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***Farming for Conservation of the Upland Landscape and Biodiversity  
in the Burren***

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## **Abstract**

The Burren landscape which stands out as one of the most magnificent managed landscapes in all of Europe has recently come under threat due to a shift in farm management practices. As a result of evolving market trends and social structures, traditional farming methods are being replaced by more conventional/commercial practices and in some cases a gradual abandonment of the lands for off farm income sources is occurring. Agri-environmental schemes such as the Rural Environmental Protection Scheme (REPS) with its generic farm management prescriptions have not proved to be effective in conserving this landscape along with its natural and cultural values.

The BurrenLIFE initiative which has been experimenting on 20 farms over the last five years have targeted their efforts specifically on the Burren region to find the best scientific practices required for farming for conservation. In this study we investigate whether the farming practices recommended by BurrenLIFE project (BLP) are economically viable in providing a desirable public good. This work employs a survey based valuation technique (Choice Experiments) as well as a relatively new valuation approach (using a prediction technique) to estimate the value of some of the positive externalities generated by the BurrenLIFE management practices. Along with the positive externalities, the multiplier effect related to tourism is estimated and incorporated into a Land Portfolio Allocation (LPA) model to examine the effect of various policies and subsidies on the farming practices of the 20 BurrenLIFE farms ('Burren 20 farms').

Our results indicate that even with the most conservative reported willingness to pay from survey data, the rate of return on government support for these systems is no less than 235%. However, we also find that these farming practices are sensitive to the various government and BurrenLIFE subsidies to the farms; thus highlighting the importance of these payments in encouraging farmers to farm for conservation.

## **Keywords**

Landscape Valuation; Choice Experiments; Hypothetical Bias; Land Portfolio Allocation; Agri-environmental Schemes; Sustainability

## **Introduction:**

Traditionally the economy of Ireland has been dominated by agriculture. In the last few decades however the market has witnessed tremendous changes with the development of other industries. As a result agricultural practices as well as policies have constantly evolved to adapt to these changes. Regardless of the shift in market dominance, agriculture remains at the forefront in terms of Ireland's identity through heritage, tradition, the farming vocation, landscape and biodiversity. It is therefore essential to implement correct agricultural policies that enhance this multitude of factors. With farm management practices as the primary tool, it is a constant struggle to design and implement an ideal agricultural policy that is able to endure evolving market trends and social structures and still manage to preserve the natural environment.

The Burren provides an example of a landscape where the natural environment has evolved together with the farming culture to form an interdependent alliance. Traditional farming practices in the Burren were developed and implemented for the purpose of promoting agricultural production and sustaining a livelihood. Although these ends have undergone immense devaluation as a result of changing market trends, the externality from the extensive farming practices in terms of the remarkable landscape and biodiversity holds significant value.

The problem however lies in realizing the value of the externalities such as the landscape and biodiversity. Their value is implicit; that is, it is not actively traded in the market and as a result there are no economic incentives for farmers to continue with past practices that preserve them. Various studies analyzing externalities and market failure have been conducted in multiple areas including deforestation (Pearce, et al. 2002), urban sprawl (Brueckner 2000), air pollution (Henderson 1977), and waste management (Eshet, et al. 2006). The changing market structures result in the traditional farming practices of the Burren no longer yielding a profitable commodity. As a result the trend has been a gradual abandonment of these practices in favor of conventional/commercial methods and other paid employment.

The primary goal of agri-environmental schemes in the last decade has been to fill in such gaps by recognizing the value of such externalities which the market fails to acknowledge. However, such intervention has not always led to desired outcomes or has led to unexpected consequences due to flaws in the policy design and/or implementation (Latacz-Lohmann and Hodge 2003; Kramm, et al. 2008). Often statutory agricultural and rural development agencies are not sufficiently well integrated and focus on different aspects of rural, agricultural, social and environmental management/development or are too remote from local agronomic conditions to make local agri-environment schemes more effective by adapting them to local requirements and conditions. Agencies such as the BurrenLIFE project (BLP) on the other hand may be much better equipped to enhance the efficacy of agri-environment schemes due to their locally targeted participatory approach to land management issues. Thus the BurrenLIFE project sets out to

address local challenges and thereby deliver environmental public goods that are unique to this landscape.

There is a danger that in the absence of proper valuation the external benefits created conservation practices go ignored, and therefore the Burren is undervalued and the benefits associated with the intervention by BurrenLIFE are lost. The reasons for this are twofold. First, policy makers acknowledge that managed landscapes provide use values and bring a number of additional indirect monetary benefits into the local economy. Better landscapes matched to local visitor and tourist needs may increase the proportion of trip expenditures spent locally and bolster local employment because people actively visit and use the landscape. The indirect economic values associated with tourist expenditure in the Burren may be considerable, due to a multiplier effect of tourist income on the rural economy (Midmore 2000; Keirle 2002). These include an increase in the sale of food and/or local products from farmers markets, and employment created from the provision of accommodation and meals for tourists. There may be a strong case for promoting certain agri-management practices in order to maximize the local economic benefits captured by towns and villages in the Burren. Green tourism needs to be linked to, and often depends on unique managed agricultural landscapes such as the Burren in order to prosper. An economic study of this type broadly recognizes this issue.

It is also recognized that landscapes such as the Burren provide non-use values to European tax payers living in Ireland and elsewhere who do not visit the Burren but still nevertheless derive utility from knowing it exists.

The discovery of the best scientific practices in terms of farming for conservation does not guarantee its adoption and hence cannot promise the achievement of desirable environmental outcomes. Despite its greater overall benefits to society, the lack of proper incentives to farmers could lead to the adoption of suboptimal practices. Hence it is important to understand how market structures as well as rural and environmental policies influence decisions taken by farmers and why they frequently fail to protect biodiversity and other non-market values. The land portfolio allocation model (LPA) proposed in this study helps to understand these processes and can provide fundamental insights into decisions taken by the farm household. First, it will determine whether or not the farming for conservation systems are financially and economically viable and secondly, how market and policy trends impact on viability, land use and the associated amenity and biodiversity.

Through the inclusion of the estimated values of external benefits of the Burren landscape<sup>iv</sup> as well as the indirect economic values associated with tourist expenditure<sup>v</sup> in the Burren region,

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<sup>iv</sup> In this paper the only external benefits we consider are the landscape and biodiversity benefits; benefits received from the karst limestone pavements and the orchid rich grasslands. These benefits are only aggregated amongst Irish taxpayers.

<sup>v</sup> The only tourist expenditure we consider are those from domestic tourists. A significantly large amount of expenditure that is obtained through international tourists are excluded.

the LPA model sets out to determine what weight and compensation should be given to biodiversity or landscape amenity in the interest of society as a whole. This paper details the attempt of the BurrenLIFE project to counter deficiencies in the agri-environmental schemes currently implemented in the Burren and to value the external benefits that arise from this intervention. Through the proper valuation of some of the potential positive externalities that result from the BLP recommended practices, the significance of implementing the scheme on a wider geographical scale of Burren farms is assessed.

This paper has the following aims:

1. To quantify the external benefits associated with Burren landscape and its floral biodiversity
2. To develop a Land Portfolio Allocation model to establish whether or not the farming for conservation systems are financially and economically viable and secondly, how market and policy trends impact on viability, land use and the associated amenity and biodiversity.
3. To determine whether the BurrenLIFE agency has been effective at promoting local agronomic practices that enhances environmental public goods that are unique to the Burren.

### **Background on Agri-environmental Schemes in Ireland**

Upon establishment, the objective of the Common Agricultural Policy (CAP) was to improve agricultural productivity while ensuring a higher standard of living for the agricultural community. By the 1980s, in addition to achieving self sufficiency, there was a surplus in many of the agricultural products. This however came with a high cost in terms of external trading, concerns over food safety and most importantly adverse environmental impacts. These consequences were a motivation for the MacSharry reform in 1992. The adjustments entailed major shifts from a production oriented policy to ones designed to promote better environmental quality.

Agri-environmental schemes thus became a crucial component of the CAP which was used to pay farmers in return for the (environmental) services they provided. In Ireland, the Rural Environmental Protection Scheme (REPS) was introduced in 1994 and included a set of guidelines in terms of permissible farming practices.

By the end of 2007 over 2.45 Billion Euros had been paid to farmers through REPS (DAF, 2007). The direct beneficiaries of these payments have been the farmers receiving them; however, several positive externalities that result from the specific farm management practices

have benefits for the entire society. These include rural landscape aesthetics, recreation amenities, wildlife preservation, improved water quality, and the maintenance of historical and archaeological features (Finn 2003)

The move from production based schemes to single farm payment has increased the demand for environmental goods partly because of the greater visibility of such direct payments (Gorman, et al. 2001). It is through the agri-environmental measures that the society purchases various environmental services from the farmers and it is crucial that the society gets good value in return (Hamell 2001).

The number of studies evaluating the effectiveness of agri-environmental schemes in Europe are growing but still quite limited with the ones available providing contrasting results (Kleijn and Sutherland 2003; Kleijn, et al. 2001; Hoogereen, et al. 2002; Swetnam, et al. 2004).

There have been even fewer evaluation studies of the REP scheme in Ireland (Dunford and Feehan 2001; Feehan, et al. 2002; Flynn, et al. 2001; Aughney and Gormally 2002). The study by Flynn, et al. (2001) of the impact of REP schemes on birds revealed no significant difference in species richness on REPS and non-REPS farms. A similar conclusion was made by Feehan, et al. (2005) for their evaluation of the REP scheme on plant and insect diversity.

One of the reasons cited for the lack of significant effectiveness of these schemes is its voluntary nature which allows for erratic spatial distribution of farms that have adopted the agri-environmental schemes. This decreases the effectiveness in enhancing populations as their dispersion from one field to the next would be restricted (Geertsema 2005; Whittingham 2007; Dasgupta, et al. 2007). Farms not under the REPS scheme but receiving direct payments under the 'Single Payment Scheme' are obliged to observe certain conditions in their farms which are known as 'cross compliance'. However, it is not clear whether the practices under cross compliance complement those under REPS. It is also believed that the time commitment required from farmers which is generally five to six years may perhaps be too short for appropriate levels of regeneration of populations (Berendse, et al. 2004).

