The Price of Conservation and the Agony of Choice
A case study of British Birds

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Abstract

Economic or market factors have almost always played an important role in any policy area, with the exception of conservation, where economic factors are frequently relegated to a reactive role at the last stages of the decision making process. This paper takes the distribution of British Birds and its different alternative biodiversity conservation policies as a case study. A comparative study is developed between the biological outcome, based purely on biodiversity conservation measures and the one that includes an *economic factor* reflecting actual market prices such as agricultural land prices throughout Britain. This study focuses on the classification of broad geographical zones in order to implement future conservation policies and the selection of area networks to achieve the highest possible amount of biodiversity conservation. The difference in the outcomes between the natural science and the economic studies in favour of the latter uniquely illustrates the decisive role of economic factors in the decision making process of biodiversity conservation.

Introduction

Economic and biological factors have almost always seemed incompatible in selecting priority areas for conservation. According to conventional wisdom conservation was expensive, and planners had to choose between "conserving and spending", or "developing and saving". Currently, biological parameters, based on biodiversity and endemism rates as well as state of conservation, are predominant when selecting areas for conservation. Economic factors play a much smaller role and are usually only incorporated when the decision has already taken place. Today, more than one hundred years after the first natural reserves were created, economy and ecology still play opposite each other in the process of selecting areas for conservation and there is no methodology to include both economic and ecological parameters at the early stages of area selection policies. This paper proposes a new methodology that will reverse this situation

The aim of this research is to include economic factors in the area selection process by inserting a set of economic parameters reflecting current market trends in an area selection algorithm based solely on natural science parameters. First it will examine the historical background of the area selection policies from its origins. After selecting an appropriate case study it will incorporate a set of economic parameters and correlate it with the original study. The difference in the correlation results will determine the role of economic factors in area selection policies.

The role of economic factors in area selection policies for biodiversity conservation

In the last half of the 19th century, a desire to preserve parts of the national heritage in the United States and Canada originated a movement to set aside a series of reserves. These reserves were selected mainly for the aesthetic value of either their landscape or the animal and plant species it comprised, regardless of their ecological role or the amount of inherent biodiversity (WCMC, 1998). Nevertheless, economic values prevailed at the time of selecting natural reserves. The two factors comprising the economic aspect of conservation were consumption of resources, which include payment for the use of resources and indirectly the benefits from not developing a particular area, and territorial management of land use. It seemed logical therefore to set aside an area for conservation if the benefits associated with leaving the area more or less untouched seemed bigger than the territorial management costs

(Rafikov, 1992). A selection pattern can thus be found in the creation of the first National Parks in zones that met this economic paradigm, i.e. mountainous areas with spectacular landscapes but not very productive soils to the detriment of more ecologically important areas of either lower aesthetic value or higher opportunity cost (i.e. marshes and steppes in the Mediterranean region and lowland woods, carrs and heaths in the temperate zones). This trend originated in the US (Yellowstone, Wyoming, 1872), and Canada (Banff, Alberta, 1885) expanding afterwards throughout Europe and the rest of the world at a more or less steady pace (WCMC, 1998).

Although economic factors were taken into account at broad level, there were not any comprehensive economic studies regarding area selection. The aforementioned biased and patchy results were based therefore on a set of values foreign to any systematic scientific or economic studies dictating the early policies of reserve selection (WCMC, 1998). Since the 1950s and 1960s, when as a result of a higher environmental awareness and a broader scientific knowledge, reserves started to be allocated systematically, biological and ecological factors started being taken into account in a comprehensive manner, with the emphasis on protecting ecosystems rather than regions. This has shed new light on which objectives to consider in establishing new reserves, especially in organisations like UNEP, UICN or WWF interested in conservation at an international level (WCMC, 1998). With the assumption that it is impossible to conserve *all* biodiversity, especially with the aforementioned scarcity of data, let alone of land, the most desirable outcome will be a structured empirically based strategy to maximise biodiversity. This can be rephrased in "Since we cannot conserve everything, let's conserve as much as possible".

