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Arable land and habitat diversity in Natura 2000 sites in Greece

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Agriculture is the dominant land use in Europe, with direct consequences for biodiversity. In the European Union, the Habitats Directive (92/43/EEC) focuses conservation efforts on the preservation of habitats. In order to elucidate the impact of agriculture on habitat diversity, we examined the effects of agricultural area and spatial configuration on the diversity of habitats of the sites proposed to be included in the Greek Natura 2000 network. The extent and fragmentation of agricultural land in a site had a weak effect on the diversity of habitats in the surrounding landscape. This effect was more significant in the case of freshwater habitats in lake ecosystems and even then, freshwater habitat diversity was positively correlated with agricultural area. Sites with high habitat richness of grasslands and/or with huge extent of grasslands were characterized by limited agricultural area. The diversity of habitat types designated as conservation priorities was not correlated with the spatial configuration of agriculture. The effect of agriculture on habitat diversity in sites undergoing agricultural decline and abandonment was different from the one in sites with more constant agricultural land use. In our study sites, agricultural practices do not diminish the potential of a site to host a diverse array of habitats, even those of conservation priority. In sites with a historic record of agricultural practices (e.g. around lakes), agriculture is not negatively related to landscape habitat diversity and so conservation efforts should not necessarily rely on agriculture restriction.

Key words: agricultural decline, landscape metrics, Natura 2000, protected areas, biodiversity.

INTRODUCTION

Agricultural area covers approximately 47% of the European Union land (EEA, 2006). Changes in agricultural practices during the twentieth century aiming at maximizing production are among the driving forces for environmental degradation. As a first step towards mitigating this situation, European Union supports agri-environmental schemes. An even bigger step to this direction is the reform of the Common Agricultural Policy (2000-2006), where environmental components are fully integrated and support is partially decoupled from production. In this context, emphasis is given on the role of agriculture in preserving biodiversity. This development in the foreground of ecological research has put the question of how agriculture affects biodiversity. The effect of farming practices on species diversity is variable and depends on the taxonomic group examined as well as on the scale of the analysis (e.g. Bengtsson *et al*., 2005). One common place of such studies is that the effect of agriculture on biodiversity does not depend only on processes at the farm level, but also at the landscape level (Roschewitz *et al*., 2005). For example, habitat heterogeneity in the landscape enhances biodiversity (Jeanneret *et al*., 2003).

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There is an argument that the loss of ecological heterogeneity at multiple spatial and temporal scales is a universal consequence of agricultural intensification (Benton *et al*., 2003). Meeus (1993) argues, if the world market for agricultural products has its way, landscape planning will be ignored, and the variability in agricultural landscapes of Europe will probably diminish. We already witness that landscape configuration becomes progressively more homogeneous within agricultural areas with preference for monocultures and removal of hedgerows, ditches and fallow (Stoate *et al*., 2001; Deckers *et al*., 2004). Simultaneously, forests are turned into agricultural land (Kristensen, 2003).

Modern agricultural practices influence the flora and fauna of adjacent forest patches (Bayne & Hobson, 1997), aquatic ecosystems (James *et al*., 2005) and hedgerows (Deckers *et al*., 2005). Even more importantly, the runoff of fertilizers and pesticides to aquatic ecosystems lead to phenomena like eutrophication of nearby lakes and reservoirs (Nebbache *et al*., 2001). Therefore, we expect agricultural land use to have a direct effect on the surrounding landscape that could be identified at the level of landscape habitat diversity.

The Habitats Directive 92/43/EEC "on the conservation of natural habitats and of wild fauna and flora" aims at preserving, protecting and improving the quality of the environment, conserving natural habitats, wild fauna and flora, while taking into account economic, social, cultural and regional requirements. The Habitats Directive is a major contribution of the European Community towards implementing the Biodiversity Convention of Rio in 1992 and underpins a European network of protected areas known as Natura 2000 (Dafis *et al*., 2001). In Greece, sites included in this network are distributed fairly uniformly covering approximately 16% of the national territory (Kallimanis *et al*., 2008). The aim of this network is to contribute to the maintenance of biological diversity within the Mediterranean biogeographic region. In the sites included in the Natura 2000 network, human activities are not excluded and agroecosystems are the most frequent habitats (Dimopoulos *et al*., 2005a).

The Habitats Directive (article 1b) defines habitats as terrestrial or aquatic areas distinguished by geographic, abiotic and biotic features, whether entirely natural or semi-natural. The classification of habitats is standard and uniform for all European Union member states (Dimopoulos *et al*., 2005b). Thus, a possibility is provided to estimate habitat diversity within various regions in a consistent way. To our knowledge, this is one among the first studies examining habitat diversity based upon this classification system, i.e. estimating biodiversity at habitat level in nature protected areas (but also see Kallimanis *et al*., 2008).