One of the most important factors impeding its effectiveness could be that the environmental scheme is not well suited for the farmland or the entire region. REPS, CFP (Control of Farmyard Pollution) and cross compliance which are nationwide schemes, cannot produce the same level of outcome when implemented on different types of landscapes and ecosystems. This is a key reason why the Burren region has not acquired substantial environmental benefits from these schemes and thus provides the primary motivation for designing a scheme in the Burren region that is tailored for its unique ecosystem.

### **Study Site: The Burren**

The Burren is one of Europe's most important and most widely recognized landscapes. Located in the west of Ireland in county Clare and Galway, it spans across an area approximately 720 km<sup>2</sup>. The specialty of the Burren is not only limited to its exceptional beauty but also to the wealth of natural and cultural heritage.

The most prominent feature of the Burren has to be the rocky uplands with its mysterious landscape formed by karst limestone pavements. This landscape is described as a 'glaciated karst' landscape, as it was shaped by the last glaciation and then further sculpted by thousands of years of rainfall (Moles and Moles 2002; Dunford 2002). At the time of arrival of Neolithic farmers to the region, the entire landscape was covered with woodlands dominated by pine and hazel. The farming practices over the next thousands of years led to the gradual clearing of the woodlands. With the disappearance of this abundant vegetation, the soils washed away revealing the karst limestone pavements underneath, which characterize the present landscape of the Burren.

Despite the barren appearance of the Burren, its orchid rich grasslands host almost three quarters of all of Ireland's native flowers, and includes most of the country's orchid species. Hence it has also been termed 'a fertile rock' (O'Rourke 2005).

Furthermore, the agrarian settlers from thousands of years have endowed the region with a wealth of culture that can be seen through the many archaeological features dispersed across this landscape. Remains of many ancient structures ranging from wedge tombs, dolmens, and ring forts, to more recent stone houses, animal enclosures and a network of stonewalls demonstrates the unbroken human influence on the landscape ([www.burrenlife.com](http://www.burrenlife.com)).

To preserve the unique wealth that is offered by the landscape, much of the Burren region (47,000 ha) has been designated 'Special Areas of Conservation' (SAC) under the 1992 EU Habitats Directive. Five different priority habitats are included under this designation which includes the karst limestone pavements, orchid rich grasslands, turloughs, petrifying springs and cladium fens.

As described above, the unique landscape of the Burren is not entirely a natural phenomenon. Although a dramatic geological phenomenon is responsible for shaping the foundations of the landscape and the various habitats, it is the thousands of years of traditional farming practices that has molded and preserved the beauty of the area. So the best way to maintain this would be to continue with the traditional farming techniques. Besides, being designated as an SAC under the Habitats Directive, it is required that the habitats are maintained in 'favorable conservation status' ([www.burrenlife.com](http://www.burrenlife.com)).



In recent decades, the Burren has potentially been faced with the most drastic changes it has experienced in thousands of years. The radical changes in the market and social structures have severely impacted the farming community and as a result led to transformations in farming practices. As the traditional labor intensive mixed farming is no longer regarded as being sustainable, farmers have either altered their farming methods or even completely left the land. This has caused the number of farmers in the Burren to have reduced by over 50% since 1970 (Dunford 2002).

Traditional practices involving the mixture of grazing (especially the outwintering of cattle<sup>vi</sup>) along with ongoing shrub removal are likely to be the most important management practices for preserving the Burren landscape (Dunford 2002; Deenihan, et al. 2009). The grazing in the winter prevents excessive growth of shrub species such as hazel and blackthorn, and hence allows for greater visibility of the karst limestone pavements. Similarly, the grazing of the grasslands keeps rank grasses and shrub species in check providing sunlight and space for various flower species to grow (Moles and Breen 1991; Dunford 2002). However, due to the labor intensive nature of this practice, its continued practice is on the decline. More and more farmers are moving on to part-time farming and shedding traditional practices.

The abandonment of the uplands has led to the encroachment of shrub species which reduce the visibility of the karst limestone pavements. Also, the grasslands are occupied by coarse grasses and shrubs which eventually drown out other floral species (Dunford 2002; Deenihan, et al. 2009). The abandonment of the uplands has also been encouraged by the shift in market demands which have forced farmers to replace traditional breeds with continental breeds which may not be as suitable for outwintering. Silage feeding and slatted houses have led to further environmental issues related to nutrient enrichment, poaching and water pollution. The abandonment of the uplands and the intensification of some of the lowlands has also had adverse effects on archaeological structures such as the lack of maintenance of stonewalls.

The BLP project provides one such example of a scheme that does attempt to develop environmental management practices that are suited for the region and this study aims to capture the market and non-market values associated with this management regime. A short description of the BurrenLIFE project is discussed next.

### **The BurrenLIFE project**

For the last five years, the BurrenLIFE project (BLP) has been experimenting on 20 different farms spanning across a total of 3,000 hectares in order to identify practical farming methods that

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<sup>vi</sup> Outwintering is a traditional farm management practice where livestock are not housed indoors during the winter months; rather they are kept outdoors where they are allowed to graze freely.

would improve the conservation status of the Burren habitats. Taking into account both the market and social trends, it has examined various land use practices to ensure the preservation of the various habitats while securing a bright future for its people.

The highly applied approach taken by the BLP involves working closely with the farmers and drawing on their traditional knowledge and skills. This information has been used to formulate management schemes by tracing back the traditional practices while adjusting them to the modern society.

One of the fundamental elements of the BLP scheme involves the revival of the traditional outwintering of cattle. However to make up for the labor shortage that is required for clearing the shrub, herding the cattle, building and maintaining stonewalls, and the provision of water to the herd, employment of workers from the locality is recommended. This strategy is thus able to generate additional employment in the community while providing a valuable service of preserving the habitats. The new feeding system that involves more foraging for the animals and less time poaching around silage feeders has several benefits including lower costs of feed, less nutrient enrichment and as a result better water quality. This system of farming results in hardier and healthier cattle which further reduces veterinary costs as well.

While adoption of these farming practices is beneficial to the farmers themselves, it also has benefits that are shared by the local community and the society at large. The improvement in the visual appearance of the farmyard through better farm management is a benefit enjoyed by all (Campbell, et al. 2006). But most importantly, the BLP through its farming practices aims to conserve the Burren – Ireland's flagship heritage landscape. The value associated with the conservation of this landscape to the Irish public is multi-dimensional and is bound to be associated with substantial values (Mazzanti 2002). In addition to the use and several types of non-use benefits one derives from such sites, its mere existence is capable of providing satisfaction to a person in the form of an enhanced sense of local identity, pride and prestige. The value of these heritage sites are substantial enough for their preservation to be defended with intense public outcry. Such instances recently witnessed in Ireland include the protests against the M3 motorway (currently under construction) to save the 'Hill of Tara' and the refusal for building a visitor center in the Burren which was believed would accelerate environmental degradation and diminish the scenery and rural character of the area.

To justify the implementation of the scheme proposed by the BLP on the wider Burren region, it is essential that the scheme passes the standard costs/benefit efficiency test – do the overall benefits provided outweigh the costs? In the next section that follows we report on the results of a survey technique that was designed specifically to estimate the value placed by the Irish Public on the Burren landscape. In particular, the survey was developed to focus on the features that best characterize the Burren. Thus the study focused only on the two dominating landscape

features the karst limestone pavement and the orchid rich grasslands with the aim of estimating their overall value using willingness to pay estimates.<sup>vii</sup>

### **Landscape Valuation:**

The justification for the management of a natural resource should not only be based upon the tangible outputs it produces (such as timber and fodder) but it should also give priority to less tangible ones such as aesthetics, wildlife and recreation. Recent decades have witnessed a shift where non-market products have been given a great deal of focus with plenty of studies conducted using both qualitative (DeLucio and Mugica 1994; Garcia Perez 1998) and quantitative methods (Hanley, et al. 1998; Bonnieux and Le Goffe 1997) for valuing various types of non-tangible products. Consequently, the valuation techniques used to value these commodities (using both revealed preference techniques such as hedonic pricing and travel cost methods) as well as stated preference techniques such as contingent valuation and conjoint analysis have come a long way since it was first introduced over fifty years ago.

Stated preference techniques have been used extensively to value various types of environmental benefits including the external benefits of farmland in Great Britain (Willis, et al. 1995; Willis and Garrod 1993; Bateman, et al. 1994), Sweden (Drake 1992) in the US, South Carolina (Bergstrom, et al. 1985), Massachusetts (Halstead 1984) and Kentucky (Ready, et al. 1997). Although stated preference techniques have come a long way from the introduction of the contingent valuation technique, they are not free from errors and biases, primarily related to hypothetical bias. Critics argue that because both the provision and payment for the good are hypothetical in nature, it is likely that the values obtained are also hypothetical. The existence of hypothetical bias has been well documented (List and Gallet 2001; Murphy, et al. 2005) where the values obtained are on average 2.5 to 3 times the actual values (Harrison and Rutstrom 2002). The degree of hypothetical bias is particularly higher when respondents perceive an 'important ethical dimension' in the good being valued (Johansson-Stenman and Svedsater 2003). The cost of acquiring a 'warm glow' (Andreoni 1990) through the 'purchase of moral satisfaction' (Kahneman and Knetsch 1992) is much lower in a hypothetical survey which promotes higher willingness to pay values.

The stated preference technique we use in this study is known as Choice Experiments (CE). Today choice experiments (CE) are regarded as most reliable amongst stated preference techniques available due to the many advantages it has over other techniques (see Hanley, et al.

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<sup>vii</sup> It should be noted that there are several other positive externalities that result from the BLP management practices which are not included in this study for valuation.