The strategy of supplementing networks of designated areas based on a comprehensive survey of local biodiversity, also known as Gap Analysis, deals not so much with the "*How?*" as with the "*Where first?*" It has a more holistic and pro-active approach to biodiversity conservation than earlier "firefighting" policies motivated by the increasing number of endangered species. In recent years a new system for an efficient reserve allocation with the help of computer software has been developed by Paul Williams at the Natural History Museum in London, UK (Williams *et al*. 1991). Williams and his colleagues have created a computer programme named WORLDMAP (http:\\WWW.WORLDMAP.com). This programme, which has the same basic structure as a standard GIS Software, is capable of selecting the best allocation of reserves in order to achieve the highest amount of Biodiversity in a particular zone. Once both the geographical information of a zone and the biodiversity data of all the subdivisions of this zones are entered in the software the programme can automatically select the combination of reserves

that achieve the outcome with the most efficient combination of sub-units in the map. These outcomes thus could serve as guidelines in order to implement a particular policy of efficient reserve allocation in a particular zone based on biodiversity conservation. This programme, commonly known as the ”minimum area algorithm” deals with the difficult task of selecting the most adequate ones. In other words: *Where to start and how to separate the chaff from the wheat in Conservation?*

Once a rational system is set to select an adequate combination of reserves in order to preserve the highest amount of biodiversity, it is important to calculate the monetary values attached to it. This is a very important question, because of the importance of economic factors in any policy decision. Unfortunately, the very few studies that have tried to discern the price of Biodiversity conservation, although very accurate in the measurement of biodiversity and economic parameters, did not use the same size area units. Thus, any improvement results using economic parameters could therefore be masked by the sheer difference in size of areas considered as units with the same value (Polaski & Solow, 1996). Apart from the aforementioned paper from Polaski and Solow in the US and another study by Paul Williams and Robert Pressey in Australia, still under publication, very few studies have tried to calculate the cost of preserving Biodiversity in a systematic way.

Nevertheless the role of economic parameters such as land value in the decision-making process concerning conservation should not be overestimated, since most administrations have a clear zoning system that distinguishes between so called green zones and developed zones, normally based on political or cultural, rather than economical, reasons, although this is not so much the truth in cash-trapped developing countries. Price considerations have thus a much smaller impact at the time of the decision making process concerning the selection for preservation or development in any given zone. This regulation seems necessary since valuing the environment has proved to be more difficult than expected (Jacobs, 1991; Flynn and Pratt, 1993; Sagoff, 1988) and nothing indicates that economic optimality will provide either equity or long term stability in a particular zone (Rees, 1990; Perrings and Opschoor, 1994).

The aim of this research, though, is not to put a “price tag” on biodiversity conservation or to include economic factors in the debate of to conserve or not to conserve a particular area, but to establish a hierarchical and comprehensive process based on economic as well as ecological parameters in order to maximise results at the level of biodiversity conservation with a limited amount of economic resources. It also aims to explore if land is an accurate enough surrogate for cost. That is, if it is just necessary to optimise the use of

protected land in order to minimise costs, or, on the other side, local variation of economic parameters can play a determinant role at the decision making process.

Selection of the case study

The selected study was the aforementioned paper based on the distribution of British Birds done by Paul Williams and his research group at the Natural History Museum in London (Williams *et al.*, 1995). This study was chosen due to a set of characteristics that made it very suitable for the inclusion of economic parameters (**Table 1**).

Table 1: Factors in the study of British Birds using the WORLDMAP programme favourable to the inclusion of economic parameters.

1. The study range, Britain, is one of the most geographically scanned countries in the world, through the British National Grid, as well as having one of the best species based distribution data in the world. Besides, as one big island with small adjacent ones, it forms a geographical as well as a political unit, and has available information about economic factors.
2. Birds are very good surrogates for calculating Biodiversity because of their abundance, conspicuous character, heterogeneity of diets and habitats as well as high habitat specificity and high position on the trophic pyramid, which establishes their presence as a pre-condition to the presence of a wider amount of other organisms (Wessels et al, 1998). Birds are also on of the best-recorded groups of organisms in the country.
3. The WORLDMAP Software had the capacity to incorporate economic data and its greedy algorithm could also be altered to select the maximum amount of biodiversity according to the cost rather than land.
4. National Park land and other areas under conservation status in the UK, unlike in many countries, are mostly in private hands, although under strict regulation. Therefore it makes more sense to include market prices in the study concerning their designation as potentially protected areas.
5. The study considered (mainly because of lack of data) land as an estimated surrogate for cost, which leaves the door open to verify how precisely this assumption is true.

Williams and his colleagues used the heuristic or minimum area algorithm for the records of all breeding species of Birds in Britain. The data were taken from a study by the British Trust for Ornithology that comprised England, Wales and Scotland. Northern Ireland and the Republic of Ireland were left apart because they have a different conservation system and the collection of data did not have the same level of accuracy. The Channel Islands were also excluded because they are usually considered together with continental Europe. The territory was divided into 2748 10x10Km grid cells according to the British National Grid and all breeding and non-breeding Bird species in every grid cell were recorded. Records of Birds were divided into sightings and possible breeding (value 1) and positive breeding records (value 2). Disregarding the value 1 or non-breeding records, a pool of data was set based on records of at least one breeding pair as an arbitrary minimal value in every grid cell as a unit (only one grid cell, in Southern Wales, had no breeding species recorded). This set of data was fed to the WORLDMAP Programme, a GIS similar programme that contains the algorithms to calculate hotspots of richness as well as the minimum area algorithm to calculate the highest amount of Biodiversity in the minimum number of areas.

