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SCENARIOS FOR RURAL LAND MANAGEMENT: EXPLORING ALTERNATIVE FUTURES

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Prospects for the management of rural land face particular uncertainties associated with future commodity prices, agricultural policy and climate change.Possible futures are considered through four scenarios relating to financial returns to land and government environmental policies. After discussing the characteristics of these scenarios, the implications are considered for agricultural systems and returns, agri-environment schemes and non-agricultural activities. Future business development will need to consider the resilience of businesses, the management of key environmental sites and the potential for collective initiatives.

Keywords
Agriculture, scenarios, rural land, futures, farm businesses

1. Introduction

Prospects for rural land use face particular challenges and uncertainties. Recent dramatic increases in commodity prices may be seen to herald a major break from the general decline that has been the predominant experience of much of the past fifty years. Oil and other commodity prices have also recently reached historically high levels, with credible forecasts of further sustained increases in the future. And yet, in both cases, prices have eased more recently as the world has moved into what is widely predicted to be a protracted period of deep global recession. Even so, forecasts for population growth, continuing income growth, especially in Brazil, Russia, India and China, albeit at reduced levels, and concerns at the erosion of agricultural production capacity due to water scarcity and soil erosion, combine to signal major challenges to future food production capacity. At the same time compounding the uncertainties, predictions of the likely speed and intensity of climate change have been revised upwards at the recent conference on climate in Copenhagen, with the consequence that the political recognition of the reality of climate change and its potentially stark implications may lead to radical changes in policies in order to mitigate the impacts and adapt to its consequences.

The outcomes of these uncertainties will have significant implications for land uses across the world. These issues are currently the subject of a considerable volume of study and assessment, but this is unlikely to resolve the major uncertainties that are faced. It is thus critical to seek to explore the possible implications of alternative futures.

The objective of this paper is to review prospects for the rural land in Great Britain in terms of the likely constraints and opportunities over a 20 year time horizon and to draw out implications for the options and opportunities facing

1. An earlier version of this paper was presented at the RICS ROOTS conference, Clare College, Cambridge, 23-24 March 2009. It derives from work undertaken for the Crown Estate. We are grateful to the Crown Estate for supporting the work, but they bear no responsibility for the contents of the report (Hodge *et al*., 2009) or this paper.

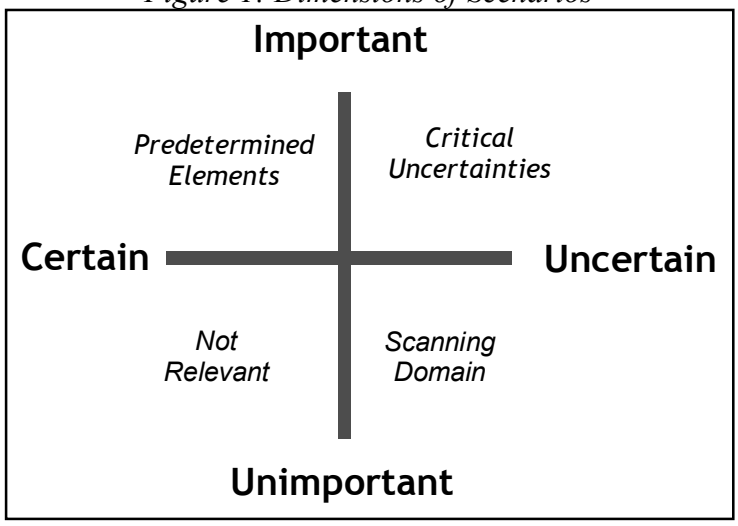
the management of rural land at the present time. This paper considers the prospects for future land use management options through four scenarios. We then consider the implications of these scenarios, focussing especially on agricultural systems, agri-environment schemes and non-agricultural businesses. The paper concludes with some more general observations on the responses for agricultural businesses.

1.1. A general summary of drivers

While the future is uncertain, it is possible to outline the factors that we anticipate will influence conditions for the management of rural land over the coming twenty years or so. One way of classifying the various drivers, such as has been applied in the Foresight Exercise on Land Use Futures[2] is to locate them within two dimensions relating to their importance and their certainty. Importance relates to their bearing on the issue in question and Certainty to the degree to which it is possible to predict their future levels. This gives four 'domains', illustrated in Figure 1.

- Predetermined Elements: Drivers that are of importance for future scenarios, but which are effectively predetermined given the present situation.
- Critical Uncertainties: Drivers which are important but at the same time uncertain. Clearly these are drivers which should be given careful attention.
- Scanning Domain: Drivers that appear not to be critical but for which there is significant uncertainty such that they may become critical in the future.
- Not relevant: Drivers that are well understood and not relevant to the present focus of attention.

Figure 1: Dimensions of Scenarios



Source: Foresight Land Use Futures Project

2. http://www.foresight.gov.uk/OurWork/ActiveProjects/LandUse/LandUse.asp

From an analysis of the potentially relevant the drivers, we might suggest the following allocations for some significant variables in Table 1:

Table 1:Allocation of Drivers to the Four Domains

Predetermined elements:	**Critical uncertainties:**
Global population growth Ageing population in the UK Climate change Developments in information technology Introduction of flat rate Single Farm Payment (and erosion of its value) Water Framework Directive	Global economic growth and trade World energy and commodity prices Exchange rates (and UK entry into Euro) Trade and agricultural policy liberalisation Government climate and energy policy Security concerns Animal and human health
Not relevant: Logically, of course, drivers that are 'not relevant' are not, in fact, drivers at all!	**Scanning domain:** Growth of rural populations Site-based conservation policies Diets and demand for quality food products and local markets Markets for SFP entitlements Requirements to meet WFD standards Carbon trading opportunities Developments in energy generation technology GMOs 'Reference level' for environmental quality

Unknown drivers

Beyond the drivers that we can recognise now as being of potential importance, we also need to recognise the 'unknown unknowns'. These can be of major significance but clearly cannot be predicted. An example would be the case of BSE in the 1980s which was previously unknown but which had major impacts on livestock producers. It would seem that such surprises might be more likely in the contexts of climate change, disease risks or international security. These unknown and unpredictable shocks to the system can have major consequences and any discussion of the future must recognise their potential to alter outcomes and hence the limits of what can be analysed at any particular time.