1998). List, et al. (2006) claim that the greater levels of information provided in CEs are capable of mitigating many types of biases including hypothetical bias. Additionally, a study by Huber, et al. (2002) show that respondents find the CE technique more realistic and also feel more confident when making decisions. Regardless of these claims, the continual presence of hypothetical bias with CEs has been witnessed (Cameron, et al. 2002; Lusk and Schroeder 2003; List, et al. 2006; Johansson-Stenman and Svedsater 2007; Ladenburg, et al. 2007; Carlsson, et al. 2008). A study by Carlsson and Martinsson (2001) find no difference between non-hypothetical and hypothetical marginal WTP in their experiment. However, they use a within-subject design, where hypothetical bias is underestimated (Johansson-Stenman and Svedsater, 2007). The same respondents when asked to state their WTP in a non-hypothetical scenario after a hypothetical one may wish to be consistent with their responses as people prefer not to lie when given a choice (Gneezy 2005).

In recognition of the possibility of biased results through choice experiments, we also employ a new technique suggested by Lusk and Norwood (2009) using a prediction based approach. According to several theories in the psychology literature, individuals constantly overestimate their personal abilities, moral goodness and as such their willingness to pay values, but are able to make correct predictions about others (Epley and Dunning, 2000). The reason for misrepresenting true values and opinions could be related to the intention of impressing the interviewer; which has been branded as the ‘Social Desirability Bias’ (Fisher 1993, Lusk and Norwood 2009).

## **Study Design and Methodology:**

### **Experimental Design:**

The design of the choice experiment began with the identification of the two most prominent features of the Burren landscape – The karst limestone pavements and the orchid rich grasslands. Due to their dominance, these two habitats were chosen as the two environmental attributes of the Burren landscape.

Using image manipulation software, photomontages were created to aid the written descriptions of the potential outcomes resulting from management (and lack of management) under the BurrenLIFE project guidelines of the two landscape features. Starting with a ‘control’ photograph for each of these habitats, various features were manipulated to provide respondents with a visual representation of changes that potentially occur to the landscapes with and without management.

The karst limestone pavement without management consisted of shrubs taking over the landscape and allowed for very little visibility of the rocks while the one with management had

very few encroaching shrubs and thus allowed for good visibility of the karst limestone pavements. For the orchid rich grasslands (referred to as biodiversity) the managed landscape had some areas where the karst limestone was visible but more importantly contained a range of flowering plant species native to the Burren. The unmanaged landscape on the other hand had very few flowers with most of the grassland being covered with overgrown shrubs. The cost attribute was described as the 'Expected Annual Cost' to the respondent of implementing the respective management practices as shown in the choice sets.

The objective of the survey and the method of implementation were discussed with several members of the public in a focus group that was conducted at the National University of Ireland, Galway. The primary purpose of the focus group was to test and refine both the photomontages as well as the accompanying descriptions of the attributes. As was suggested in the focus groups, a description with a series of pictures was added to the survey for both environmental attributes to describe the progression of karst limestone pavements and orchid rich grasslands as management from these lands were withdrawn. Additionally, the magnitude and range of the cost attribute was tested using open ended willingness to pay questions.

A few interviewers were trained for the purpose before conducting a pilot survey in the city of Galway, Ireland, with randomly chosen respondents from the streets. Following the pilot survey, the questionnaire was further refined to minimize confusions and also shortened to limit the interview time to between 12 and 15 minutes. Additionally, the photomontages revealing management vs. the lack of management were accompanied by the labels 'management' and 'no management' to avoid any possible confusion.

### **The Choice Experiment**

The three attributes included in each choice set were Landscape, Biodiversity and Expected Annual Cost. As shown in Table 1, the Landscape and Biodiversity attributes had two levels each 'With Management' and 'No Management' while there were four levels for the Expected Annual Cost (€5, €10, €20, and €40).

**Table 1: Attributes and Attribute levels of the Choice Sets**

<b>Label</b>	<b>Attribute</b>	<b>Levels</b>
Landscape	Karst limestone pavements	‘With Management’ ‘No Management’
Biodiversity	Orchid rich grasslands	‘With Management’ ‘No Management’
Expected Annual Cost	Expected annual cost of implementing the chosen alternative	€5, €10, €20, €40

Each choice set consisted of three alternatives. The first two alternatives labeled Option A and Option B were experimentally designed while the third alternative labeled ‘Status Quo’ was fixed in every choice set. The Status Quo alternative represented a scenario with no management in either of the attributes and was associated with ‘zero’ expected annual cost. While this was the case for the Status Quo alternative in every single choice set, the other two alternatives were allowed to vary given the following restrictions.

1. Both alternatives must have at least one managed attribute. This is to avoid either of the alternatives having the same management scheme as the status quo alternative.
2. The two alternatives cannot have identical management scenarios for both attributes. This is to avoid complete dominance of one alternative over the other.
3. The expected annual cost of an alternative with both attributes managed must be higher than the expected annual cost of the alternative with only one managed attribute.

With three attributes in each alternative and the different levels for each attribute, a full factorial design allows for a total of 256 different choice tasks. However, removing the invalid choices given the restrictions made above, the number of choice tasks is reduced to 56. Each individual was randomly assigned eight of these 56 choice tasks.

Before the choices were made, respondents were familiarized with the two attributes and their likely conditions with and without management. They were then provided with a sample choice task and were told that the alternatives represented the Government’s available environmental policy options. The respondents were made aware of the additional costs associated with maintaining good environmental standards through the following statements.

*“Maintaining good environmental standards and keeping the management practices in place requires financial support. So each of the management options also has a particular cost involved.”*

Respondents were reminded that the Expected Annual Cost attribute represented a monetary value that the respondent would personally have to pay per year through increased Income Tax and Value Added Tax. The respondent was then provided with a sequence of four different choice tasks and asked to choose his/her preferred alternative in each case. Upon the completion of the four choice tasks, they were given four more choice tasks in which they were asked to make predictions of what they believed others would choose if given those very choices. The following statement was provided to the respondents requesting their predictions.

*“I will now present to you another series of choices just like the ones you were shown earlier. This time instead of making your own choices, I would like you to predict the choices you think most people would make. [On average what would the general public choose?]”*

About 50% percent of the respondents were asked to make predictions before making decisions for themselves in order to account for order effects.

### **Model:**

A standard random utility model is employed in the analysis of the choice data.

$$V_{ik} = \theta_i + \alpha_k \text{Rock}_i + \beta_k \text{Grass}_i + \gamma_k \text{Cost}_i + \varepsilon_{ik}$$

The equation above represents the utility individual  $k$  receives from alternative  $i$ .  $\theta_i$  represents an alternative specific constant. As our experiment was unlabelled we only include this constant for the status quo alternative.  $\text{Rock}_i$  and  $\text{Grass}_i$  indicate whether or not the karst limestone pavements and the orchid rich grasslands are managed, and  $\text{Cost}_i$  represents the expected annual cost of implementing the management schemes.  $\alpha_k$ ,  $\beta_k$  and  $\gamma_k$  represent the corresponding parameters and  $\varepsilon_{ik}$ , the error term. The utility model is identical for individuals acting on their own interests as well as when making predictions about others. The model is estimated using a multinomial logit model using Biogeme 1.7. Using the utility specification above, the marginal willingness to pay for managing the karst limestone pavements and the orchid rich grasslands are provided by the ratio of the corresponding coefficients and the cost coefficient.

### **Sampling Method:**

A total of four trained interviewers administered the survey between July 2009 and August 2009 in six counties (See Table 2). Most of the 200 interviews were conducted in county Galway followed by Clare and Dublin. In order to account for distance decay effects (Hanley, et al. 2003)

counties Dublin, Westmeath and Sligo (counties that do not border the Burren region) were also included as survey sites. The in-person interviews were conducted at the respondents' homes that were randomly chosen. Each interview lasted between 12 and 15 minutes.

**Table 2: Total Number of Administered Surveys by County**

<b>County Surveyed</b>	<b>Total Number of Surveys</b>
Galway	86
Clare	47
Dublin	44
Sligo	12
Westmeath	11
<b>Total</b>	<b>200</b>

### **Results:**

Of all the respondents surveyed, 29% resided in the countryside. Almost all the respondents were aware of the Burren region and slightly over 70 percent had visited the area within the last five years. The average respondent age was 41.5 years with an average wage of €40,225<sup>viii</sup>. The average attained education of 4.48 signified a level between a high school degree and a college degree<sup>ix</sup>.

### **Willingness to Pay Estimates for the Burren Landscape:**

The results of the choice experiment are used to estimate the indirect willingness to pay for the conservation of the Burren landscape through the implementation of management schemes. According to the results of the Multinomial Logit Model shown in Table 3, all three attributes (karst limestone pavements, orchid rich grasslands and the expected annual cost) included in the choice experiment are statistically significant at less than one percent level of significance. This shows that each of these attributes had a significant impact on the choices made by the respondents. The positive signs on the coefficients 'Orchid Rich Grassland' and 'Karst limestone Pavements' show that respondents were more likely to choose an alternative that had a management scheme in place. Consequently, the negative sign on the "Expected Annual Cost" coefficient reveals that respondents were less likely to choose an alternative that was associated with a higher expected annual cost. From these results our estimated marginal willingness to pay per person per year to conserve the karst limestone pavements is € 59.24 and the marginal willingness to pay to conserve the orchid rich grasslands is € 56.40.

<sup>viii</sup> The income and age questions had classes. For the estimation, the midpoints were used

<sup>ix</sup> Education (Primary = 1, Junior Certificate = 2, Leaving Certificate = 3, On the job training/professional qualification of degree level = 4, College/University Degree (B.Sc., B.A., etc) = 5, Post graduate (M.Sc., Ph.D., etc.) = 6)



**Table 3: Results from the Multinomial Logit Model**

	Logit Estimates
Alternative Specific Constant	0.758 (0.729)
Expected Annual Cost	-0.0232*** (0.00486)
Orchid Rich Grassland	1.31*** (0.157)
Karst Limestone Pavements	1.37*** (0.163)
Household Income	-0.178** (0.0771)
Age	-0.0153 (0.104)
Education	0.0126 (0.115)
Adjacent County	-0.377 (0.282)
Clare County	-0.459 (0.342)

Standard errors are reported in parentheses.