The results of the richness studies showed that the abundance methodology showed a North-South gradient of increasing Biodiversity along the territory with the highest numbers concentrated in East Anglia and in the region around the New Forest, between the Counties of Hampshire and Dorset **(Figure 1)**.

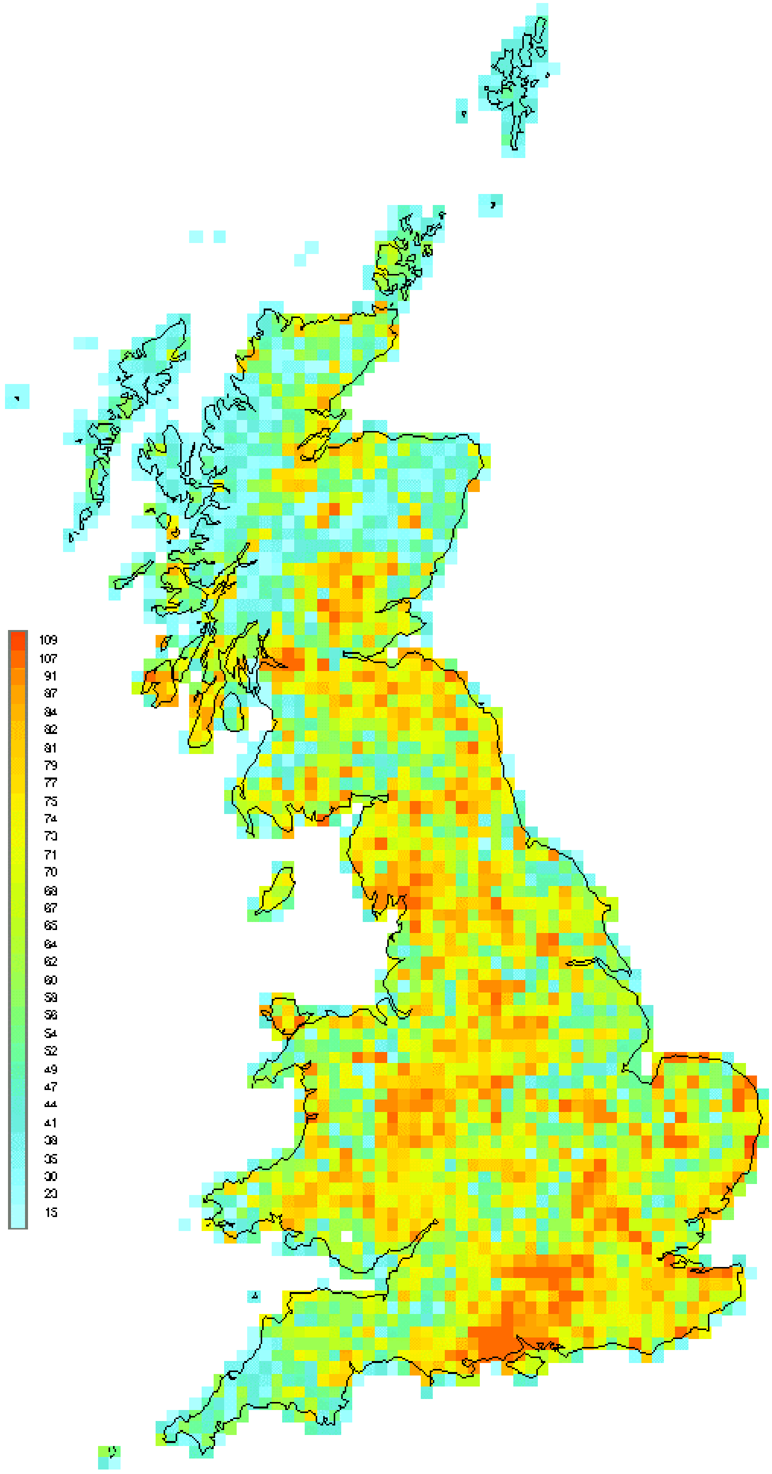

Figure 1: Distribution of Bird species richness in Britain according to the WORLDMAP Software. The colour scale indicates the amount of Bird species recorded at least once in every single cell.

Incorporation of economic data in the case study.