The aim of this study was to examine how agriculture affects the landscape habitat diversity in Natura 2000 sites of Greece. We focused on how different aspects of agricultural arable land spatial pattern affect the habitat diversity of the landscape surrounding agricultural fields. More specifically, we examined three hypotheses, i.e. whether landscape habitat diversity and conservation status are affected by: i) the amount of arable land, ii) the edge length between arable land and natural ecosystems and iii) the fragmentation and dispersion of arable land among natural habitat types.

MATERIALS AND METHODS

Towards implementing the Habitats Directive the project "Identification and description of habitat types in areas of interest for the conservation of nature, 1999-2001" was carried out under the responsibility of the Hellenic Ministry for the Environment, Physical Planning and Public Works (Dafis *et al*., 2001). The project examined 254 sites, which are included in the Greek Natura 2000 network. For these sites various habitats (terrestrial or aquatic) were syntaxonomically identified, described and delineated with the use of remote sensing data and through fieldwork at each site. Each habitat was characterized – according to the directives classification scheme – by its geographic, abiotic and biotic features, as a specific habitat type or subtype of ANNEX I of the Habitats Directive 92/43/EEC (e.g. Mediterranean pine forests with endemic black pines were identified as habitat type 9530), or as a national habitat type (characteristic or important for Greece). Arable agricultural land was included as one of the habitat types; and abandoned agricultural land as another. The habitat type maps produced from this project were the source data used in the present study.

From the 254 proposed Natura 2000 sites, 17 were composed exclusively of marine habitats, while of the remaining 237 sites (terrestrial or terrestrial and marine), 203 included arable land and consisted of 211 terrestrial areas. Some of the proposed sites consist of more than one terrestrial areas (e.g. site GR4210001

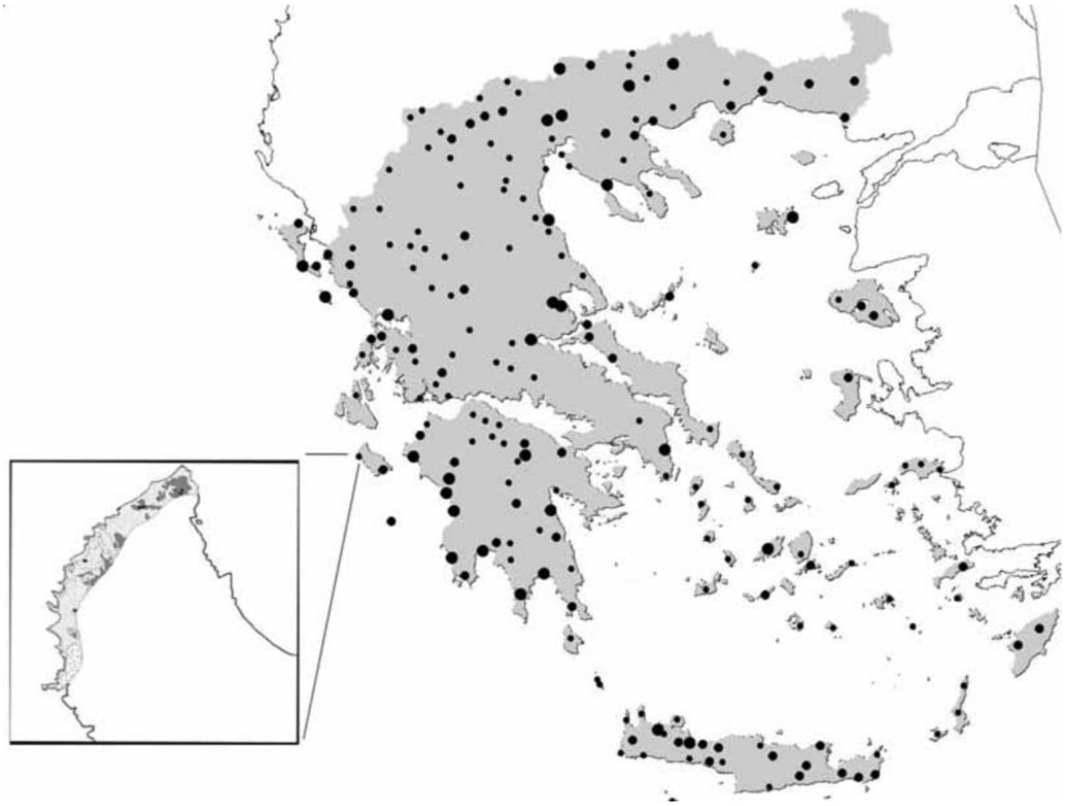

FIG. 1. Map of Greece where the protected areas of this study are highlighted. The size of the points is indicatory of the proportion of the protected area that is cultivated. The inset map shows the habitat map of a study site (GR2210001, coastal zone of northwest Zakynthos). The site has five different habitat types, including cultivated land represented with dark gray color.