\*\*\* indicates significance at 1%

\*\* indicates significance at 5%

\* indicates significance at 10%

The variable Clare County and Adjacent County indicate whether the respondent lived in county Clare or a county adjacent to County Clare (Galway, Limerick, Tipperary, Kerry) respectively. These variables were included to test whether it was more likely for an individual living in county Clare or a county close to the Burren to be less opposed to making a payment for conserving the Burren. The negative sign on both of these coefficients indicate that these respondents are indeed less opposed to making such payments in comparison to respondents living in counties further away (Sligo, Westmeath, Dublin, Waterford, and Leitrim). However, both of these coefficients are insignificant indicating that the opposition to making payments between the respondents residing in different regions of the country is not statistically different. The coefficient for household income is negative and significant indicating that respondents with higher income are less opposed to making payments to conserve the Burren landscape. However, there was no relation between age or education and the opposition to making such payments.

Table 4 provides the results of the Multinomial Logit Model for the prediction based approach where all three attributes (karst limestone pavements, orchid rich grasslands and the expected annual cost) included in the choice experiment are statistically significant at less than one percent level of significance, with the expected signs. This shows that each of the attributes had a

significant impact on the predictions made by the respondents. From these results the predicted marginal willingness to pay per person per year to conserve the karst limestone pavements is €13.86 and the marginal willingness to pay to conserve the orchid rich grasslands is €8.19.

**Table 4: Results from the Multinomial Logit Model – Prediction Based Approach**

	Logit Estimates
Alternative Specific Constant	-1.47* (0.540)
Expected Annual Cost	-0.0613*** (0.00581)
Orchid Rich Grassland	0.502*** (0.157)
Karst Limestone Pavements	0.849*** (0.163)
Household Income	-0.157*** (0.0542)
Age	0.134* (0.0723)
Education	0.289*** (0.0831)
Adjacent County	-0.330 (0.198)
Clare County	-0.032 (0.224)

Standard errors are reported in parentheses.

\*\*\* indicates significance at 1%

\*\* indicates significance at 5%

\* indicates significance at 10%

### **Aggregation of Benefits:**

The aggregate national benefits that result from the conservation of the orchid rich grasslands and the karst limestone pavements are estimated using 2000 as the reference year for the total number of Irish tax payers (Department of Finance 2000)<sup>x</sup>.

The total benefit from the karst limestone pavements and the orchid rich grasslands is estimated to be €67.93 million and €64.67 million per year respectively using the traditional CE approach.

<sup>x</sup> Normally the aggregation of willingness to pay estimates is done over the entire adult population. However, for a more conservative estimate we only consider the total Irish tax payers. This includes those who pay taxes at the higher rate (427,077), standard rate (701,953) and the special marginal relief rate (17,642). Those exempt from paying taxes due to income levels below the income tax exemption limits (463,161) are excluded. Thus the total number of individuals included is 1,146,672.

With karst limestone pavements having an estimated land cover of 18,000 hectares, its total value per hectare is estimated at €3,774. Similarly, with approximately 12,000 hectares of orchid rich grasslands, its total value per hectare of grassland is estimated to be €5,389. The average aggregate benefits corresponding to the Burren landscape is €4,420.04 per hectare per year.

Using the estimates of the prediction based approach, the total benefit from the karst limestone pavements and the orchid rich grasslands is estimated to be €15.89 million and €9.38 million per year respectively. The average aggregate benefits corresponding to the Burren landscape is then €842.42 per hectare per year.<sup>xi</sup>

### **Economic Impact of Tourism:**

In theory, the total willingness to pay value stated by the respondents represents both use and non-use values for the Burren region. However, wider economic values of the Burren can be assessed by analyzing indirect contributions. One such contribution relates to the economic values associated with tourist expenditure to boost the local economy (Midmore 2000; Keirle 2002). These include an increase in income and/or employment brought about by tourism activities. For example, an increase in the sale of walking equipment, local products (from farmers markets), food, drinks and accommodation can help boost the local economy and promote regional development.

The retention of tourist expenditures in the local economy has a direct relationship with the size of the local economy (Hurley, et al. 1994). For example, smaller accommodation establishments tend to generate higher multipliers than hotels because a greater proportion of expenditure is on locally sourced goods and services; green tourism is often more embedded in the local economy, respecting local traditions, using local produce and employing local people, and therefore often produces a large local multiplier effect (Ni Mhainnín 1996). The Shannon Development 2008 Annual Report verifies this to be the current situation of the region stating that “significance of this spend (tourism expenditure) is that its economic impact is relatively large, with low import content, high labour input and considerable spending in rural areas.”

According to our survey, 70% of respondents that have visited the Burren spend money on food; spending on average €26.6 per visit. Similarly 22.6% spend on average €48.06 on Pubs and entertainment, 11.7% spend on average €114.68 on accommodation and 7.3% spend on average €42 on other items. According to a tourism report on the Burren (Joe Saunders 2008) 60% of the 826,000 domestic tourists (i.e. 495,600) visited Clare in 2007. The total expenditure from domestic tourists in the year 2007 would be in the range of €22.8 million (€22,784,339.95).

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<sup>xi</sup> As the Burren is considered to have one of the most important landscapes in all of Europe, its value is not limited only to the Irish population. Hence the actual value is likely to be of a magnitude that is many times larger than our estimates. In this report however we ignore all these additional benefits to build the lowest possible bound on its value.

Although a majority of the visits would be related to the Burren region, we conservatively regard the visits to be evenly spaced throughout the entire county. With a total land area of 318,784 hectares for county Clare, the total revenue would then be about €71.47 per hectare per year.

It should be noted that this estimate only covers expenditures from domestic tourists. The total expenditure from 738,000 international visitors (60% of 1.2 million overseas tourists and 30,000 from Northern Ireland to the Shannon region) per year is not included in our estimations. While the number of international tourists exceed the number of domestic tourists, the per tourist expenditure is also significantly larger for international tourists (Allen and Yap 2009). Hence the aggregate tourism revenue from the Burren region would easily be a few multiples of our estimate of €22.8 million.

The externality values obtained from the 20 Burren farms are evaluated against the cost of implementing the farm management practices that ensure the provision of the externalities. We do this by incorporating the costs and benefits into Land Portfolio Allocation model which is the subject of the following section.

### **Portfolio-Theory Land Use Model Applied to the Burren**

A number of theoretical and empirical techniques motivate us to consider a micro-level household modeling approach to the Burren land use/policy support context. Many studies of land use are summarized by Barbier's (2001) synthesis model and demonstrate how 'first wave' statistical approaches were able to relate land use to a variety of key household preference and landscape amenity drivers in addition to traditional suitability and soil quality features. This motivates us to include land owner preferences for land uses ( $\varphi$ ) and the third-party's willingness to pay for the external cultural and biodiversity value ( $\omega$ ) of Burren farming for conservation practices.

Prior models with a micro modeling approach include engineering/costs studies (Moulton and Richards 1990); mathematical programming approaches (Adams, et. al. 1993); dynamic systems models (Evans, et al. 2001); agricultural household models (Ahn, et. al. 1981; Benjamin 1992; Taylor and Adelman 2003); discrete and continuous population models, respectively (Alonso 1964; Berliant and Fujita 1992; and Solow 1973). Another approach, different in theoretical form but similar in its motivation of focusing on individual households include the random utility models (Parsons, et. al. 2000). These approaches guide our constructions of the production and utility functions applied in our model, and motivate us to consider a standard profit maximization approach for land owner decision making.

We employ a model which incorporates several elements from these earlier approaches and is described as a Land Portfolio Allocation model (Blank 2001). In portfolio theory models applied

to land use, an agent's objective is to maximize utility derived from a particular portfolio of labor and land uses. Thus an agent's decision focuses on the expected payoffs from one or a variety of potential activities. Blank (2001), Kelley (2004), Parks, et al. (1995), and many other authors have shown that a traditional representation of agent's k's expected profits is:

$$E(U_k) = E(\pi_k) - \rho \cdot \sigma_k^2 + \phi_{ki} \quad (1)$$

E represents the expectations operator,  $U_k$  is the risk adjusted utility derived from applying their labor and land,  $\pi_k$  represents the payoff for k's particular portfolio of activities.

Following Parks (1995)  $\rho$  is a risk aversion parameter (zero for risk neutral, positive for risk averse),  $\sigma_k^2$  is the variance of payoff for individual farmer k's portfolio, and  $\phi$  is preference for supplying land/labor to a particular activity. This model has been shown to be an appropriate representation of portfolio managers when the number of options within a portfolio is small, and when the returns from the portfolio are relatively small compared to an agent's total wealth; both of these features are present in this context. Specifically, the numbers of labor and land use options are  $\leq 5$  and the returns from a portfolio are small relative to agent's total wealth as represented by the value of their land. For this Burren application, for simplicity, a portfolio will consist of only one of five activities, and risk is ignored  $\rho = 0$ ; this is due to the absence of a sufficient length of across time income data. Further given data on actual activities in the Burren, decision makers are assumed to pursue either dairy, dry stock beef, mixed grazing, suckler beef, or off farm labor supply activities. These activities can either be pursued in a way consistent with the Burren Life Project practices, thereby incurring slightly higher costs, or in a conventional/commercial manner with standard costs.

Table 5 below summarizes key assumptions governing the operation of our model and values for key parameters. We make a number of assumptions designed to simplify the system in order to provide specific and useful predictions.

**Table 5: Constant Model Parameters**

Parameter	Value
WTP - BLP <i>(lower bound)</i>	€4420.04 <sup>xii</sup> {€842.42} <sup>xiii</sup>
blpMult	€71.47 <sup>xiv</sup>
blpParm	1.25
labUnitConv	2000 hours
Phiadj	€300
cowDP	€1300
cowBP	€511
Offwage	€13.50
fadnop {dairy, beef, mixed graze, suckler beef}	[411,422,444,421]

First, willingness to pay WTP {WTP lower bound} is based upon survey data described in the previous sections which suggested a value of €115.64 {€22.05} per tax payer as the amount on average most third parties indicated that they were willing to pay to preserve both the landscape and biodiversity aspects resulting from the agricultural practices of the BurrenLIFE farmers. Given approximately 1,146,672 tax payers and approximately 30,000 total hectares of Burren landscape this translates to €4420.04 {€842.42} of externality value per hectare of Burren landscape. This value is used to calculate the amount of externality value produced by Burren farmers when producing in a way consistent with BLP practices and represents the average of the reported value for the Karst landscape and for the biodiversity of the Burren grasslands.