Since all Bird reserves are located in rural zones the market price of rural land was selected as the most accurate economic factor regarding the conservation of biodiversity in Birds. On the other hand, since farmers tend to optimise costs, market land prices are also a good reflection of the immediate opportunity cost of not developing a particular area of land for agricultural purposes (Willis *et al.* 1993). The opportunity cost (that is, the foregone cost of not doing something) of developing rural areas for non agricultural purposes is extremely difficult to quantify due to its hypothetical nature and subject to land planning modifications. This study will therefore ignore it and concentrate instead on the much lower opportunity cost regarding agricultural returns, which have an economic reflection through market prices. Data were sampled by the Treasury's Inland Revenue Service as the most reliable source of information for land transactions throughout the country and then analysed by the Economic and Resource Use Unit of the Ministry of Agriculture Fisheries and Food (MAFF) for England and the Welsh and Scottish Offices for Wales and Scotland respectively. The data for England were further subdivided into the 8 English regions according to the MAFF own system (**Table 2**).

Table 2: Average agricultural land prices in Britain. The data for Scotland and Wales could not be subdivided due to their respective small sizes. All price averages were calculated for 1997.

Region	Cost (£/Ha)
Northeast	1 223
Northwest	4 554
Yorkshire and Humberside	4 203
East Midlands	5 187
West Midlands	5 639
Eastern	5 699
Southeast	3 400
Southwest	4 846
Scotland	2 586
Wales	3 265

The prices, although more or less uniform, ranged from 1 223 £/Ha in the Northeastern region to 5 699 £/Ha in the Eastern region. A clear North-South pattern of increasing land value can be appreciated. The surprisingly low values in the Southeastern region may be due to the IRS consideration of land and not land-and-buildings transactions, which have much higher prices in the Southeast due to the switch from rural to suburban living patterns in the area (Ian Marlee, pers. comm, 1998).

A new map using the WORLDMAP programme and encompassing all the agricultural land values in the country **(Figure 2)** was added to the Bird species richness map **(Figure 1)**. Both maps were overlaid in a two-dimensional 4-colour matrix (green-blue, black-white) showing both abundance and scarcity and negative and positive correlation for both factors: Bird species richness and land value. The software of the programme was slightly altered to emphasise the broad area zone of each cell. The overlay map of Figure 3 shows a clear 4-colour pattern. The Southeast, South Wales, Northeast, Southeastern Scotland ad the area around Inverness show a distinct green pattern of low land values and high species richness with smaller scores in Holyhead, Southwest of Scotland and Eastern Wales. These zones should be given a preference status since they manage to encompass low land value and high richness species **(Figures 2 and 3)**.