It is not possible to discuss a significant proportion of these drivers in any detail, but from amongst them we concentrate on three sets of drivers that we believe to be of particular significance: commodity prices, agricultural policy and climate change.

1.2. Commodity prices

Agricultural Commodities

The most fundamental determinant of land use is the price received for agricultural commodities. There has been a dramatic increase in world prices in recent years coming after long period of decline that many had assumed would continue. However, when looked at in a longer term perspective, the level of prices achieved remained well below that attained in real terms through the 1970s and 1980s.The OECD (2008) in 2008 projected a return from the recent high levels to the pattern of decline to 2017 and this has

substantially already taken place. The key question of whether the higher world commodity prices may signal a break from the past clearly depends on the reasons for the higher prices and whether they will persist in the longer term. The issue has been extensively discussed, such as by Banse *et al*. (2008) or HM Treasury (2008).

On balance, it seems reasonable to suggest that while we may see some easing of commodity prices over the coming couple of years, there must be a strong probability that we will experience a period of relatively higher commodity prices in the longer term that is different from the experience that has dominated the past fifty years. But the prospects remain uncertain and price variability seems likely to continue.

Price of oil

The price of oil is especially difficult to predict, even in the short term. The Treasury in July 2008 reported independent forecasts for the price of crude oil for September 2009 that ranged between around $80 and nearly $180 per barrel (HM Treasury, 2008, p39). However, there was concern there would be insufficient investment in the supply chain and that there could be a serious oil 'supply crunch' taking prices to $200 per barrel by around 2013 (Stevens, 2008). However, in fact the oil price fell below $40 per barrel at the start of 2009, with some forecasting further collapse to $25.In fact it strengthened and is currently trading around $65. The conclusion must be that we are unable to forecast prices with any confidence within a very wide range. Again, this price uncertainty and variability seems likely to continue.

Exchange rates

A final factor with regard to commodity prices concerns the level of exchange rates. Domestic businesses are concerned with values in terms of £ sterling, agricultural policy prices are set in €, while many global commodities are traded in US$. Thus the level of the exchange rate also becomes a critical variable in determining the levels of prices faced by British producers. Again, it is not possible to project an exchange rate over 20 years, rather we need to bear in mind that there is a further uncertainty involved.

The implication is that real commodity prices in the longer term beyond the current recession are likely to be above their historical averages.But clearly the only aspect in which we can have confidence is the high degree of uncertainty.

1.3. Agricultural policy

Over the past decades, agricultural returns have been substantially determined by the operation of agricultural policy. Over time there has been a steady liberalisation of the way in which the CAP operates, through restraint in the 1980s, partial decoupling in the 1990s to 'full decoupling' in 2005. This has been advanced a little under the Health Check with some further decoupling, abolition of set-aside, phasing out of milk quotas and some more modulation.

Whether or not the Doha Round of trade talks might deliver further reform

remains unclear, but discussions are now focussing on the CAP beyond 2013.The present CAP may seem unsustainable. The Single Farm Payment may be argued to lack a credible rationale, either as compensation for past policy changes or as a payment for environmental management. The balance of payments towards the older member states contrasts with the requirements for agricultural modernisation and rural reform in the newer member states. The EU member states face a multitude of environmental commitments (Cooper, *et al*., 2008), set at both global and EU levels, for which there will be demands on agricultural policy expenditure. In the context of higher commodity prices, there has been a renewed case made for a return towards a more productivist approach to agricultural policy. The enlargement of the EU to 27 members has re-emphasised the significance of agriculture within the EU economy and the position could be further complicated by the possible membership of Turkey and ex-Soviet states. There is also a renewed focus on food security, now coupled with the question of energy security, that merges into a potential demand for an increased level of domestic production and reduced imports.

In the medium term at least, it does seem likely that there may be some further liberalisation associated with the elimination of export subsidies and a reduction in the level of tariff protection that will leave European farmers more exposed to the volatilities of world markets. At the same time, the level of funding available to the CAP, especially for agricultures within northern European member states, seems likely to decline post 2013.There is however some degree of support around the idea of 'public goods for public money' (Baldock, 2008). We can thus anticipate that some substantial elements of agricultural policy will continue. Arguments for this will be supported by concerns for food and energy security. But of course, the precise level of the policy in terms of funds available and the extent to which these benefit agricultural systems and land uses in Great Britain must be uncertain.

The policy seems very likely to continue to include a version of agri-environment policy based on the provision of public goods or ecosystem services similar to the approach that has been delivered to date. However, the orientation may well change so as to give a greater emphasis to mitigating and adapting to climate change; soil and water conservation in order to protect the productive capacity of agricultural and rural resources; and to actions to mitigate and adapt to risks and natural disasters.

Until recently the progress towards the liberalisation of agricultural policies has seemed secure. At the present time increased border protection or domestic market support for agricultural commodities, notwithstanding the failure of the Doha Round, seems unlikely but not impossible.

