including extension of NVZs and catchment sensitive farming. Their recommendation was that an enhanced cross-compliance scheme appeared the most effective policy tool for achieving emission reductions (ADAS, 2009). They do, however, see potential scope for other approaches such as an extension of NVZ regulations to produce gains. It is clear that the Scottish Government also see the CAP cross compliance regime as the possible vehicle for a mandatory approach.

> 'The present European Union Common Agricultural Policy (CAP) provides a level of income security to farmers as well as a "cross-compliance" framework for sustainable management of the environment. The CAP is due for revision at EU level in 2014 and there is potential for specific climate change mitigation measures, including some of those encouraged in Farming for a Better Climate, to be made mandatory through the cross compliance regime that links farming practices to subsidy payment.'

The advantages of cross-compliance include the fact that the regulatory framework (including monitoring) is already in place and it is associated with the carrot of receiving support (in the form of the single payment scheme). The disadvantage may be that if cross-compliance becomes too onerous and the single payment is reduced significantly (as might be the case under budget constraints to the CAP) then potentially farms may opt out of the Pillar 1 reducing the effectiveness of cross-compliance. Whilst this is unlikely to occur under current situations (because the single payment is a significant source of income for many farms) a marked improvement in profitability of commodity production might make it more viable to forego it. Of course, the option is then available for the Scottish Government to simply make the cross-compliance regulations part of general environmental constraints.

Beyond environmental regulation, there are more restrictive measures available. At the extreme this could involve land nationalization, though not since the 1940s has this been a serious consideration within the UK. However, the Scottish Government are aware of the need to satisfy many other demands on land use in Scotland (such as recreation, tourism, renewable energy, forestry, etc.) and this formed the basis of the recent Rural Land Use Study (Scottish Government, 2009c). Some form of land-use planning (for example, zoning) may potentially be an option, placing more restrictions on the ability of landowners to decide the use of land. However, the development of the Land Use Strategy (Scottish Government, 2010b) highlights that the Scottish Government favours a more hands-off approach to land use.

The extent of the reductions from agriculture will effectively determine the extent that activities are constrained. In the initial stage, the reductions are fairly unambitious and could in theory be achieved through actions that have very low cost for farms and place little restraint on their business decisions (MacLeod et al., 2010). However, after 2020 as the targets become more challenging and the scope for the use of 'win–win' measures becomes more limited then achievement of the targets will become more difficult. This means that climate change policies may not be seen to impose significantly on what farmers are doing now but more so on future choices of land use.

Conclusion

The development of climate change policy in Scotland has been shown to be a mixture of stakeholder dialogue coupled with a voluntary approach that includes the use of funds available through the rural development programme as well as schemes designed to encourage renewable energy production. Pannell's framework suggests that, in theory at least, the response is appropriate to the policy goal and the nature of the actions that are being sought from agriculture. In general, this approach places very few constraints on the freedom to farm within Scotland, both in terms of the choice of what to produce as well as how to produce it. To date a close relationship between government and industry has been evident with general agreement as to the approaches adopted. However, it is clear that the strength of this relationship is yet to be fully tested. Such a test will arise if the voluntary approach fails to deliver the required reductions; for example, due to a lack of participation or the knock-on production effects of participation. A major challenge will also arise if the expected improvement in the market situation for agriculture occurs and provides farmers with the incentive to maximize production again (though this time driven by the market rather than the policy-driven production boosts of the post Second World War period). A question then arises as to the nature of the relationship between government and farm representatives and whether the latter are strong enough to enable them to 'override' the government by increasing production from farming even if it means they fail to conform to any targets for carbon emissions. That is will government be able to constrain farming options, or will market forces be heralded as the best way to advance agriculture and the nation's future?

If GHG reduction targets do remain in place, it seems inevitable that other possible policy options to reduce emissions will be required beyond those currently in place. Potentially, these will have a greater impact on the production choices of farmers. Of these, the creation of markets for carbon and support for the development of new technologies may impose the least constraints on the choices of individual farms. However, as has been shown, there are disadvantages to these approaches and further action may be required. It would seem inevitable that a mandatory approach will have to be adopted, possibly through extension of the cross-compliance regulations. These regulations will potentially impose greater constraints on the agricultural industry depending upon how far beyond current best practice they go. Regulations to ensure best practice may be seen as a justifiable constraint to place on the industry (as is the case with most environmental regulation at the present time). That is, the restriction is not on the freedom to farm, but more on the freedom to farm badly. However, given that significant GHG emissions arise from normal best practice, perhaps more so than other forms of pollution, if future targets mean that the Scottish Government have to go beyond this then more constraints on production choice will occur. Policy will need to be designed to ensure that this is undertaken in an efficient, effective and equitable way for agriculture and wider society.