consists of the island of Kasos and several smaller islands). For the purpose of the present study, we refer to each of these 211 terrestrial areas as sites, even if they correspond to 203 proposed Natura 2000 sites. As seen in Figure 1, these sites are located throughout the Greek national territory, and in each sub-biogeographic zone of the country. Among these sites, 60 include also abandoned agricultural areas, as recorded by direct observation. The area of the studied sites ranges from 1.36 km^2 to 843 km^2 (mean 106.49 km^2). In our sites, 113 habitat types of community importance (habitat types or subtypes according to ANNEX I) are present, while 20 of these habitat types are defined as conservation priority (i.e. facing greater risk of extinction). At least one priority habitat type is found in 114 sites. Our study also includes 34 habitat types of national importance or characteristic for Greece. For these 211 sites, we used the respective topographic data and habitat and landscape metrics were computed using the vLate software.

For each site, we calculated the spatial characteristics of agricultural arable land. Agricultural land refers to cultivated fields (animal husbandry is not present). We were interested in arable total area in each site as well as in its relative contribution to the landscape (i.e. what proportion of the site is occupied by arable land) and in its mean patch size (how much area the average continuous field covers). Patches are defined in relation to other habitat types; roads bisecting the landscape are not taken into account as edges. Also, we estimated the edge of the fields (total length of the edges of arable land and edge length of the average continuous field). Again, edge refers to the ecotone between different habitat types; roads do not define edges. Finally, we estimated the fragmentation and dispersion of arable land in each site using the number of patches, division, split and mesh indices (Jaeger, 2000).

Correspondingly, for each site we measured the habitat richness, i.e. the number of different habitat types present in the landscape. This measurement showed that habitat richness at a site ranges from 4 to 35 (mean 12.8). In order to examine whether agriculture affects a specific group of habitats, we classified them into broader groups, i.e. forests, shrublands, grasslands, freshwater habitats, coastal habitats or priority habitat types, and we measured the habitat richness of each group at each site. Shrublands refer to mattorals, heaths and scrubs, while coastal habitats include coastal dunes and coastal halophytic habitats. The characterization "priority" refers to ANNEX I habitat types (Directive 92/43/EEC) that are of conservation priority at the European level. A site could consist of more than one group of habitats, e.g. lake Kerkini includes both freshwater and forest habitat types.

Another aspect of interest was the conservation status of each site. The description of habitat types during the implementation of the project "Identification and description of habitat types in areas of interest for the conservation of nature, 1999-2001" included an estimation of their conservation status (Dafis *et al.*, 2001). For this procedure, the following items were taken into consideration: how well the structure of vegetation and expected functions of the ecosystem are preserved and what the restoration potential is. A given habitat type at a site scored A (i.e. score 1) when its conservation status was excellent, B (i.e. score 2) when it was good, and C (i.e. score 3) when it was of low quality. A final case was when the habitat type was not representative of its typical form or its presence was insignificant at the specific site (score 4). We used this estimate as an indicator of the probability that a habitat type at a site becomes extinct in the future. In order to derive a landscape scale indicator, we estimated an area-weighted average of the conservation status according to the formula (1):

$$CS = \frac{\sum_{i=1}^{n} CS_i A_i}{\sum_{i=1}^{n} A_i} \quad (1)$$

where A_i represents the area occupied by habitat type i in the site, CS_i represents the conservation status of habitat type i in the site and n is the number of habitat types with a conservation status score. Agricultural arable land was not taken into consideration when estimating the sites conservation status. A system for conservation status assessment of habitat types within each Natura 2000 site is described, documented and proposed to be implemented in Greece by Dimopoulos *et al.* (2005a).

We were interested in the distinction between sites undergoing agricultural decline and sites under more constant agricultural utilization or even agricultural intensification. Since information regarding this aspect of agriculture was lacking, we used a surrogate index, namely the mean patch of agricultural land. Small mean patch size might indicate that this field is no longer financially profitable to be cultivated in an intensive manner. We grouped our sites according to this metric into two categories: (*a*) sites with mean arable land patch size smaller than 0.2 km^2 and (*b*) sites with mean arable land patch size larger than 1 km^2. We considered group *a* as indicative of agricultural decline and group *b* as indicative of constant agricultural pressure or even intensification.