1.4. The climate change context for the UK[3]

Climate projections have been published for the UK in June 2009[4]. Assuming medium Greenhouse Gas (GHG) emissions levels, projections indicate a 50% probability of summer temperature rises ranging between 1.5

3. This section draws on Anita Wreford's contribution to the project for the Crown Estate
4. http://ukclimateprojections.defra.gov.uk/

to 2.5°C across the country by the 2020s and 2.3 to 2.7°C by the 2050s.Winter temperature rises are lower, ranging between 1.1 to 1.3°C by the 2020s and 1.7 to 2.2°C by the 2050s.Mean winter precipitation projections indicate a 50% probability of a 4 to 8% increase by 2020s and 9 to 17% by 2050s.Mean summer precipitation projections indicate a decline of 3 to 8% by 2020s and of 10 to 22% by the 2050s. Further information is provided by Jenkins, *et al*. (2009).

These changes in climate will have implications for agricultural producers through changes in variability, seasonality, changes in mean precipitation and water availability, and the emergence of new pathogens and diseases. Some of the changes may be positive, while others are likely to have negative impacts. There are various sources of uncertainty in the impacts of climate change on agriculture. First, these concern the rate and magnitude of climate change itself. Second, there are uncertainties around the biological response of agricultural outputs, for example with regard to CO_2 fertilisation. Third, there are uncertainties regarding how society responds or has the capacity to respond to projected and expected impacts. The main effects can be discussed in general terms.

The elevated CO_2 levels driving the climatic changes will also have an effect on plant growth. CO_2 effects increase with temperature, but decrease once optimal temperatures are exceeded for a range of processes, especially plant water use. However temperature and precipitation changes in future decades will modify, and often limit, direct CO_2 effects on plants; increased temperatures may reduce CO_2 effects indirectly, by increasing water demand. Grasslands can also be sensitive to CO_2 and areas in upland Britain which are already colonised by relatively unpalatable plant species such as bracken, matt grass and tor grass, may see an increase in these species, which could have detrimental effects on the nutritional value of extensive grasslands to grazing animals. A mild warming generally increases grassland productivity, with the strongest positive responses at higher latitudes.

Thermal stress reduces productivity and is potentially life-threatening to livestock. Increased heat often results in declines in eating and grazing activity. High temperatures put a ceiling on milk yield regardless of feed intake. Cattle in confined feed-lots often show catastrophic losses, with economic losses from reduced cattle performance exceeding those associated with cattle death losses by several-fold. With increased heat stress, water requirements for livestock will increase significantly. Extreme events may also make the timing of field applications more difficult, thus reducing their efficiency. Other extreme events such as flooding and windstorms, may also have serious detrimental effects on agriculture.

Increased climate extremes may promote plant disease and pest outbreaks, as well as facilitating the spread of animal diseases and pests from low to mid-latitudes (such as blue-tongue, which mostly affects sheep, and occasionally goat and deer, which would continue to spread from the tropics to mid-latitudes). Multiple stresses, such as limited availability of water resources, loss of biodiversity and air pollution are increasing sensitivity to climate change and reducing resilience in the agricultural sector.

2. The Scenarios

We cannot know the outcomes of these uncertainties and challenges. Rather the aim here is to explore the range of possibilities and their implications for land use options. We do this through the development of some simple scenarios. The approach adapts that taken previously by Hodge and Reader (2006). As explained by Foresight (2002), scenarios are not intended to predict the future. Rather they offer a framework within which to review the future on the basis of explicit assumptions about how the various drivers and their outcomes may develop over a given period of time.

It is possible to relate scenarios to any particular sets of circumstances, either general or specific. In this context, the focus of our attention is on the land use options and the challenges and potentials for rural businesses. Thus our primary focus is on the potential financial returns to rural land and associated businesses, but we also recognise that these must be set within their wider social, economic and environmental contexts. We have already noted the very many possible drivers and potential outcomes. Thus scenario development involves a mix of rational analysis and subjective judgement in selecting appropriate approaches on which to concentrate, given the particular focus of the analysis.

Clearly, in practice these factors are interdependent and interrelated. There are no simple linear causal relationships between them and so no logical order in which they may be considered. But some aspects may seem more 'exogenous' to our focus than others.

2.1. Approach to the scenarios:

Given large numbers of drivers, all of which may operate at many different levels in different ways, it is helpful to give some structure to the discussion of future possibilities. We develop our scenarios on the basis of clusters of relevant drivers, especially relating to prospects for commodity and energy markets and changes in agricultural, forestry, water, climate, biodiversity and international trade polices. The aim in principle is to identify clusters within which the drivers show a high degree of correlation. It is necessary to keep to a small number of scenarios in order to keep the analysis tractable and in this case we develop four scenarios within a 2x2 matrix. We also believe that it is helpful for discussion if the concepts behind the scenarios are relatively simple and transparent. This implies that we have to identify two core clusters of drivers.

The two clusters of drivers adopted here relate first to the financial returns to land use and second to the state of government policies, primarily towards the environment and the attitudes amongst voters and consumers, which we assume in turn influences policies. The scenarios are designed to represent extreme sets of circumstances as a basis for a structured discussion. However, in practice we anticipate that the future outcomes are likely to lie somewhere within the space mapped out by these four scenarios.

Financial returns to land use

The first set of drivers determine the financial returns associated with land

management, i.e. the prices received for the outputs and paid for the inputs associated with alternative land uses. A substantial range of drivers have their major influence on the levels of commodity and energy prices which will determine the revenues that can be generated from commercial land uses. This includes factors associated with both demand and supply: the drivers of population and economic growth that determine aggregate demand for land use products and the capacity of economic and natural systems to supply them. Climate change will have impacts on prices both through instability that it causes in weather patterns and through longer term changes in the production potentials of different regions. Higher prices may also be associated with global security or disease risks. The costs of production will be influenced by raw material costs, the costs of manufactured inputs and the costs of labour. Input costs are probably more predictable, although again, energy prices will be a key factor introducing uncertainty as to the price levels faced for a range of inputs.