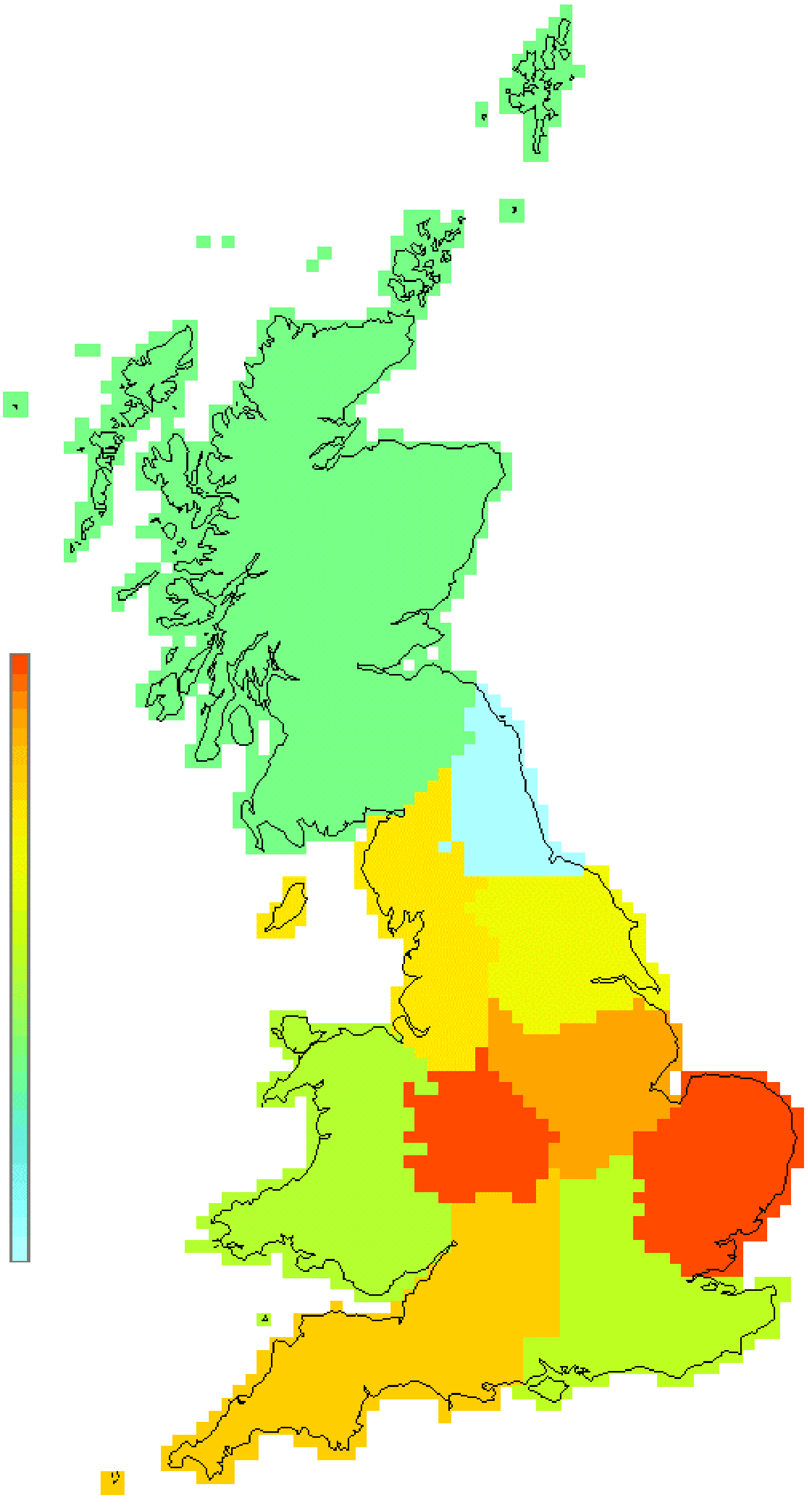

Figure 2: Agricultural land prices throughout Britain ranging from a maximum of 5 699 £/Hain the Eastern region (red) to a minimum of 1 231 £/Ha in the Northeastern region (blue).