In our statistical analysis we used the non-parametric Spearman's rank correlation coefficient, because our variables are not normally distributed. In all cases, the dependent variable was either habitat richness or conservation status. As independent variables we used the landscape metrics for agricultural land. Each point in our analysis represents a different site.

RESULTS

Characteristics of agricultural areas

The area occupied by arable land per site ranged from 0.09 to 290.68 km^2 (mean 19.10, median 6.01 km^2). The area of the arable land as a proportion of the total area of the site varied from 0.1% to 85.5% (mean 20.8%, median 13.2%). Agricultural arable land is divided into continuous fields ranging from 1 up to 274 fields per site (mean 19.4, median 9 fields per site). The area occupied by each continuous field (Mean Patch Size) ranged from 0.023 to 19.16 km^2 (mean 1.58, median 0.59 km^2). This indicated that the degree to which arable land is fragmented in the different sites covers a wide range of values, with 66 sites having all arable land in a single field, and thus scoring 0 for the Division, Split and Mesh landscape metrics.

The total area occupied by arable land in each site was significantly but weakly correlated with the total area of the site ($R = 0.564$, $p < 0.001$). On the other hand, arable land area as a proportion of the total site area is weakly correlated with total arable land area ($R = 0.540$, $p < 0.001$), and weakly negatively correlated with the total area of the site ($R = -0.205$, $p = 0.003$).

Agriculture and diversity of habitats: area effects

Our first hypothesis was that the amount of agricultural arable land in a site affects the habitat richness of the site. Intuitively, we expected that as the agricultural arable area increases, the habitat richness and the conservation status of the site would deteriorate. We analyzed arable land area in each site with three metrics: total area occupied by arable land (total area), arable land area as a proportion of the total site area (proportion) and the average continuous area occupied by arable land (mean patch size).

Figure 2 shows the correlation between habitat richness and total arable land area; due to the large range of values of total arable land area, the X-axis is logarithmically transformed. Even though there is a significant correlation ($R = 0.319$, $p < 0.001$), it is obvious that this correlation is weak with limited predictive ability. Despite the long range of values for total arable area (over three orders of magnitude), sites with intermediate values of arable area scored both the minimum and the maximum values of landscape habitat richness (Fig. 2). Habitat richness is also (and more strongly) correlated with the total area of the site ($R = 0.569$, $p < 0.001$) and the total area of the site is correlated with the total agricultural arable area. Thus, the observed correlation might be a reflection of a "habitat-area relationship" rather than the effect of agriculture. We analyzed the correlation between habitat richness and arable land area as a proportion of the total site area. This correlation is not significant ($R = -0.135$, $p = 0.07$). Also, the correlation between mean patch size and habitat richness is not significant ($R = 0.080$, $p = 0.37$).

We analyzed the correlation between arable land area and richness of particular groups of habitats. Table 1 shows the results of these correlations, which are not identical with the ones of overall habitat richness. Total arable area is correlated only with richness of freshwater habitat types ($p < 0.001$). Mean arable land patch size is correlated only with richness of forests ($p = 0.008$) and with richness of freshwater habitat types (but interestingly the correlation is positive, $p < 0.001$). Arable area as a proportion of the site is, on one hand, correlated negatively, but weakly, with the richness of forests ($p < 0.001$), grasslands ($p < 0.001$) and conservation priority habitats ($p < 0.001$), while on the other hand it is correlated positively, but weakly, with the richness of freshwater habitat types ($p < 0.001$). The correlations between agricultural arable area and freshwater habitat richness are applied mainly on lake ecosystems, while for rivers and estuaries they are insignificant (results not shown).

The correlation between richness of grasslands and conservation priority habitat types with arable land area as a proportion of the site is enlightening (Fig. 3). Even though the correlations are significant,