These factors will determine the returns to alternative land uses and land managers' decisions. The returns thus flow through to other land use sectors, even where the commodities are not generally traded internationally, including livestock and biofuels. Market forces will tend to generate some degree of correlation amongst prices and returns giving greater justification for treating financial returns as a single cluster of drivers. The level of prices in the UK will increasingly reflect the levels on world markets. There may of course be many other types of government intervention and this is the focus of the second cluster of drivers.

Government environment policies and public attitudes

Within a democracy, we assume that attitudes towards the role of government and the nature of government policies are interrelated. The focus here is particularly on the environment, and attitudes towards the environment will influence both the way in which governments respond to environmental issues and the actions of consumers with regard to decisions about their food and energy consumption. We assume that under 'pro-environmental' attitudes, governments will be willing to be more interventionist and be motivated to adopt more ambitious environmental targets and take actions in order to achieve them, even if this risks slowing economic growth and imposing costs on producers, taxpayers and consumers.

Policy towards climate change will be a significant element of any government's environmental policies in the future, with the objectives both of mitigating future climate change and promoting adaptation to the inescapable levels of climate change that cannot be avoided. But the extent and vigour of government policies remain to be seen. This cluster of drivers relates particularly to government's willingness to impose limits, constraints and incentives on land managers in order to advance environmental and related public objectives. We assume that a 'pro-environment' government will take more vigorous actions in order to limit GHG emissions and to promote adaptation to climate change. This may take the form of tighter regulation, environmental taxes or trading schemes or greater incentives to change

behaviour.

A 'pro-environment' government would also be expected to maintain an active agri-environment programme that supports environmentally sensitive agricultural land uses, either by maintaining them where land might otherwise be abandoned or by restricting their intensity elsewhere. It may also be assumed that the general public will have higher expectations for the standards of land management and that these may be incorporated into stricter conditions and regulations. We anticipate too that a 'pro-environment' government will generally take a more interventionist approaches towards other areas of policy, such as spatial planning, in demanding higher standards for new developments and redistributing economic activity away from congested areas.

Pro-environmental attitudes are also expected to reflect consumer behaviour in using consumer choices to advance environmental objectives. This would relate to the selection of products and adoption of behaviours that cause lower levels of environmental harm. We anticipate that this would be associated with an increased demand for higher quality food products perhaps sourced on a local or niche basis, successful operation of assurance schemes, demand for green energy and demand for products associated with environmentally related activities, such as outdoor recreation and rural tourism. A third element of pro-environmental behaviour would be revealed in terms of support for conservation organisations that own and manage land with conservation objectives and through contributions to local environmental funds that can allocate resources for environmental and land management projects.

These two clusters of drivers combine to produce four scenarios as illustrated in Figure 2.

2.2.The characteristics and implications of the scenarios

Limitations of scenarios

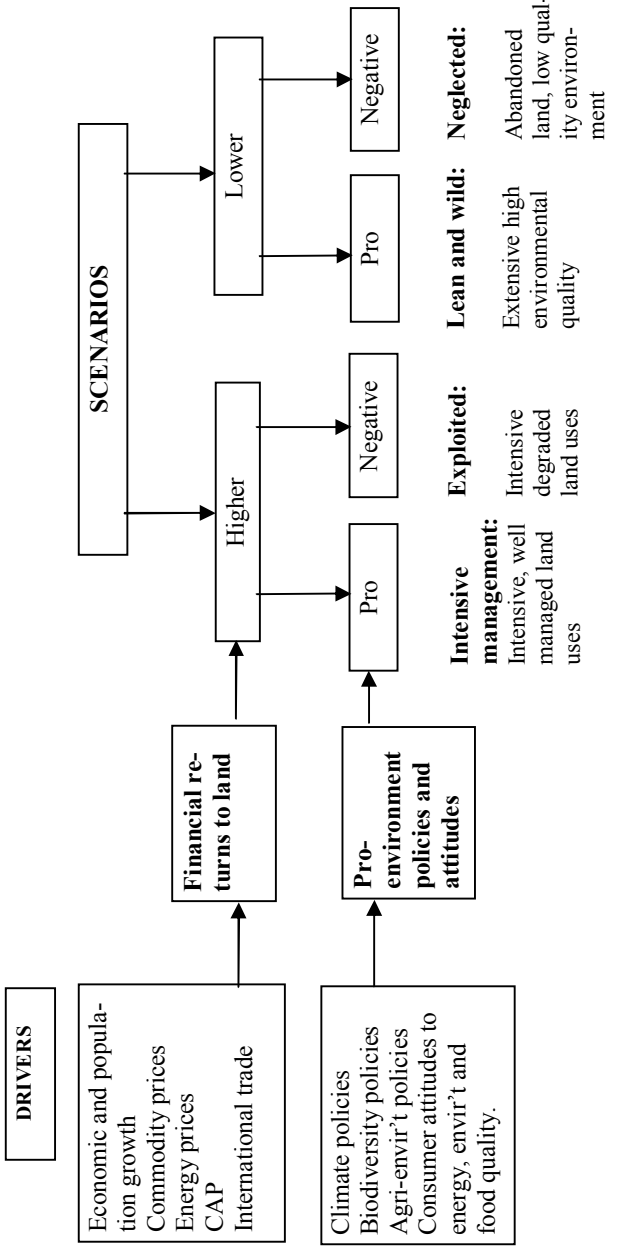
As we have indicated, in practice the multiple drivers identified as potential influences are more likely to pull in different directions leading to more complex but probably less extreme outcomes. There is no necessary direct correlation between global energy and global food prices. And the prices received by farmers in the UK are also subject to exchange rates and government intervention. Similarly there may be circumstances where public preferences are favourable towards the environment, but where public policy is not. This would place a greater emphasis on market and voluntary initiatives.