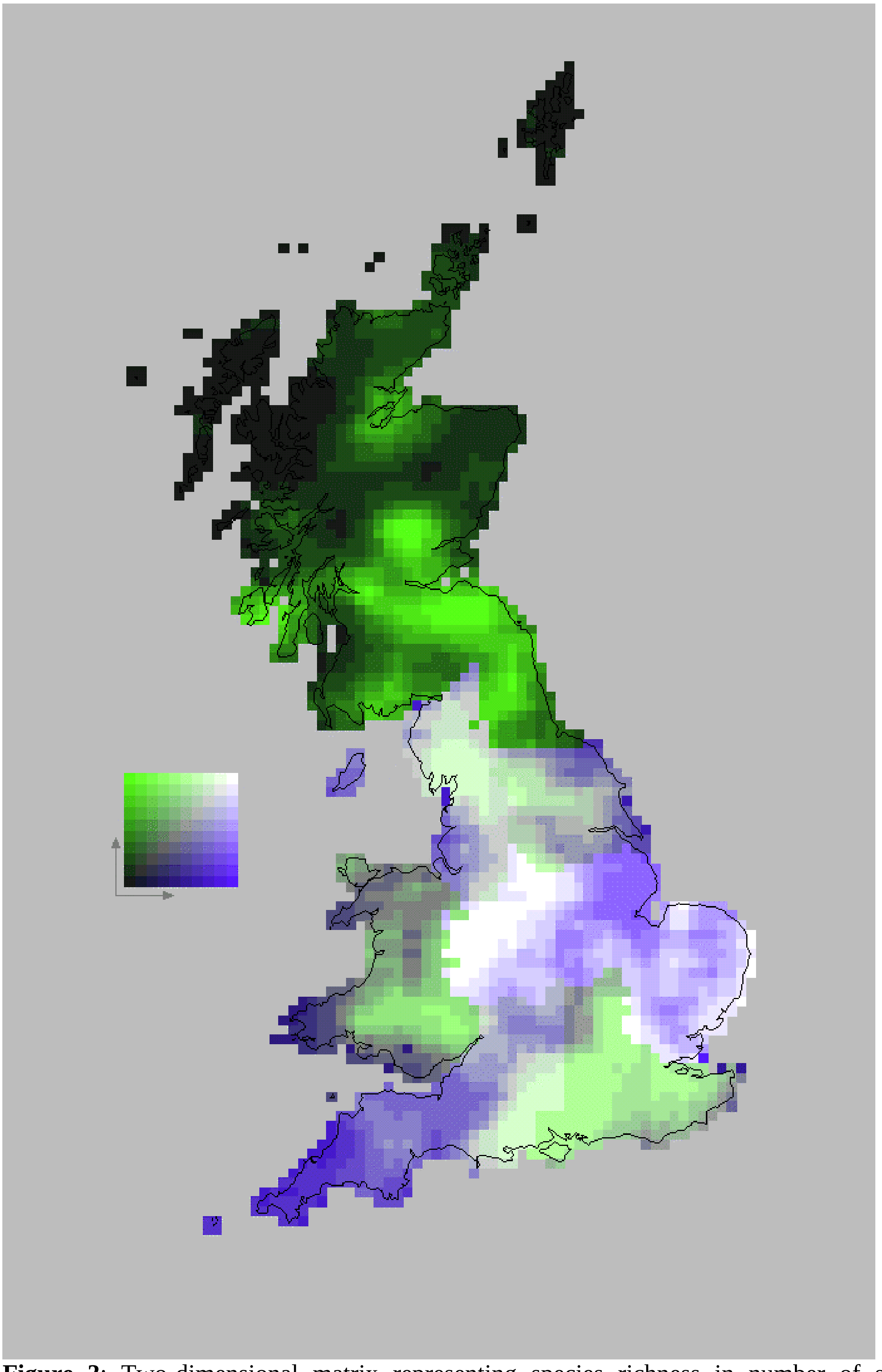

Figure 3: Two-dimensional matrix representing species richness in number of species recorded at least once per grid cell (vertical scale) and regional land prices in £/Ha (horizontal scale).

On the other side of the spectrum, the Southwest, Eastern and East Midlands regions and East of West Midlands region, show a distinct blue pattern of high land values and poor species richness, with smaller scores at the Isle of Man and coast of Lancashire, Yorkshire and Humberside. These zones should be particularly avoided as they manage to encompass a negative combination of high land values and low species richness and should only be taken into consideration under extreme circumstances.

The rest of the map shows paler colours and a black and white pattern with different shades of grey. Any secondary conservation policies should be directed towards the zone in a black and white pattern according to the present budget constraints. If the budget is not very restricted attention should be given to the zones showed in white, which manage to encompass both high species richness and land values (West and North part of the West Midlands, Northeast of the Southeastern region, parts of the East Anglia coast). In case of a very tight budget, policy should be oriented down the diagonal scale to areas showed in grey or black (North and West of Wales, Yorkshire and Humberside, North Cumbria, the east of the Southeastern region, parts of western Scotland, Highlands and Islands) according to the particular budget constraints. Any new policy towards broad area selection for future biodivesity conservation should take these results into account.

Minimum amount of areas according to the correlation of land and cost.

It may be argued that even if the broad area correlation indicates potential zones for opportunity, the actual process of area selection is so specific and the room to manoeuvre so small that economic factors would play no significant impact in biodiversity conservation. In order to find out the role of land values in selecting a set of reserves with the highest amount of Bird species the greedy algorithm was modified in its software to maximise biodiversity not by land but by cost. This way it would select a minimum set of reserves with the highest amount of Bird species, but this time also taking into account the land values of the different zones. The new cost related greedy algorithm was overlaid with the old land related greedy algorithm in a matrix similar to the one used to work in the broad area analysis and their results compared. As an arbitrary measure, both studies calculated the total potential cost of conserving one hectare per grid cell **(Figure 4)**.