Second, the multiplier effect of tourism dollars for community income, *blpMult*, is also included. For all of county Clare €22,784,339.95 are provided by tourism, dividing this by the 318,784

<sup>xii</sup> (115.64€)\*1,146,672/30000

<sup>xiii</sup> (22.05€)\*1,146,672/30000

<sup>xiv</sup> 22,784,339.95€/318,784 Ha for county Clare

hectares of country Clare yields the per hectare tourism income multiplier to which we can compare the hectares of BLP landscape produced. This is of course an approximation but it importantly allows us to estimate the multiplied tourism benefit for communities for each hectare of tourism generating landscape produced by BLP landowners. The weakness of this measure is that it does not account for the fact that a completely karst or biodiverse Burren landscape is likely to be more attractive to tourists compared to small amounts or dispersed hectares of karst throughout the Burren. However, given that only a small amount of landscape is currently under the BLP scheme, the amount represented by *blpMult* (€71.47) must therefore be the minimum amount of tourism income that can be generated per hectare.

Third, it is assumed that pursuing the BLP practices involves an additional cost compared to the traditional production approach. The parameter *blpParm* represents the increased cost of this approach (which is mainly due to higher labour costs), and we assume the cost is 25% higher. In fact the magnitude of this parameter is less important than the fact that it is simply greater than 1. As a result, using a profit maximizing decision strategy, a producer will always prefer to pursue a conventional approach due to lower cost (even if the value is 1.05) unless preferences ( $\phi$ ) are included in their utility structure.

Fourth, total available labor supply hours *labUnitConv* is assumed to be 40 hours per week for 50 weeks resulting in a baseline total labor supply endowment of 2000 hours. This figure is then modified by the reported labor supply units for the Burren 20 farms or the national farm survey labor variable (59).

Fifth, when calibrating the preference parameter ( $\phi$ ) in order to allow the simulated farmers to reproduce the actual production activities of the true stakeholders, this parameter is adjusted by €300 per increment. Thus *phiadj*<sup>xv</sup> is €300. So if a farmer's actions are not correctly predicted by comparing actual and counterfactual payoffs with  $\phi=0$ ,  $\phi$  is increased for the known/observed BLP action by €300 until the payoff for the observed production activity is a higher payoff compared to the counterfactuals. Crucially,  $\phi$  is increased only for the observed action reported in the Burren 20 dataset.

Sixth, we assume there are fixed costs associated with changing agricultural production activity among dairy to either beef, mixed grazing, or suckler beef. We do not assume a fixed cost to shifting between the last three categories or among similar BLP and traditional activities. And, this fixed cost is simply represented by the price of purchasing a new activity specific herd and potentially a dairy parlor. We assume a per animal purchase price for dairy *cowDP* of €1,300 per

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<sup>xv</sup> This is a subjective value used as the level of increment for adjusting the preference parameter. A smaller value would cause the duration of the simulation to be too long while a larger value may be too large to accurately distinguish the differences across farmers.

animal, and *cowBP* equals €511<sup>xvi</sup> per animal for beef or suckler. When these values are combined with the average per activity herd size obtained from the national farm survey for farms of similar soil category (4, 5, and 6) we can estimate the approximate minimum fixed cost associated with switching an activity.

Finally, the average off farm industrial wage is assumed to be €13.50 per hour, thus *offwage* equals €13.50. Finally, based on the Burren 20 dataset we consider the BLP production activities given by *fadn* (Farm Accounting Data Network) codes *fadnop* [411,422,444,421, 100]. Activity 100 represents supply of labor to off farm wage generating activities. Conventional versions of these activities replace the '4' by '1' in the model. Note the index *i* described later in the technical appendix refers to the nine total activities across BLP conventional and off farm potential production activities.

## Summary of Procedures

To determine how a farm owner may respond to policy or other changes we must calibrate our model to farmers actual decisions by comparing the payoffs they receive for actions actually undertaken to the estimated or counterfactual payoffs they would receive for pursuing alternative actions. For actual actions undertaken we can measure the value of output and the value of costs and subsidies received which allows us to calculate the risk adjusted payoff, i.e. gross margin. We also need to estimate the gross margin for counterfactual production processes; this is where econometric estimation is involved.

Using the national farm survey data for farms of similar soil categories (4, 5, 6) and with household inputs labor, land, herd, and investment, we estimate total factor productivity and the marginal rates of substitution from the farms in this dataset. This allows us to estimate what the gross production output value would be for alternative actions given the Burren farms known labor, land, herd, and investment inputs, as well as the fixed costs of changing activity.

To estimate counterfactual costs we also employ econometric estimation employing the NFS data for farms pursuing only activities undertaken by Burren farmers. For this we make the strong assumption that production costs are mainly determined by farm (grazable land) size. We can correlate observed direct costs of farms of type *i* with the land available for activity *i*. Then for each farm we subtract gross estimated costs from gross returns described in the previous paragraph providing the counterfactual payoff margin for comparison to the actual margin. This will allow us to conduct policy experiments to determine whether land owners may switch to

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<sup>xvi</sup> This price is an average of the bullock and heifer cattle prices including VAT for 2008 from the CSO dataset (for the 250kg-199kg category)



alternative actions in response to increases or reductions of support payments or other market changes.

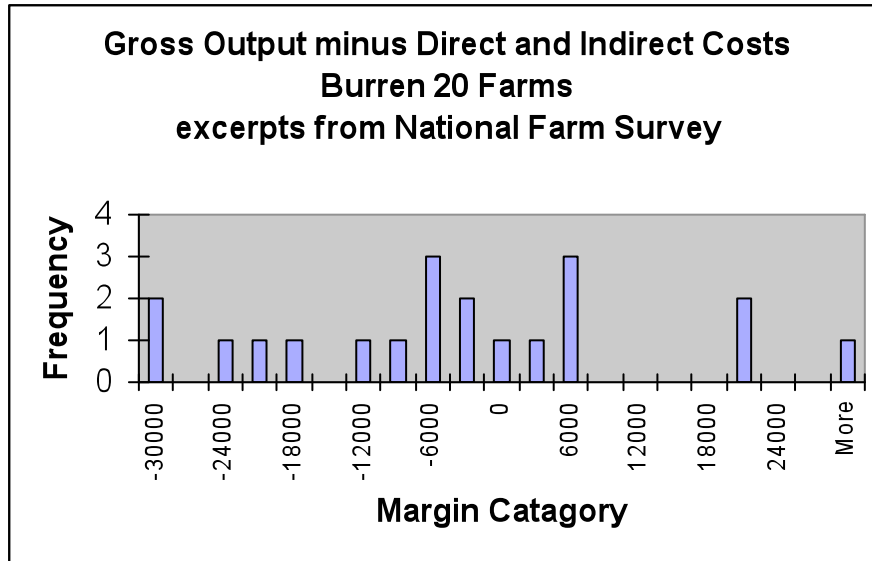
To determine the value of the community and cultural, biodiversity, and multiplied tourism income externalities produced by Burren farmers we need to compare their land use decisions for their hectares of usable land to the per hectare willingness to pay for the Burren landscape. Although the amenity/cultural value of the Burren is not directly part of the owners payoff structure, we can estimate the cultural externality produced by the set of Burren farms. Given the willingness to pay, and the predicted land use actions we can cumulate up the external cultural and biodiversity value provided by the 20 BurrenLIFE farmers, as well as the externality produced by multiplied tourism income. We can also compare how the externality value might adjust in response to farmers adjusting their land use given policy or other market changes. Key data required to allow this will be the values for the farm specific variables described below for the 20 BurrenLIFE farms. The analysis could be extended with general information about farm size and activity for an additional 100 or more Burren farms. Importantly we are able to combine the chosen land use action with the per hectare multiplied tourism income value described earlier allowing us to estimate the amount of tourism income each farmer could provide by working their hectares of land in a manner consistent with BLP practices.

### **Burren Model Experiments**

This study is not the first to focus on farmers in the Burren. The National Farm Survey includes a sub-set of the Burren 20 farms highlighted in the current study. Results from this analysis demonstrate that for the majority of these farms the adjusted gross margin generated by BLP agricultural operation (gross output value minus direct and indirect costs), were quite small or even negative; See Figure 1. This indicates that these farms are individually at most marginally financially viable compared to more commercial non-externality generating practices or relative to off farm labor supply. In both of these latter cases the landscape public good externality will not be provided. Alternatively, a small BLP payment and given farmer preferences for producing in a way consistent with BLP results in a landscape with positive amenity value. Combining the estimate of the economic value of the positive externality produced with the gross margins demonstrates that these Burren farms although not financially viable can be economically viable. These farms would even be financially viable if there were policies in place that would return part of the amenity value enjoyed by third parties to the producers of the externality. An absence of this type of feedback is a key problem because financial non-viability governs individual farmers' decision to participate in this program. By contrast economic viability describes the overall social desirability of having farmers produce in the BLP manner. A case can be made for continued government support given evidence of economic viability, i.e., government support payments produce greater than a one for one return on investment. An absence of this support

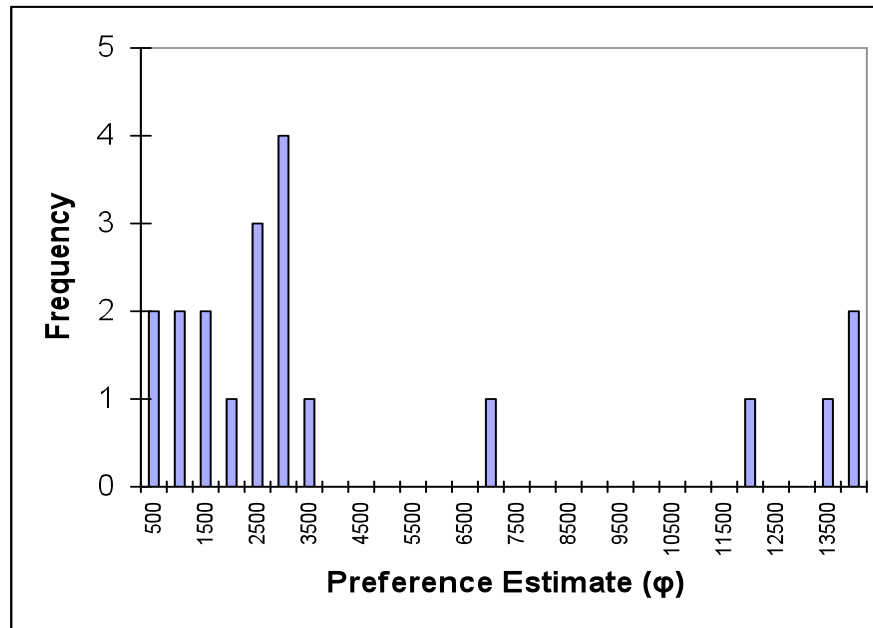
could lead to financial non-viability and would lead to a reduction in the use of these practices and an eventual absence of the positive externality landscape.