We may now summarise some of the characteristics and implications of these four scenarios.

Intensive management

In the 'intensive management' scenario financial returns to land are relatively high implying higher potential farm incomes and agricultural rents. This assumes that increases in output prices more than counter the increase in input costs that are likely to be associated with the higher output prices.

Figure 2:Scenarios and Their Drivers



In these circumstances, land managers face an incentive to intensify their agricultural production, but this is likely to conflict with pro-environmental attitudes and government policies.

A critical issue will be the way in which government policies are developed, either treating the impacts of agricultural production as pollution and hence imposing strict regulations over agricultural practices, or else treating environmental quality as a public good or ecosystem service implying that farmers will be paid in order to provide an higher environmental standard. In practice, and as reflected in current policies, there will be some mix of these two approaches. In recent years we have seen the introduction of positive payments for agri-environment schemes but with a rising 'reference level' that defines the standard of environmental management that is required as a 'duty' of land management before payments for higher standards can be justified. This approach will influence, for instance, whether the current cross-compliance standards are simply incorporated into legal requirements.

The same arguments will apply in the debate about the changes in agricultural systems required in order to meet the likely reductions demanded in GHG emissions. If past experience to this is a guide, we may anticipate that the initial changes will be encouraged by means of voluntary adaptation and positive incentives but that once the environmental standards come to be regarded as 'normal' the policy approach will become more regulatory. This suggests initial policy approaches may be introduced through the existing agri-environment programmes whereby land managers can be subsidised for introducing innovations and changes to their systems that mitigate GHG emissions. In the longer term, given that the requirement to reduce emissions will continue indefinitely, the necessary incentives may be transferred onto more specific trading schemes or built into legal regulations. Again, some mix of these would seem most likely.

However, we cannot assume that because government adopts a pro-environmental policy stance there will be generous environmental payments. In fact, because of the relative profitability of agricultural production activities in this scenario, the opportunity cost, or the income foregone from reducing production intensity or placing land into conservation uses is also relatively high. This implies that conservation activity could need to be more highly targeted by government policies on higher priority, more critical areas for conservation.

The pro-environment consumer attitudes imply that there will be opportunities to gain a price premium by marketing higher quality and environmentally friendly products.

Exploited

Under the 'exploited' scenario, financial returns to land uses are high, but without strong pro-environmental attitudes or government policies. We again assume that the higher level of output prices outweighs any increase in input costs. This presents farmers with a high degree of market choice as to how to manage their land with relatively few regulatory constraints or environmental incentives. Farmers have a strong incentive to intensify their production

activities without significant countervailing actions by government or consumers to restrain the impacts on the environment, while the general philosophy of government is to let the market solve potential supply problems.

The extent of land use conservation activity within the rural environment in these circumstances would then tend to depend to a great extent on the security of the conservation measures introduced in previous time periods. Given that most agri-environment schemes permit landholders to opt out at the end of a set contract, it is likely that much of this protection will be lost once farmers perceive the long term nature of higher prices and respond to it.

Weak consumer attitudes and preferences towards the environment also mean that there are limited opportunities for linking environmental conservation to market opportunities. The primary incentives facing farmers will relate to the financial returns available from commodity production. They may have personal preferences for environmental conservation, and the relatively high returns would allow some farmers to pursue this approach, but it will generally not be supported by community pressures or social norms.

Lean and wild

The possibility remains that in a few years' time we may revert to the longer term decline in the levels of commodity prices and lower returns to agricultural land. In these circumstances attention returns to how to minimise agricultural production costs, how the resources available to farming businesses may be organised in order to maximise returns, and whether resources may achieve a higher return in alternative uses. The direction of change for farm businesses would be likely towards simpler, lower input, probably larger scale agricultural systems. This would be exacerbated should inputs costs, especially energy prices, remain relatively high.

The presence of pro-environmental attitudes and government policies may offer some opportunities. This scenario does offer the prospect of some environmental advantages, such as reduced emissions of minerals or pesticides from agricultural production, but the lack of management would also have detrimental effects in terms of landscape and biodiversity.This would promote more extensive land uses and, depending on government responses, the potential for land to be abandoned. In this context, it is the lack of agricultural management that represents the primary threat to conservation and landscape values. The lack of management is most likely to arise in the uplands, but could also affect lowland areas too, especially with regard to problems of undergrazing.

Thus we may anticipate agri-environment schemes that promote a continuation of relatively low intensity agricultural systems. With relatively low returns to agricultural production, the opportunity costs of conservation activities would be low with the implication that an agri-environment policy with a given level of funds available could influence land uses across a relatively large area. We might then envisage ambitious schemes to reorient large areas of land towards conservation uses.

The pro-environment consumer attitudes will generate some commercial opportunities for products and farm activities.

Land would be relatively cheap and there could be opportunities for managers of particularly efficient farming operations to expand the scale of their operations, but to a lesser extent than would be the case in the fourth 'neglected' scenario.

Neglected

With low financial returns and without any active agri-environmental policy, land would be commonly unmanaged in ways not seen since the 1930s. There would inevitably be calls for a resumption of protection for farming, but perhaps in the context of a long run decline in the political importance attached to agriculture these may not be politically attractive, in the UK at least. In these circumstances, without even a lifeline of support for land use through agri-environment schemes, we may expect substantial extensification of all types of agricultural system as well as land abandonment.