Notes

1. Transformational outcomes are seen as major changes that need to be in place by 2030 in order for Scotland to meet its 2050 target.
2. This figure is based on the Climate Change Act target which is equivalent to a 42% reduction on 1990 levels in overall emissions in Scotland. There was some leeway for this target to be revised; for example, on advice from the UK climate change committee that the target is not achievable.
3. It should be noted that Pannell develops his framework using numeric examples to account for learning costs and other factors; however, for the purposes of this article the simple exposition is deemed sufficient.
4. In economics, the Jevons paradox (sometimes called the Jevons effect) is the proposition that technological progress that increases the efficiency with which a resource is used, tends to increase (rather than decrease) the rate of consumption of that resource.
5. Cross-compliance is an element of the Common Agricultural Policy (CAP) within the EU. The CAP is split into two pillars. Pillar 1 comprises direct payments to farms (known as the Single Payment Scheme) that are conditional on farms complying with a range of requirements relating to environment performance (known as cross-compliance).

References

ACCSG (Agriculture and Climate Change Stakeholder Group) (2008) *Final Report and Recommendations*. Published online <http://www.scotland.gov.uk/Publications/2008/05/15115150/0>, accessed 15 December 2010.

ADAS (2008) *Investigating the Role and Effectiveness of Scottish Monitor Farms*. Wolverhampton: ADAS. Published online <http://www.scotland.gov.uk/Publications/2008/10/29093936/0>, accessed 15 December 2010.

ADAS (2009) *Analysis of Policy Instruments for Reducing Greenhouse Gas Emissions from Agriculture, Forestry and Land Management*, Defra report RMP/5142. Wolverhampton: ADAS.

Adger, W.N., Agrawala, S., Mirza, M.M.Q., Conde, C., O'Brien, K., Pulhin, J., Pulwarty, R., Smit, B. and Takahashi, K. (2007) Assessment of adaptation practices, options, constraints and capacity, in: M.L. Parry, O.F. Canziana, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds) *Climate Change 2007: Impacts, Adaptation and Vulnerability: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press , pp. 717–743.

Barnes, A.P. and Toma, L. (2011). A typology of dairy farmer perceptions towards climate change, *Climatic Change*, DOI: 10.1007/s10584-011-0226-2.

Borck, J.C. and Coglianese, C. (2009) Voluntary environmental programs: assessing their effectiveness, *Annual Review of Environment and Resources*, 34, pp. 305–324.

Brouhle, K, Griffiths, C. and Wolverton, A. (2004) *The Use of Voluntary Approaches to Environmental Policy Making in the US*, Working Paper No. 04-05. Washington, DC: US Environmental Protection Agency, National Center for Environmental Economics.

Burt, S.L. and Sparks, L. (2003) Power and competition in the UK retail grocery market, *British Journal of Management*, 14(3), pp. 237–254.

Burton, R.J.F. and Paragahawewa, U.H. (2011) Creating culturally sustainable agri-environmental schemes, *Journal of Rural Studies*, 27, pp. 95–104.

Burton, R.J.F, Kuczera, C. and Schwarz, G. (2008) Exploring farmers' cultural resistance to voluntary agri-environmental schemes, Sociologia Ruralis, 48(1), pp. 17–37.

Defra (2009) *British Survey of Fertiliser Practice*. Published online <http://www.defra.gov.uk/ evidence /statistics/foodfarm/enviro/fertiliserpractice/documents/2009.pdf>, accessed 3 January 2011.

Evans, N., Morris, C. and Winter, M. (2002) Conceptualising agriculture: a critique of post-productivism as the new orthodoxy, *Progress in Human Geography*, 26(3), pp.313–332.

Farming Futures (2008) Farmers being challenged on their environmental performance. Published online <http://www.farmingfutures.org.uk/news/farmers-beingchallenged-their-environmental-performance>, accessed 10 December 2010.

Feder, G. and Umali, D.L. (1993) The adoption of agricultural innovations: a review, *Technological Forecasting and Social Change*, 43, pp. 215–239.

Gbetibouo, G.A. (2009) *Understanding Farmers' Perceptions and Adaptations to Climate Change and Variability: The Case of the Limpopo Basin, South Africa*. Washington, DC: International Food Policy Research Institute.

Gunningham, N. and Sinclairi, D. (2002) *Voluntary Approaches to Environmental Protection: Lessons from the Mining and Forestry Sectors*. Presented at OECD Global Forum on International Investment conference on 'Foreign Direct Investment and the Environment', Paris, 7–8 February.

Gwimbi, P. (2009) Cotton farmers' vulnerability to climate change in Gokwe District (Zimbabwe): impact and influencing factors, *Journal of Disaster Risk Studies*, 2, pp. 81–92.