**Figure 1: Adjusted Gross Margin Generated by BLP Agricultural Operation**



To move beyond financial viability instead to economic viability, we first calibrate our model in order to reproduce the actual decisions of the 20 Burren farms for which we have data. We assume the BLP payment is available, in addition to the actual subsidies reported for REPS and for suckler beef. This calibration first calculates actual payoffs as reported and estimates the counterfactual payoffs that could be obtained by switching to conventional methods for the current activity or from pursuing other traditional or commercial agricultural activities, or supplying labor off farm. This is assuming that the preference for the observed activities  $\phi$  equals zero. If the utility payoff comparison provided by the model does not immediately predict the action actually undertaken, i.e. the maximal utility is not the observed action, the model begins adjusting  $\phi$ . This preference parameter is increased for the observed activity until the payoff for this activity is maximal compared to alternative counterfactual payoffs. When performing this exercise the activity all 20 farms can accurately be reproduced and the value of pursuing the observed actions is worth between €0 and €21,000 across the farms, with the majority of preference values lying between €0 and €3,500; see Figure 2 below. A value for this parameter that is  $>0$  indicates that the activity undertaken is not strictly the profit maximizing activity a producer may pursue, and that to continue producing as they are, they must be deriving preference value equivalent to the magnitude of the parameter in order to offset negative profits. Alternatively, this parameter (to the extent it is positive) could be thought of as the estimate of the opportunity cost of pursuing a particular BLP activity. Figure 2 provides a histogram of the estimated preference parameters for the Burren 20 farms.

**Figure 2: Histogram of estimated preferences for observed practice of Burren 20**



Our first experiment with the calibrated model assumes farms receive the relevant BLP, REPS, and suckler beef subsidies as actually reported to Teagasc. In this case all farms maintain the BLP activities conditional upon their implied preferences. Given the willingness to pay per hectare of Burren reported in the earlier section of this paper this amounts to a positive externality value of €12,731,920 {€2,427,697} compared to the direct payment program payments of  $20 * €750 + \sum S_k$  or €687,605 of investment. These numbers indicate that these programs are producing positive externality rates of return of 1852% {353%} per Euro of subsidy investment for average {lower bound} externality values respectively. Including the multiplied income generated from tourism income per hectare of landscape these values increase to €12,937,794 {€2,633,573} or 1882% {383%} rates of return per Euro of subsidy investment.

Our second experiment maintains the BLP payment and calibrated preferences from experiment 1, but removes the suckler beef payment. In this case two of the suckler beef producing farms are predicted to change their activities out of the BLP approach to conventional dry stock beef agricultural activity or off farm labor supply. As a result of the changes by these farms the externality value produced falls to €11,410,328 without multiplied tourism income and to €11,594,835 inclusive of multiplied tourism income. This result suggests that when combined with the BLP payment, the suckler beef payments reported for these farms of €3718.5 is producing up to an additional €1,321,592 of landscape externality and multiplied tourism value. This represents a 355% rate of return to government suckler beef subsidy investment conditional upon the presence of the BLP program.

Our third experiment removes the BLP payment but maintains the suckler beef payments and the calibrated preference parameters from experiment 1. In this case all 20 farms no longer find it maximal to maintain the BLP given the current estimated preferences. As such the externality value produced is predicted to eventually fall to zero as these farms switch to conventional and sometimes entirely different agricultural practices. Importantly, three of the 20 farms no longer find it optimal to pursue agricultural activity whatsoever and instead are predicted to switch to off farm wage earning activities.

The final experiment removes both the BLP and suckler beef payments but maintains the calibrated preference parameters. The results are nearly identical to experiment 3 with zero externality value produced. The exception is that one conventional suckler beef producing farm is predicted to change to off farm labor supply, suggesting that four farms in total will find such non-agricultural activities more profitable in the absence of both types of payments.

### **Sensitivity Analysis**

A variety of additional simulations are provided to compare the robustness of our predictions to variations in key parameters. First, we assume all Burren 20 farmers' preferences for their observed BLP action are zero. This experiment provides an indication of how many farmers are operating in a strictly profit maximizing way. In this case only one dry stock beef producer maintains the BLP approach. Three other farms are predicted to switch to off farm labor supply, and one suckler beef farm switches to conventional dry stock beef production. All other farms pursue the conventional version of their current BLP activity. This suggests that preference calibration is crucial for providing an accurate account of Burren Life farmers' activities. Or equivalently, participating in the BLP is not strictly profit maximizing for 19 or 20 farms if one excludes stakeholders preferences for producing in a way consistent with the BLP approach. For the one farm which maintains the BLP approach in the absence of preferences, the cost difference between the conventional and BLP approach was small enough to be dominated by the small BLP subsidy payment of €750. For all others, this payment was insufficient to overcome the increased cost of the BLP approach.

The next sensitivity analysis removes the BLP payment of €750 per farm but reduces the estimated increased cost of the BLP compared to traditional methods to 12.5% and then 5% from the 25% higher cost in the baseline case. These cost changes represent BLP costs that are respectively  $\frac{1}{2}$  and then  $\frac{1}{5}$  of the costs estimated in the baseline case. Calibrated preferences from the baseline case are maintained. Intuitively this experiment indicates the extent to which BLP practices can be maintained without direct payments and despite higher production cost by relying on owners' preference for this form of production technique and the non-pecuniary value this production technique provides. Remember that when costs were 25% higher, removing the BLP payment results in all 20 farms switching to conventional or non-BLP activities. For the

first experiment, 12.5% higher BLP costs with no BLP payment, 12 of 20 farms maintain the BLP approach. The externalities produced in this case are €9,536,674 for landscape and biodiversity only, and €9,690,884 including multiplied tourism income. So without the BLP payments and when the BLP is only 12.5% more costly than a conventional approach 40% of farms are predicted to revert to conventional practices, although the remaining 60% are able to produce significant externality benefits. Next, reducing the increased BLP cost to only 5% higher than conventional results in 14 of 20 farms retaining the BLP system; again in the absence of the BLP payment. This indicates that if BLP costs are only 5% higher than conventional, 30% of farms still find it more profitable, despite their preference for the BLP system, to switch to conventional methods. Although many farms still remain in BLP with no payment and the lower cost, the socially dispersed BLP landscape is in actuality likely to produce substantially less external benefits compared to a more cooperative and uniform landscape.

### **Limitations**

Limitations of our approach are centered on a few primary issues. First, estimating the non-pecuniary value of individual land owners for pursuing particular production techniques is difficult. This is because a number of household specific preferences must be aggregated into one preference measure that can be represented in monetary terms. Our approach of aggregating these items is appropriate given the absence of more specific information regarding an appropriate disaggregation of household production preferences. Next, much of our analysis relies upon cross sectional variation among Burren 20 or National farm survey farmers given the absence of longer time series data. Our analysis could of course be strengthened once additional time series data becomes available. This would allow more appropriate panel estimation techniques to be applied when estimating counterfactual production value and costs. Finally, there may be more relevant independent variable useful for predicting production value and costs for counterfactual activities. Although some of this predictor information may be available for the National Farm Survey, we are limited by what is reported for our farms of interest, the Burren 20. As an attempt to control for this unobserved variation constant terms are included in all econometric exercises. Although there are commonly known limitations to the use of constant terms in regressions to control for observed variation, this technique also has known advantages.

### **Recommendations and Conclusions:**

With respect to willingness to pay (WTP), the choice modelling method used in this study produces what appear to be reasonable results. Willingness-to-pay is price-sensitive and income sensitive and the results of this present study are comparable with those noted in the literature for similar valuation studies (Hanley, et al. 1998; Campbell, et al. 2006). Additionally, a very new approach using a prediction based technique was implemented to estimate lower bounds of WTP

values. While this technique is still in its experimental stage, we report the values in order to obtain more conservative estimates. The positive WTP values stated by the respondents (the Irish public) suggest that the Burren landscape carries significant value and thus deserves to be well protected. We report marginal willingness to pay estimates of €59.24 {€13.86} and €56.40 {€8.19} for the conservation of karst limestone pavements and orchid rich grasslands associated with the Burren landscape.

It should be noted that the externality values associated with the BurrenLIFE farming system estimated in this study are limited mostly to the visual impacts made by the karst limestone pavements and orchid rich grasslands. Many other ecosystem services such as better water quality, better health of livestock, etc which are by products of the BLP system are not factored into the total externality value. Furthermore, the survey was limited to Irish Nationals and the aggregated value only considers the population of Irish taxpayers. Hence the true externality value should be much larger than what is reported here.

In theory, the total willingness to pay value stated by the respondents represents both use and non-use values for the Burren region. In addition to this, we also estimate the wider economic values of the Burren region related to its ability to attract tourist expenditure to the local economy. According to a tourism report on the Burren (Joe Saunders 2008), the structure of the tourism industry in the entire region is capable of retaining much of this expenditure in the local economy and as a result is capable of making a significant impact. Using 2007 as the reference year for the number of visitors, the total revenue from domestic tourists is estimated to be about €71.47 per hectare per year. While this is a very conservative estimate even for domestic tourists, we do not even incorporate the spend from international tourists which are generally much higher.