Agricultural land prices would be low and so there could be some more positive intervention by private individuals and conservation organisations, even if this did not represent a general public pro-environmental attitudes, who may be attracted to acquire land to be managed for environmental values. The extent of such activity in the absence of strong government environmental policy clearly depends on attitudes towards the rural environment and the willingness of individuals to allocate their own resources towards it, either individually or collectively through non-profit organisations.

What government policies that are directed towards the conservation of the rural environment would be targeted on critical conservation values are most threatened by neglect and abandonment. But even here, we may anticipate that government would tend to adopt a regulatory approach rather than offer positive payments.

3. The Implications of the scenarios for agricultural businesses.

These scenarios have implications for particular issues that will be crucial to the development of farm businesses.We here consider the implications for agricultural systems, agri-environment schemes and non-agricultural businesses.

3.1. Agricultural systems and returns

The different scenarios are likely to have significant implications for the types of agricultural systems that are adopted.

Intensive management

Under this scenario, returns to farming are high while at the same time the government is pursuing a vigorous policy to mitigate and adapt to climate change. This suggests a more intensive, higher technology approach towards land uses that achieves the required reductions in GHG emissions without excessively depressing and perhaps at the same time as increasing production levels. Thus we may expect more intensive land uses, including the adoption of biofuels where they are effective in reducing lifecycle carbon emissions. At the same time, land is valuable and so we may expect high levels of public

investment in infrastructure to protect coastal land areas.

While much of the focus of the current debate about climate change mitigation has been on carbon, much of the GHG emissions from food production arises in the form of N_2O and CH_4 on which there has been much less research. The Strategy Unit (2008) report concludes that agriculture is set to have a more prominent place in GHG abatement strategies in the future. This will involve detailed changes to agricultural systems.

Higher commodity prices will lead to more intensive agricultural systems. There will be a premium on achieving the 'best' use for all available land areas as judged from a 'pro-environmental' perspective; agriculture will be 'multifunctional'. The pro-environmental policy environment may enable smaller businesses to survive but this may not be the case if the high degree of control over production systems necessitates large, intensive, high technology systems, especially for livestock production.

It is perhaps tempting to assume that the most environmentally sensitive forms of agricultural production will tend to be small scale and extensive, but this is certainly not always the case. Large scale operations can achieve very high levels of environmental control and economies of scale in the generation of energy and management of waste. They will also benefit from the traditional economies of size with regard to agricultural production processes. The point is illustrated by two recent examples of very large investments in different types of agricultural production 'thanet earth'[5], a hi-tech greenhouse complex, is being constructed by Fesca Group Ltd on the Isle of Thanet. £80 million is being invested in a 91 hectare site. Production will use hydroponic techniques in fully controlled glasshouses. Energy supply will be by a Combined Heat and Power installation that will provide sufficient electricity for 50,000 homes and the CO_2 will be absorbed by the plants. Robert Wiseman Dairies[6] have recently opened a new dairy on a 21 acre site at Bridgewater, based on £100 million investment, which will process and pack almost 10% of the nation's raw milk. Plastic milk bottles are manufactured on site. There will be water treatment and effluent plants on site. These sorts of facilities have the potential to alter the context within which agricultural production and processing is undertaken much more widely.

New technology will be called upon to deliver this high level of intensity in an environmentally sensitive way, although a 'pro-environmental' policy may well place limits on the range of technological innovation that is acceptable. This suggests a vigorous debate on issues such as GMOs or animal welfare. Similarly, we may anticipate strong demands on consumers to alter their diets, especially away from the consumption of livestock products. Local production may no longer be seen as appropriate as large scale production systems require a national food distribution system.

Exploited

In this scenario, agricultural producers are left relatively free to pursue activities that can maximise their profits. We anticipate that oil prices and

5. http://www.thanetearth.com/pdf/thanetearth_sept07.pdf
6. http://www.wiseman-dairies.co.uk/pdf/Bridgwater_Formal_Opening_Release_Final.pdf

prices of inputs that are heavily dependent on oil are higher than at present. Under this scenario, profit maximisation and technological innovation are given free reign, even if they compromise environmental quality and longer term resource conservation. In the face of high input costs there will be incentives to adopt technology which can increase agricultural production cost -effectiveness, irrespective of its environmental consequences. This will give an incentive for changes to be made to production systems which would economise on fossil fuel inputs and thus reduce carbon emissions. But N_2O and CH_4 emissions would be likely to remain relatively high and there would be little incentive for land managers to introduce systems that can protect or sequester carbon. In the longer term, this will lead to higher rates of climate change and higher temperature increases, but this will have greatest impact beyond 2028.

It seems likely that this will tend to favour large scale farming businesses, although the higher prices may permit the survival of smaller business operations where costs may be lower because they are not required to adopt low environmental impact innovations

The freedom to farm and the potentially high returns may make land an attractive investment to large financial institutions who can assemble areas and achieve economies of size in production.

Lean and wild

With lower returns to farming, and lower land prices, targets to mitigate GHG emissions are likely to be met more by reductions in production levels and the operation of more extensive agricultural systems. With more extensive systems there is much less pressure on land and so environmental objectives can be achieved by reducing production intensity or even by taking land out of production entirely. It has been suggested that the greatest gains in terms of CO_2e emission reductions are likely to come from taking cropping organic soils out of production (Laurence Gould and CRED, 2008).Areas of land, such as peat soils, whose cultivation causes high GHG emissions, will be taken out of production.Land may be put into forestry in order to sequester carbon or used for biomass for renewable energy production. The environmental impacts of agricultural production systems may be reduced through the introduction of versatile crop rotations including crops with high root biomass and cover crops.