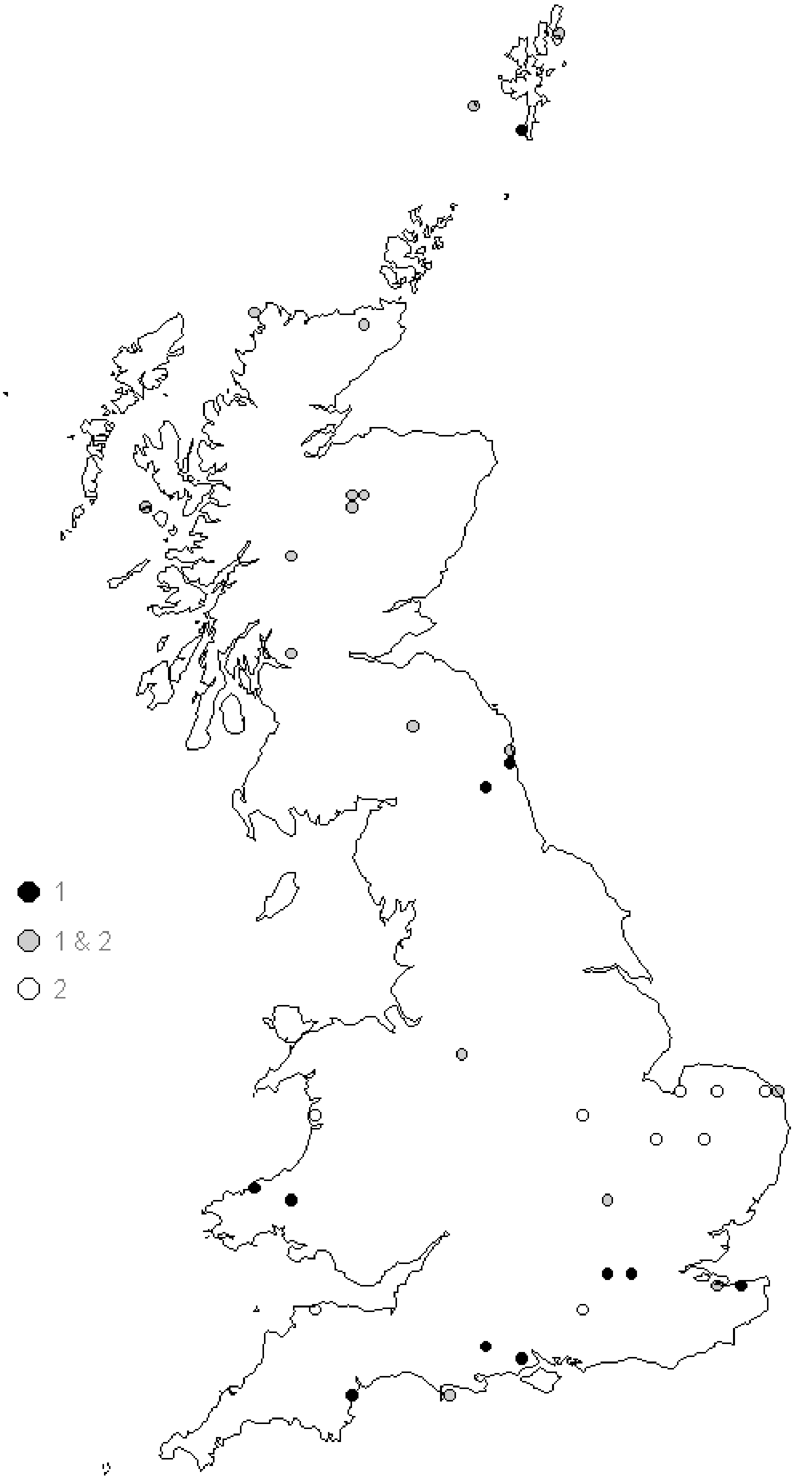

Figure 4: Land and cost related algorithms showing the minimal combination of reserves to achieve maximum biodiversity conservation of British Birds (at least one pair breeding recording for all 218 species of British Birds). 1 (black spots) indicates the combination set by the land.

The cost related algorithm could achieve the same biodiversity conservation targets (single representation of all 218 breeding Bird species in Britain) as the land related algorithm with a 10.68% decrease in the total cost with two more grid cells added to the minimum **(Table 3).** The high amount of grid cells to both algorithms (17) also shows that these algorithms are very efficient, since they manage to achieve a very significant decrease in the total cost with a very small room to manoeuvre (£10 399 in 9 grid cells, which makes £1 300 per grid cell, provided every grid cell is represented by one hectare.).

Table 3: Results of the minimum area selection algorithms based on land (left-hand scale) and cost (right hand scale). The data show the number and code of cells in the left column as well as the species richness in the middle column, represented by the amount of new Bird species incorporated into the total account (inc) and the cumulative number (cum). The right column shows the cumulative cost in £.