The estimates of the externality values are incorporated into a Land Portfolio Allocation model to examine the effect of various policies and subsidies on the farming practices of the Burren 20 farms. Results from the LPA model indicate that the suckler beef and BLP payment systems are crucial for the BLP 20 farms and together produce between €2,427,697 and €12,731,920 in positive cultural, karst landscape and biodiversity externality value. Importantly, these values respectively represent the lower bound and average survey-based cultural values of preserving a form of agricultural practice which produces this landscape. When including the multiplied income (through tourism expenditure) generated for the community these externality values increase to between €2,633,573 and €12,937,794. These estimates suggests that for the most conservative reported willingness to pay from survey data the rate of return on government support for these systems is no less than 353% excluding estimated tourism income and 383% inclusive of this. Using the average estimate of the willingness to pay reported in the survey for the karst landscape with associated biodiversity and including multiplied tourism income for the community, the rate of return per Euro of government support could be as high as 1882%.

Providing an even more conservative estimate by additionally including the yearly BLP administrative costs of €446,097 per year, based upon the 5 year total of €2.23m, (which increases the aggregate cost to €1,118,702 per year) the previous rates of return are reduced from 1882% (383%) to 1156% (235%). These results suggest that incorporating all BLP operating costs as well as the all direct payments for these 20 farms produces at least a 235% rate of return in terms of non-pecuniary and tourism value for the broader Irish community.

Our results further suggest that landowners' preferences for producing in a manner consistent with the BLP practices are significant and represent between €0 and €3,500 in non-pecuniary income. The ability to calibrate our model with respect to owners' preferences was only made possible by the initial pilot funding for this project that allowed us to compare actual and counterfactual payoffs of the supported Burren 20 farms with the broader sample available in the National Farm Survey. Our experiments further suggest that in the absence of direct payments, at the very least payments to mitigate increased production costs associated with the BLP can provide some broader external value to the citizens of Ireland and represent sound government investment producing more than a one for one rate of return for each Euro invested.

As mentioned earlier in the paper, resources are frequently allocated to different institutions working on different aspects of rural, agricultural, social and environmental management/development. The optimal management design tailored to a specific location is extremely difficult when these institutions function independently to service large and diverse regions. Farmers themselves are often too busy while engaged with the business of farming or part time employment to coordinate their activities themselves and they may not have the scientific knowledge required. The specialty of the BurrenLIFE project has been to act as an agent to pool available resources from several institutions (and further supplement them when required) to design a plan specific to the Burren. They employ trained professionals with specialist scientific training and indigenous knowledge gathered over many years about the Burren ecosystem. Focusing the diverse expertise of the BurrenLIFE agency members of the Burren region has been key in developing optimal management practices for the Burren.

Although the REPS plan does help promote low intensity farming, most of these measures seem to be a passive way of avoiding any further damage to the landscape and the environment rather than a move to encourage progressive farming that engages farmers in creating a better public good. Some of the guidelines of REPS include the following recommendations:

- Outwinter livestock on fields identified in your plan
- Avoid excessive poaching
- Avoid both overgrazing and undergrazing
- Control noxious weeds and shrub encroachment
- Maintain of stonewalls and farm boundaries
- Protect features of historical and archaeological importance

- Additionally, some supplementary measures involve the adoption of traditional breeds and proper grazing regimes to maintain farming activity on specific habitats that might be in danger of abandonment.

All of the farm management practices listed above parallel those recommended by the BLP. However, it is evident that these REPS measures have not provided desired results in the Burren. This is primarily due to the generalized form of these prescriptions which are not in harmony with the particular landscape of the Burren. The BLP has taken these very remedies and through rigorous field experiments, refined them to cater to the specific needs of the Burren landscape. Although REPS planners are able to exercise varying degrees of flexibility when prescribing farming practices to individual farmers, they wouldn't have the knowledge or the expertise to be able to design such efficient practices as those developed by the BLP.

The Burren landscape covers an extensive area over several thousand hectares, and the coordination of agronomic activities may be the only means of managing a public good, such as a karst limestone landscape and its biodiversity, at an ecologically appropriate scale. The geographical nature and scale of many of the environmental concerns in the Burren (abatement of diffuse pollution, the enhancement of biodiversity and karst landscape management) requires at the very least coordination of agronomic activities by multiple landowners. Agri-environment schemes such as REPS are frequently an ineffective way of delivering such benefits because the schemes are voluntary and focus on individual farms and not the watershed. Biodiversity often involves a range of environmental media such as land, air and water calling for a degree of integrated management across large areas. The role of the BurrenLIFE agency as a means of ensuring that the activities of farmers are coordinated in the delivery of local environmental public goods is a move in the right direction and something to be very much encouraged.

Given the substantial level of farm support and the reluctance of the agricultural sector to reduce farming intensity without some form of compensation, it is difficult to envisage a situation in which the Burren is managed in the absence of state intervention. Indeed we do not advocate such an approach. Our results from the LPA model would appear to show that the exchequer costs associated with supporting BurrenLIFE and the farms involved with the scheme passes the standard cost/benefit efficiency test. Indeed our results show that the BurrenLIFE project management practice should go to scale to achieve greater overall/social benefits. Because the market is unable to recognize the implicit values of the externalities, it is necessary for the Government to step in and fix this distortion. In the light of recent changes to the REPS schemes there is a possibility that some farmers may consider signing up to REPs an altogether too risky option. This could jeopardize the provision of these local public goods which support tourist activities and would be a move in the wrong direction.



An important limitation of many agro-environmental programs is the lack of feedback from the beneficiaries of external amenity value or recipients of tourism income to the producers of the externality. In general a policy to correct this type of market failure would be described as a Pigouvian tax/subsidy geared toward internalizing the externality. A number of approaches may be taken. One might be user fees for third parties who come to enjoy the Burren landscape. Another might be a tourist tax which has been employed in many cases throughout Europe. In both cases this income can be used to support farmers in the way the BLP payment does, providing an incentive to maintain the BLP. Such payments can offset financial non-viability leading to a decision to remain in the program and leading to greater economic efficiency.

We suggest a number of steps be taken to make agricultural policy and the work of the BurrenLIFE agency more effective.

While it is necessary for the BurrenLIFE agency to constantly update their design (through constant experimentation, etc) with the ever evolving markets and changing social and environmental structures, it is also important that more sustainable sources be explored for maintaining the farming practices and hence securing the externalities. The dependence upon government subsidies are uncertain as has been seen from the recent modifications of the REPS schemes. Such uncertainties act as a deterrent from participation in such policies (Vanslebrouck, et al. 2002). Hence it is necessary that the BurrenLIFE agency take their research a step further to explore the possibilities of a more sustainable approach by incorporating the externalities into the market.

Currently the incentives (subsidy payments) through agri-environmental schemes are being channeled from all tax payers through the government into the farms. Although these subsidies are very similar to PES<sup>xvii</sup> schemes, PES schemes are generally characterized by payments which are financed by the direct beneficiaries of the ecosystem services. In order to establish such systems it is necessary to assess the range of the ecosystem services and the value of benefits received by the different groups of people. Following this categorization of the different groups and levels of benefits, the appropriate policy, subsidy, or market should be designed.

According to Perrot-Maître (2006), while it was crucial to secure adequate finances (for compensation) to maintain the income levels of land managers at all times to implement the PES scheme, the primary reason for their program's success was not financial. Rather, it was the

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<sup>xvii</sup> PES (Payment of Ecosystem Service) schemes have been rapidly developed in different forms in the past decade. The primary function of PES schemes is to protect ecosystem services by providing an economic incentive to land managers to adopt land management practices that promote the sustainable provision of such services. The most common types of ecosystem services being subject to PES schemes are watershed services (Perrot-Maître 2006), carbon sequestration (May, et al. 2004), biodiversity (Wertz-Kanounnikoff, 2006) and landscape beauty (Landell-Mills 2002). Essentially a PES scheme creates a market for ecosystem services where one does not exist.

ability of the intermediary institution to gain the trust of the local land users, and work on long term goals. The BurrenLIFE agency through their active involvement in the local community over the past several years has successfully established such trust with the local landowners. Having made this valuable investment should be able to reduce various types of complications in developing such programs.

The most visible demand for the ecosystem services (primarily landscape beauty) and recreation services would be from tourists (or private tourist operators) and related businesses. As the key element here is to reward land managers for their contribution in maintaining the landscape responsible for attracting the tourists, it is necessary to establish a system where tour operators and related businesses facilitate the collection of revenues from tourists which trickle down to the land managers. By setting up such an arrangement, the greater community including the land managers (who are the primary caretakers of the resource) are provided with an incentive to work together to generate better incomes while maintaining proper management of the natural resource.

Upon the establishment of trust between various stakeholder groups through an agency such as BurrenLIFE, avenues for promoting various types of ecotourism<sup>xviii</sup> activities can be explored for sources in financing the land managers. Some possible avenues are listed below.

- Introduction of a user fee for tourists hiking in the Burren.
- An additional ‘tourism tax’ charged for all tourists in local businesses
- An additional ‘conservation tax’ charged for local businesses that benefit from the business provided by tourists
- An additional tax from local towns or factories that benefits from the clean water that is maintained by the BLP farming practices.
- Further promotion of the Burren ‘conservation grade’ beef and lamb.

While the above are possible ways of generating funds from the users of the environmental services to reward those providing them, further investigation of the market as well as the preferences of the stakeholders in the local community would be required to decide upon a system that works best. Not only will the preferred methods of collection be important but also the way in which they are to be distributed.

The revenues generated from the various mechanisms could be directly transferred to the farmers. This approach may be the most direct way of compensating the farmers and it also has

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<sup>xviii</sup> tourism that promotes responsible travel to natural areas which conserves the environment and improves the welfare of the local people

the advantage of providing a clear incentive to the farmers for continuing their conservation based farming methods. However, deciding upon the actual distribution may not be as simple. This approach requires an exploration of a fair distribution, which involves the identification of appropriate indicators such as each farmer's level of investment on their farms, land size, level of externality generated, etc. upon which the distribution is to be based. Other methods may include using the funds for improving the local town or community. Regardless of the methods used in channeling the revenues, it is crucial that the benefits are made visible/accessible to the farmers.