Farming systems would be expected to minimise on fertiliser and chemical use in arable systems, using sophisticated information systems to produce selectively on only the best land and use optimal levels of inputs. Given the GHG potential of intensive livestock systems and the costs of controlling emissions, we may expect a switch to livestock production by extensive grazing systems. There may also be potential for the development of agro-forestry systems that can hold high levels of carbon in the soil.

There will be serious risk of land abandonment, especially in the uplands, but agri-environmental policies may be expected to guide land uses either maintaining traditional upland farming, ecosystems and landscapes, or else they may facilitate the transfer of land into large scale conservation where

agricultural production activities are substantially removed and areas are allowed (or managed) to develop into new landscapes and habitats. This may be achieved by the accumulation of land areas into a single ownership, or else by means of very long term agreements with existing landowners.

Neglected

Weak regulation has little impact on agricultural systems and GHG emissions continue unabated.Again, this will be a cause of more extreme climate change in the longer term, but beyond the period to 2028. However, the emissions associated with less intensive systems are lower than they might otherwise have been. In this context we see a mix of land uses across rural areas. Farming may be profitable, but only where it is undertaken on high quality land by well managed and equipped businesses. These will demand very high management standards and comprehensive collection and application of information about production conditions at a very detailed scale. Adjustment to higher energy and input costs will be by means of extensification, use of fallows, clover leys and avoiding unproductive areas of land.

We can expect the development of extensive ranching systems in the uplands, where production takes place at all. Other areas will simply be abandoned. In time and with the impacts of climate change, this may lead to the development of different types of habitats and landscape which may come to be appreciated by the general public so that the loss of the older more intensively farmed landscapes is no longer regretted.

3.2. Agri-environment schemes

Agri-environment schemes and policies may be expected to develop in a variety of ways. Under the 'pro-environment' scenarios funds are made available for the implementation of substantial agri-environment programmes, but the approaches adopted will be quite different.

Intensive management

The pressures for intensive agricultural production threaten the quality of the rural environment in a variety of ways and the role of agri-environment policy is primarily to mitigate the impact of intensification. This becomes more significant if the cross-compliance leverage of Single Farm Payment is lost, although it seems quite probable in the event of fundamental reform of the CAP, the cross-compliance requirements would be re-established as regulations enforced by penalties. Agri-environment schemes are then most likely to offer payments for extensification and the removal of critical areas of land from production, such as sensitive habitats, areas adjoining watercourses or peatlands. There are strong demands for land and the opportunity costs of conservation are high. We may thus anticipate careful targeting of agri-environment interventions, especially on locations which have the potential to secure a range of ecosystem services. They may be made more robust through the use of longer term conservation measures such as land purchase or conservation covenants. The cost of the scheme could be relatively high, but it

is assumed that funds would be found where government policy is favourable towards agri-environmental policy.

Given the importance of land for social as well as private reasons and a more interventionist approach, the policy response is to seek to develop 'intensive conservation'. This will explore the potential for adopting novel technologies towards conservation, perhaps using *ex situ* approaches.

There is an argument as to whether higher levels of government expenditure on agri-environment schemes promote higher voluntary environmental investments, or whether high government expenditure may crowd out voluntary expenditure. The view may be taken by land managers that while government takes on the responsibility for environmental enhancement and maintenance, private organisations no longer need to; that the responsibility for environmental stewardship has been taken on by the government by commoditising then environment, so that private organisations will only do what they are paid to do.

Exploited

This scenario represents the greatest threat to rural environmental quality. It would seem unlikely that in this context government would continue to operate an active and wide-ranging agri-environmental scheme at all. Voluntary schemes are expensive given the high opportunity costs of land taken out of agriculture and so regulation could be the primary approach to protection of the environment. This may be acceptable to a government that is less committed to the environment. What schemes are implemented will necessarily be highly targeted given the limited funds that are made available for agri-environment policy. Schemes are likely to be operated on a more competitive basis, perhaps along the lines of the use of the Environmental Benefit Index under the Conservation Reserve Program in the USA. The policy approach taken is likely to depend on whether government's lack of commitment to environment reflects an unwillingness to allocate funds for environment or a simple lack of concern for environmental values.

Lean and wild

This scenario gives considerable scope for wider-ranging schemes influencing land management across a substantial proportion of the agricultural land area. Regulation may be less necessary given the relatively low threat from pollution and an active agri-environment scheme. There is likely to be a shift away from a narrow focus on conservation on sites that happen to carry rare species or habitats towards a wider countryside approach and efforts to achieve conservation at a larger scale. Efforts would be made to build the resilience of the countryside against threats associated with climate change, pollution and low levels of water availability.

A major threat to the environment is associated with the low returns to farming and the lack of management and abandonment of agricultural land. This will be most acute in the uplands. Thus the prime focus of agri-environment schemes will be to support the maintenance of environmentally friendly farming systems that are not profitable under market trading

conditions. But support will need to be qualified in order to avoid supporting environmentally harmful intensification and to meet any World Trade Organisation rules that are still applied.

Neglected

Again, the threat to the environment is associated with neglect and abandonment, but given that government has little interest in environmental conservation, the problems are likely to remain unaddressed. Policy will depend on the rationale behind the lack of government intervention, as between lack of willingness to allocate funds or a lack of concern for the environment. In the case of the former, government could implement a regulatory approach, but this may only have a limited impact where the environmental requirement is to increase levels of land management rather than to prevent certain actions.

As noted in the context of agricultural systems, the shift to very extensive systems in remoter areas may lead to the development of different types of landscapes which may, in due course, come to be appreciated by the public.