Harrington, L.M.B. and Lu, M. (2002) Beef feedlots in South Western Kansas: local change, perceptions, and the global change context, *Global Environmental Change*, 12, pp. 273–282.

Hahn, R.W. (1989) Economic prescriptions for environmental problems: how the patient followed the doctor's orders, *Journal of Economic Perspectives*, 3(2), pp. 95–114.

Hatch M. (2005) Assessing environmental policy instruments: an introduction, in: *Environmental Policy-making: Assessing the Use of Alternative Policy Instruments*. Albany, NY: SUNY Press. Published online <https://www.sunypress.edu/pdf/61062.pdf>, accessed December 10th 2010.

Holloway, L.E. and Ilbery, B.W. (1996) Farmers' attitudes towards environmental change, particularly global warming, and the adjustment of crop mix and farm management, *Applied Geography*, 16, pp.159–171.

Howden, S.M., Soussana, J.-F., Tubiello, F.N., Chhetri, N., Dunlop, M. and Meinke, H. (2007) Adapting agriculture to climate change, *Proceedings of the National Academy of Science*, 104, pp. 19691–19696.

Iglesias, A., Avis, K., Benzie, M., Fisher, P., Harley, M., Hodgson, N., Horrocks, L., Moneo, M. and Webb, J. (2007) *Adaptation to Climate Change in the Agricultural Sector*, AGRI-2006-G4-05. Didcot: AEA Energy and Environment. Published online <http://ec.europa.eu/agriculture>, accessed on 15 December 2010.

Ilbery, B. and Bowler, I. (1998) From agricultural productivism to post-productivism, in: B. Ilbery (ed.) *The Geography of Rural Change*, London: Longman, pp. 57–84.

Krarup, S. (2001) Can voluntary approached ever be efficient?, *Journal of Cleaner Production*, 9, pp. 135–144.

Lindner, R.K. (1987) Adoption and diffusion of technology: an overview, in: B.R. Champ, E. Highley and J.V. Remenyi (eds) *Technological Change in Postharvest Handling and Transportation of Grains in the Humid Tropics*, Canberra ACT: ACIAR, pp. 144–151.

Lochhead, R. (2010) *NFUS 2010 AGM Speech, 19 February*. Published online at <http://www.scotland.gov.uk/News/Speeches/Speeches/Greener/nfus-speech>, accessed 10 December 2010.

MacLeod, M., Ekins, P., Vanner, R. and Moran, D. (eds) (2009) *Understanding the Costs of Regulation in the EU*. Cheltenham: Edward Elgar.

MacLeod, M., Moran, D., Eory, V., Rees, R.M., Barnes, A., Topp, C.F.E., Ball, B., Hoad, S., Wall, E., McVittie, A., Pajot, G., Matthews, R., Smith, P. and Moxey, A. (2010) Developing greenhouse gas marginal abatement cost curves for agricultural emissions from crops and soils in the UK, *Agricultural Systems*, 103(4), pp.198–209.

Maddison, D.J. (2007) *The Perception of and Adaptation to Climate Change in Africa*, World Bank Policy Research Working Paper No. 4308. Published online <http://papers. ssrn.com/sol3/papers.cfm?abstract_id=1005547>, accessed 15 December 2010.

Mather, S., Hill, G. and Nijnikb, M. (2006) Post-productivism and rural land use: cul de sac or challenge for theorization?, *Journal of Rural Studies*, 22, pp. 441–455.

Mathijs, E. (2003) Social capital and farmers' willingness to adopt countryside stewardship schemes, *Outlook on Agriculture*, 32, pp. 13–16.

Mertz, O., Mbow, C. Reenberg, A. and Diouf, A. (2009) Farmers' perceptions of climate change and agricultural adaptation strategies in Rural Sahel, *Environmental Management*, 43, pp. 804–816.

Ministry of Agriculture and Forestry New Zealand (2010) *A Guide to Agriculture in the Emissions Trading Scheme*. Wellington: MAF.

Moran, D., Macleod, M., Wall, E., Eory V., McVittie, A., Barnes, A., Rees, R., Topp, C.F.E. and Moxey, A. (2010) Marginal abatement cost curves for UK agricultural greenhouse gas emissions, *Journal of Agricultural Economics*, 62, pp. 93–118.

Morris, C. and Potter, C. (1995) Recruiting the new conservationists: farmers' adoption of agri-environmental schemes in the UK, *Journal of Rural Studies*, 11, pp. 51–63.

National Farmers Union (1998) *Memorandum to Environment, Transport and Regional Affairs Committee*. Published online <http://www.publications.parliament.uk/pa/cm199798/cmselect/cmenvtra/1126/112617.htm>, accessed 15 December 2010.

National Farmers Union of Scotland (2008) Response to Consultation on Climate Change (Scotland) Bill. Ingliston: NFU Scotland.