As mentioned above, a fair distribution of revenues should be based upon the farmer's level of contribution towards the public good. Although this measure is bound to be very subjective, some level of monitoring/evaluation should be included in order to assess the level of conservation. It is not only for the sake of rewarding the farmers that some level of monitoring is required but also for the successful implementation of the BLP scheme to conserve the Burren landscape and biodiversity.

To begin with, the management practices on farms can be based upon strict prescriptions set out by BurrenLIFE farm planners. The compliance level here can be assessed by monitoring the farm inputs. Additionally an alternative method could allow for some flexibility by permitting farmers to employ their preferred measures as long as they deliver the desired output. Although the latter is preferred in theory, it is necessary that some method of evaluating the output is devised.

Monitoring of farm inputs and the evaluation of outputs is necessary during the initial stages. However, the constant requirement of these measures for the progression of the conservation scheme in the long run can be viewed as a weakness of the scheme itself. Instead of exercising controls and penalties, the development of a strong social network between the participating farmers will be able to generate a better equipped working structure. Lopez, et al. (2009) in their study of effective monitoring strategies have shown that in communities where mechanisms for triggering pro-social emotions exist, a more effective management may be achieved through emotions such as shame and guilt rather than monetary penalties. Consequently, one of the goals of the scheme should be to induce a sense of responsibility and ownership of the lands. Instead of simply paying the farmers for their services, by changing the attitude of the individuals, the scheme may be capable of promoting a self-sustaining system.

Other useful measures such as those encouraging farmers to undertake collective planning or implementation of environmental or productive activities should be promoted. Incentives should be made available to offer choices to land managers to operate either as individuals or part of a group. Additionally, innovative ideas from farmers (especially younger farmers) that supplement the conservation process while generating additional revenues should be encouraged. This is crucial as the public attitudes towards farming which is generally associated with being 'behind the times' and 'lacking innovation' (causing fewer people to take up farming) needs to change.

This point of view was also verified through some of the attitudinal questions in this study. While most respondents agreed that it was necessary for farmers to preserve the natural environment and maintain wildlife habitats in the countryside, the response was not as unanimous when asked if farmers should maintain traditional farming practices. The BLP has demonstrated that the means to protecting the Burren landscape and biodiversity is by promoting extensive farming practices. This they have done by incorporating both local knowledge as well as scientific experimentation on the fields.

As confirmed by our study, most people are unaware of the current conditions of the Burren and the importance of proper management for maintaining this unique landscape. It is thus absolutely necessary that the BLP expand their existing educational programs to educate the general public about the significance and vulnerability of this landscape.

The BLP has already demonstrated its potential by making a significant impact on the community in a short period of time by working on only 20 farms. However, the ultimate success of the BLP shall be determined by its ability to make a sustained impact not just on the Burren landscape but also upon the individual farmers and the community at large. What will be the state of the landscape and the community if BLP were to cease its activities at some point in time? Will they revert back to pre-BurrenLIFE conditions or will the project have secured sufficient local support and financial means to enable local farmers to continue farming for conservation?

The BurrenLIFE project has developed an innovative participatory model that engages local farmers and best scientific practices to deliver ecosystem goods and services from a unique landscape. This model provides useful lessons for landscapes around the world that are renowned for their provision of ecosystem services that are not confined to the market. However, perhaps the greatest challenge facing BurrenLIFE is to develop local informal and formal institutions and economic instruments that ensure that their activities are sustained and locally governed and that are to a large extent independent of the exchequer funding provided by statutory agencies.

## Appendix A:

### Modeling Theoretical Details

Farm Agent and Land use Type  $i$  receiving support type  $sj$

Suckler Beef (Traditional and BLP)	ssu
Dry Stock Beef (Traditional and BLP)	sB
Mixed Grazing (Traditional and BLP)	smg
Dairy (Traditional and BLP)	sD
Off farm labor supply	sREPs

### Variables:

Output Beef	$y_B$	Labor, Land, Herd	$L, M, H.$
Output Milk	$y_M$	Farm Investment	$\varepsilon$
‘Output’ Off farm	$y_{off}$	Commodity/wage prices	$p$
Non Market Amenities	$\alpha, \varphi$	Willingness to Pay per Ha	$\hat{\omega}$

### Production Structure: for each farm $k$

$$E(U_k) = E(\pi_k) - \rho \cdot \sigma_{\pi k}^2 + \hat{\phi}_{ki}$$

$$E(\pi_k) = \bar{p}_i \cdot y_{ki} - C_{ki} + \bar{s}_{kj}$$

$$\bar{p}_i \cdot y_{ki} = \hat{A}_i + \beta_L \cdot \bar{L}_{ki} + \beta_M \cdot \bar{M}_{ki} + \beta_H \cdot \bar{H}_{ki} + \beta_\varepsilon \cdot \varepsilon_{ki} \text{ with}$$

$$M_{off} = 1, H_{off} = 1, \varepsilon_{off} = 1, A_{off} = 1, \beta_L = 1$$

$$C_{ki} = \gamma_{off} \cdot \bar{c}_T + (1 - \gamma_{off}) \cdot (F_i + \hat{c}_i \cdot \bar{M}_{ki})$$

$$\alpha = \hat{\omega} \cdot \sum_k \hat{M}_{k,mg}(s_{k,mg}) + B \quad B = \delta \cdot \left( \frac{\sum_k \hat{M}_{k,mg}}{M} == 1 \right)$$

Ignore risk and Burren agglomeration/total cooperation bonus:  $\rho = 0, \delta = 0$

$$\text{Counterfactual fixed costs: } \tilde{F}_D = \bar{p}_D \cdot \tilde{H}_D \ \& \ \tilde{F}_B = \bar{p}_B \cdot \tilde{H}_B$$

For alternative activities:  $\tilde{H}_D = \text{ave}(H_D \cdot (i = \text{Dairy}))$  Dairy for MG|B

$$L_D = L_{mg,B} \& M_D = M_{mg,B} \quad \tilde{H}_{mg,B} = ave(H_{mg,B} \cdot (i = MG|B)) \quad MG|B \text{ for Dairy}$$

**Experiments:** Remove support  $s_{SB} = 0$   $s_{REPs} = 0$   $s_{BLP} = 0$ , and compare model outputs.

**Model Outputs:**

Predicted profit margin for each farm  $k$   $\hat{\pi}_k$  for comparison to actual profit,  $\pi_k$  {70}.

Predicted land use for each farm  $k$   $\hat{M}_{ki}$  for comparison to actual use,  $M_{ki}$ .

Given predicted land use  $\hat{M}_{ki}$ , a predicted landscape amenity value  $\hat{\alpha}$  given WTP  $\hat{\omega}$ .

**Econometric Estimation:** Using National Farm Survey data and WTP survey yielding  $(\hat{A}_i, \hat{c}_i, \hat{\omega})$ .

$\hat{A}_i$  Production Technology, Employ cross section analysis across farms  $k$  in category  $i$  {18}:

Dependant variables: Outputs  $y_i$  { $y_D$ (135),  $y_{B\&S}$ (156),  $y_{off}$ (311+314)}.

Independent variables: Labor  $L_i$  {59}, Land  $M_i$  {24},  $\varepsilon$ (Σ62-65), Herd  $H_i$ (85,86).

$$\bar{p}_i \cdot y_i = \hat{A}_i + \beta_{L_i} L_i + \beta_{M_i} M_i + \beta_{H_i} H_i + \beta_{\varepsilon} \varepsilon_k + \eta \quad \text{with } \eta \approx iid$$

Regression parameters: represents TFP and MRSs for model and are used to determine potential revenue from counterfactual production activities.

$\hat{c}_i$  Operating Cost,  $\frac{\partial C}{\partial M}$ . Employ cross section analysis across NFS farms  $k$  in category  $i$  {18} with:

Dependent variable  $C_i =$  Direct {109} + Indirect {133} cost.

Independent variable  $M_i =$  Total Land in category  $i$  { $M_{mg}$ (31) graze land}

$$C_i = \hat{c}_i \cdot M_i + \varepsilon$$

Regression parameter: represents how costs change with farm size and activity and used to estimated counterfactual costs for alternative activities given farm size.

$\hat{\omega}$  Willingness to pay, for Burren in per Hectare form.

**Modeling Methodology:** Select  $i \forall k$  so that utility maximized ( $\max_i U_k$ ).

Calculate actual and counterfactual  $\pi_{k,i} \forall i, k$  given  $p \cdot y, C, s, \phi = 0$ .

Selects production category  $i$  given a farm's Labor, Land, Herd, and Investment by comparing utilities. Pursue activity that satisfies:  $U_{ki} \geq U_{ki'} \forall i \neq i'$ .

Adjust preference parameter  $\hat{\phi}_{ki}$  if/until land prediction matches actual reported activity for the Burren 20 farms.

Report amenity externally created with baseline calibrated model (WTP  $\alpha$ ).

Conduct policy experiments with model & report changes in amenity externally.

## Appendix B:

### Input/Source data for simulation and econometric estimation

National Farm Survey and Burren 20 Data List (by farm  $k$ ) in record form ( $k$  -rows, *variable*-column)

#### General Data:

$n$	Number of <b>taxpayers</b>
$p_i$	<b>commodity prices</b> (Beef, Dairy)
$w$	average rural <b>non-agricultural wage</b>
$p_D$	average price of 1 Dairy cow/bull for herd
$p_B$	average price of 1 Beef cow for herd

#### Farm Specific Data: (RE: NFS response variable number)

$H_{mg,B,k}$	(86)	
$H_{D,k}$	(85)	
$M_{mg B D,k}$	(31)	
$M_{Tot,k}$	(24)	
$L_k$	(59)	
$\varepsilon_k$	(62-65)	
type $i$ by $k$	(18)	
$y_{off}$	(311, 314)	Note: allows creation $\gamma_{of}$
$S_{j,k}$	(413, 415, 429, 430, 445)	
$c_T$	(193)	
$\pi_k$	(175 vs 68)	
DCost	(109 & 175)	
IDCost	(133)	
$y_{B,su}$	(156)	Note: actually $p_{B,Su} \cdot y_{B,Su}$ , i.e. value.
$y_D$	(135)	Note: actually $p_D \cdot y_D$ , i.e. value.
$y_{Out-Test}$	(174)	



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