Land related algorithm					Cost related algorithm				
#	Cell Location	Species Richness inc	Species Richness cum	Cost (£)	#	Cell Location	Species Richness inc	Species Richness cum	Cost (£)
1	1785 TF62	102	102	5 699.00	1	1047 NU20	84	84	1 223.00
2	492 NG20	28	130	8 285.00	2	1117 NZ07	19	103	2 446.00
3	509 NH90	19	149	10 871.00	3	820 NS48	25	128	5 032.00
4	1946 TL48	11	160	16 570.00	4	10 HU69	16	144	7 618.00
5	10 HU69	8	168	19 156.00	5	2465 TQ96	14	158	11 018.00
6	1950 TL88	7	175	24 855.00	6	509 NH90	10	168	13 604.00
7	1792 TG32	6	181	30 554.00	7	2687 SU30	7	175	17 004.00
8	131 ND05	5	186	33 140.00	8	131 ND05	5	180	19 590.00
9	1836 SH60	4	190	36 405.00	9	492 NG20	4	184	22 176.00
10	2465 TQ96	3	193	39 805.00	10	2467 TR16	3	187	25 576.00
11	2529 SU84	3	196	43 205.00	11	1070 NZ29	1	188	26 799.00
12	1047 NU20	3	199	44 428.00	12	479 NJ01	2	190	29 385.00
13	479 NJ01	2	201	47 014.00	13	478 NH91	2	192	31 971.00
14	478 NH91	2	203	49 600.00	14	39 HT93	2	194	34 557.00
15	1651 SJ85	2	205	54 154.00	15	1651 SJ85	3	197	39 111.00
16	1858 SK80	2	207	59 341.00	16	2139 SN43	2	199	42 376.00
17	39 HT93	2	209	61 927.00	17	2088 SN14	2	201	45 641.00
18	1793 TG42	1	210	67 626.00	18	2165 TL03	2	203	49 041.00
19	2777 SY77	1	211	72 472.00	19	2421 TQ07	2	205	52 441.00
20	105 NC16	1	212	75 058.00	20	1793 TG42	3	208	58 140.00
21	618 NN46	1	213	77 644.00	21	2644 SU01	2	210	62 986.00
22	1788 TF92	1	214	83 343.00	22	2774 SX97	2	212	67 832.00
23	988 NT42	1	215	85 929.00	23	105 NC16	1	213	70 418.00
24	2165 TL03	1	216	89 329.00	24	618 NN46	1	214	73 004.00
25	820 NS48	1	217	91 915.00	25	2507 SS64	1	215	75 590.00
26	45 HU31	1	218	96 761.00	26	988 NT42	1	216	78 176.00
					27	2423 TQ27	1	217	81 576.00
					28	2777 SY77	1	218	86 422.00
Total amount of areas: 26					**Total amount of areas: 28**				
Total cost: £ 96 761.00					**Total cost: £ 86 422.00 (-10.68%)**				

The grid cells that are not in common predominate in Scotland and the Northeast in the cost related algorithm and in the Eastern region in the land related algorithm. These areas

correspond respectively with green (cheap and species rich) and white (expensive but species rich) in the broad area selection study. This correspondence seems to confirm the affinity of both methodologies as well as demonstrate that the inclusion of economic factors through GIS could improve the area selection policies at both broad area selection and specific area correlation levels.

Conclusion

This research shows that economic factors such as market land values, long regarded as unnecessary or antagonistic to conservation, are a very useful tool in order to determine priorities in future biodiversity conservation policies. Therefore they should be comprehensively incorporated into any reserve selection viability study in order to achieve an economically efficient, as well as effective, biodiversity conservation policy.

The real importance of these results is to show in comparative terms the improvement in economic efficiency, at the same level of effectiveness, of incorporating economic factors into a biodiversity conservation analysis. Although it only considers one case of study (breeding species of Birds in Britain) and one economic parameter (average market value of agricultural land), the uniqueness of this study lies in the fact that it has managed for the first time to include a comprehensive set of economic data divisible into units (in this case, £/Ha.) into a Biodiversity distribution study *divided in equal area units.* The combination of both sets of units gives a comprehensive and measurable account of the possible economic efficiency improvements in a biodiversity conservation strategy at the same level of effectiveness (the highest possible amount of biodiversity).

The aim of this study was to work as a blueprint for further research in other geographical areas with other groups of organisms provided there is a desirable amount of scientific certainty about the quantity and quality of the data. These studies may prove to be a useful tool for planners at implementing a comprehensive biodiversity conservation policy with the double targets of maintaining the highest possible amount of biodiversity according to the inevitable budgetary limits. On the other hand, it can help impoverished developing countries, eager to develop their land but also to maintain the highest possible amount of their natural capital at the cheapest possible way. Moreover, since results provided by greedy algorithms are only based in one parameter, they can have not only one but multiple solutions, in this case different combinations of 26 possible reserves encompassing all 218 breeding species of birds in Britain (Paul Hopkinson, pers. comm.). Economic indicators can

therefore be used as a secondary parameter to achieve the most economically desirable outcome within this combination of possible solutions.

As a matter of fact, the results shown in Figure 4 may prove useful by planners at the time of implementing a particular set of reserves in a territory. If the outcome proves-as in this case -the best combination of reserves to be located all around the country it can have the double positive effect of seeming fair to the general public and distributing the possible negative and positive consequences inherent to setting a reserve around the territory. Moreover, it will help to bring back economic factors, right after scientific considerations, to the early stages of biodiversity conservation policy processes from where they should not have been relegated in the first place.

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