3.3. Non-agricultural activities

The alternative scenarios will have an impact on the range of opportunities available to farm businesses to develop income from non-agricultural activities associated with both the likely characteristics of consumer demand and the costs facing consumers and so influencing their choices. While not explicitly defined by the scenarios, there will be a general relationship with levels of economic growth. Higher income levels will tend to stimulate the demand for higher quality and added value products that can be sold at a price premium. This will create opportunities for businesses both to sell value-added products directly to consumers, whether through farmers' markets or through the internet, or to sell such products into the supply chain. Higher incomes may also be associated with more leisure time and increase the demand for rural tourism, while, as already being argued at present, higher energy costs with raise the costs of transport and so make UK tourism more attractive to UK residents. Of course, high travel costs will tend to reduce the numbers of overseas visitors coming to the UK, but it is assumed that UK residents would be more likely to engage in farm-based and rural tourism than overseas visitors who will be more attracted by internationally recognised sites and localities.

Intensive management

This scenario involves relatively high commodity prices which we assume will tend to be associated with relatively high rates of economic growth, although this need not necessarily be the case. We assume that pro-environmental policies are likely to levy higher taxes on travel to reflect their full impact on the environmental. So transport costs generally are likely to be high. At the same time, pro-environment attitudes will to some degree at least, and especially in the context of higher rates of economic growth, influence consumers to purchase more environmentally friendly products. This creates

opportunities for farm-based recreation enterprises catering for the domestic market.

It is possible too that farmers will be able to combine the creation and maintenance of attractive and biodiverse local environments through participation in agri-environment schemes, with the provision of complementary tourism opportunities and services.

Exploited

In the context of relatively lax environmental standards, the costs of travel fail to represent the full environmental costs so that there is less of a boost to domestic tourism activities. The weaker pro-environmental attitudes on the part of consumers reduce the premia that are available through the production of higher quality or environmentally friendly products. This then re-emphasises the focus of agricultural businesses of the bulk production of agricultural commodities. The implication is that while there will still be opportunities for non-agricultural enterprises, they are less likely to be complementary to and supportive of land management.

Lean and wild

The pro-environmental attitudes of the public mean that there is a demand for higher quality agricultural products. The lower production intensity of land use also means that there are fewer potential conflicts between agricultural production and provision for public access and recreational provision on the land. And government schemes are likely to be available to support this, especially in the uplands. Thus we may expect the allocation of land to recreational and tourist activities to be attractive to a population for whom international travel is highly taxed.

Neglected

The limited public interest in the rural environment means that, as in the Exploited scenario, there is relatively little connection between non-agricultural activities and the management of the land. Agricultural buildings and land will be potentially available for non-agricultural activities in view of the extensive nature of agricultural production and the level of demand will depend on their location relative to towns and cities and the level of economic activity and incomes.

4. Conclusions

The aim of the scenarios is not to predict particular circumstances, but rather to explore the range of possibilities. But three more general issues have emerged from the discussion.

The resilience of agricultural businesses

Farm businesses need to develop their resilience in the face of greater exposure to the volatilities of world markets and reduced level of support under agricultural policy. They also face a more uncertain future against the uncertainties associated with climate change. Farms will need to make efforts

to build up the resilience of their businesses over time.

We are experiencing a period of substantial dis-integration in terms of the ways in which agricultural businesses are owned and operated, especially in terms of the means by which they gain access to land. Farm businesses are not simply mixed tenure but gain access to land and resources by a wide variety of arrangements. They can achieve economies of scale by specialising in particular types of production across several different holdings. Businesses involve a mix of agricultural and non-agricultural enterprises. This flexibility and diversification will be increasingly important, and complex. At the same time, the separation of long-term land occupation from its use and management threatens to undermine the traditional land occupier's sense of environmental stewardship and this is an issue for consideration.

Farming also faces threats arising from climate and environmental change. Investments will be needed aimed at reducing the risks of natural disasters, such as flooding, or from environmental stress, such as limits imposed on water for agricultural uses. Risk assessment should identify threats to particular types of businesses both directly from climate change and indirectly from policies that will require then to mitigate GHG emissions. This should be based on a comprehensive analysis of GHG emissions and stocks. Generally, we assume that adaptation will be better earlier than later; that there will be first mover advantages. But there is the issue as to whether Government may offer higher financial support at some later stage; so there may be a penalty in acting too early.

Land management, land use and ecosystem services

There will be changing and probably increasing pressures on the social values and implications of land uses, especially under the Intensive Management scenario. We have identified a variety of ways in which land use and management will be called upon in addressing climate and environmental impacts. Changes in land use and in management have the potential to make a significant contribution to enhancing water quality, mitigating flood risk, protection reserves of soil carbon, achieving biodiversity conservation targets.

Land use changes in these contexts have the potential to enhance the provision of ecosystem services and increase the resilience of ecosystems in a variety of ways, such as in terms of adapting to climate change and in enhancing the capacity of biodiversity to withstand shocks especially associated with climate change. There would seem to be considerable spatial overlap in terms of the particular areas of land that have the potential to contribute towards these objectives, implying that there are certain critical areas where land use change could make a major contribution towards the provision of a range of ecosystem services. This may be achieved by planting trees, taking land out of intensive production or extensifying land uses. We may expect such areas to become the key focus of policy initiatives from across the range of agencies.

Collective initiatives by businesses

There will be circumstances when businesses can benefit from acting

collectively rather than individually. There are various issues that might be addressed in this way, such as in terms of water management, renewable energy and waste management, collective marketing or biodiversity management. There could be opportunities for businesses to work together to develop complementary tourism enterprises within local areas. Thus for instance there could be opportunities for the co-ordinated development of tourism enterprises perhaps based on forest recreation or farm-based activities, alongside farm-based accommodation. The same sorts of argument would apply too to more conventional farming issues such as machinery sharing or group selling of commodities. Particular opportunities may be associated with water supply, anaerobic digestion and a quality mark and marketing.

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