National Farmers Union of Scotland (2009) *Response to Consultation on Forestry and Climate Change*. Ingliston: NFU Scotland.

National Farmers Union of Scotland (2010) *Submission to House of Lords Inquiry into the Adaption of Agriculture and Forestry to Climate Change: The EU Response*. Ingliston: NFU Scotland.

National Farmers Union of Scotland, Quality Meat Scotland and SAOS (2010) *Producing More with Less: A Joint Industry Commitment on Climate Change*. Published online <http://www.nfus.org.uk/uploaded

Files/Campaigns/Climate_Change.pdf>, accessed 4 January 2011.

Observer (2008) Eco-farming ditched as food prices soar, *Observer*, 28 May, published online <http://www.guardian.co.uk/uk/2008/may/25/ruralaffairs.food>, accessed 15 December 2010.

Pannell, D.J. (2008) Public benefits, private benefits and policy mechanism choice for land use change for environmental benefits, *Land Economics*, 84(2), pp.225–240.

Renwick, A.W, Ball, A.S. and Pretty, J.N. (2002) Economic, biological and policy constraints on the adoption of carbon farming in temperate regions, *Philosophical Transactions of the Royal Society A*, 360, pp. 1721–1740 .

Scottish Government (2009a) *Climate Change Delivery Plan: Meeting Scotland's Statutory Climate Change Targets*. Edinburgh: HMSO. Published online <http://www. scotland.gov.uk/Publications/2009/06/18103720/7>, accessed 10 December 2010

Scottish Government (2009b) *Scotland's Climate Change Adaptation Framework. Edinburgh: Scottish Government*. Published online <http://www.scotland.gov.uk/ Resource/Doc/295110/0091310.pdf>, accessed 10 December 2010.

Scottish Government (2009c) *Rural Land Use Study*. Published online < http://www.scotland.gov.uk/Topics/farmingrural/Rural/rural-land/land-use-study>, accessed 10 December 2010.

Scottish Government (2010a) *Adapting to Climate Change: Consultation on the Environmental Impacts of Adaptation*. Published online <http://www.scotland.gov.uk/ Publications/2010/12/10140608/0>, accessed 4 January 2011.

Scottish Government (2010b) *Getting the Best from Our Land: A Draft Land Use Strategy for Scotland*. Published online <http://www.scotland.gov.uk/Publications/ 2010/09/23100015 /0>, accessed 15 December 2010.

Scottish Government (2010c) *A Vision for Scottish Agriculture*. Published online <http://www.scotland.gov.uk/Resource/Doc/302424/0094642.pdf>, accessed 10 December 2010.

Scottish Government (2011) *Low Carbon Scotland: Meeting the Emissions Reduction Targets 2010–2022: The Report on Proposals and Policies*. Edinburgh: Scottish Government.

SEI (Stockholm Environment Institute) (2009) The Need for Sound Carbon Accounting in Scotland. Published online <http://www.censa.org.uk/docs/SEI_Carbon_ Accounting_Scotland.pdf>, accessed 10 December 2010.

Smith, K., Lawrence, G. and Richards, C. (2010) Supermarkets' governance of the agri-food supply chain: is the 'corporate-environmental' food regime evident in Australia?, *International Journal of Socciology of Agriculture and Food*, 17(2), pp. 140–161.

SRPBA (Scottish Rural Property and Business Association) (2008) *Response to consultation on Climate Change (Scotland) Bill*. Musselburgh: SRPBA.

US EPA (US Environmental Protection Agency) (2010) *CAP and Trade*. Published online <http://www.epa.gov/captrade/index.html>, accessed 4 January 2011.

UKCCC (UK Climate Change Committee) (2008) *Building a Low-carbon Economy: The UK's Contribution to Tackling Climate Change*. Published online <http://www.theccc.org.uk/reports/building-a-low-carbon-economy>, accessed 4 January 2011.

Ward, N., Jackson, P., Russell, P. and Wilkinson, K. (2008) Productivism, post-productivism and European agricultural reform: the case of sugar, *Sociologia Ruralis*, 48(2), pp. 119–132.

Wilson, G.A. (1996) Factors influencing farmer participation in the environmentally sensitive areas scheme, *Journal of Environmental Management*, 50, pp. 67–93.

Wilson, G.A. (2007) *Multifunctional Agriculture: A Transition Theory Approach*. Oxford: CABI.

Wilson, G.A. and Hart, K. (2001). Farmer participation in agri-environmental schemes: towards conservation-orientated thinking?, *Sociologia Ruralis*, 41, pp. 254–274.

Wu, J. and Babcock, B.A. (1999). The relative efficiency of voluntary versus mandatory environmental regulations, *Journal of Environmental Economics and Management*, 38, pp. 158–175.