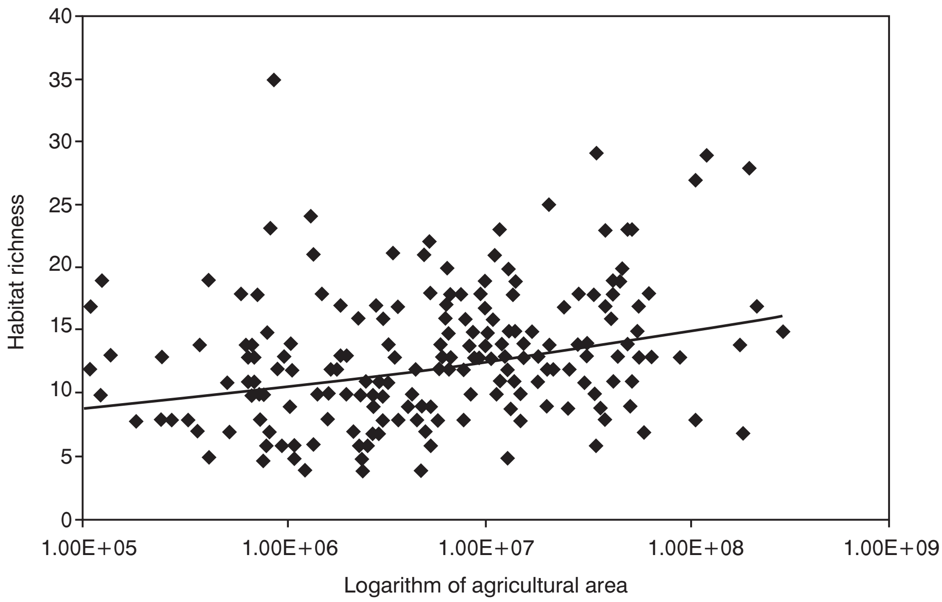

FIG. 2. The relationship between agricultural area (m^2) and habitat richness (number of habitat types in the site). Each point in the graph represents a different study site. The line represents the power model (coefficient of determination $R^2 = 0.094$, $p < 0.001$).

TABLE 1. Spearman's rank correlation coefficient (R) between each landscape metric for agricultural land and the habitat richness of different groups of habitats. Statistically significant correlations ($p < 0.05$) are indicated by asterisk

Landscape metrics for agriculture	All habitat types	Forests	Shrublands	Grasslands	Freshwater habitats	Coastal habitas	Priority habitat types
Number of sites	211	205	173	111	61	95	114
Area metrics							
Total area	0.319*	0.142	0.008	0.014	0.551*	–0.006	0.052
Area proportion of the landscape	–0.135	–0.363*	–0.071	–0.240*	0.288*	–0.071	–0.269*
Mean patch size	0.080	–0.170*	–0.076	–0.044	0.430*	0.024	–0.047
Edge metrics							
Total edge	0.314*	0.179*	0.024	0.028	0.515*	–0.012	0.045
Mean patch edge	0.001	–0.259*	–0.071	–0.094	0.372*	0.015	–0.109
Fragmentation metrics							
Number of patches	0.354*	0.390*	0.077	0.087	0.331*	–0.039	0.130
Division	0.242*	0.227*	0.116	–0.198*	0.326*	0.021	0.083
Mesh	0.291*	0.129	0.098	–0.019	0.549*	0.099	0.158
Split	0.246*	0.217*	0.114	–0.184	0.322*	0.012	0.108

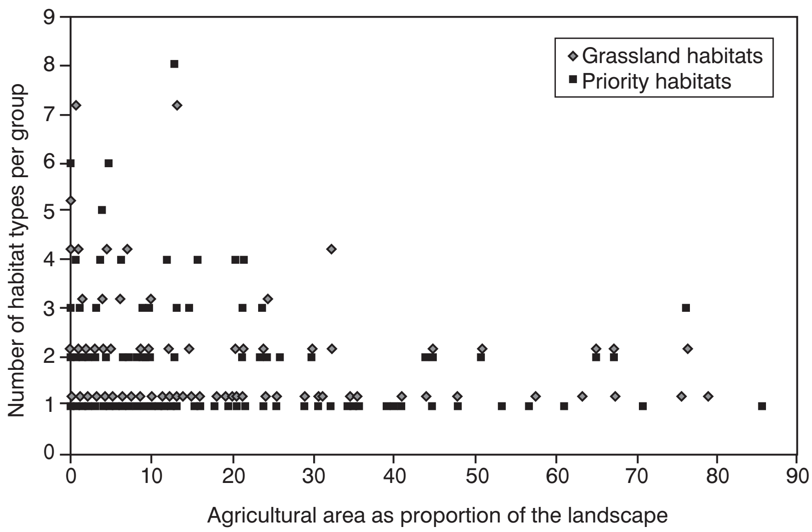

FIG. 3. The relationship between agricultural area as a proportion of the landscape (%) to habitat richness of grasslands and conservation priority habitats.

they are weak. The main reason is that the sites with small arable area have both high and low habitat richness. But for both of these groups of habitat types, sites with high diversity are characterized by small arable land surface. This pattern is even more pronounced in the relationship between arable land area and grassland area (Fig. 4). The sites where grassland area is more than 10% of the site, arable land is limited, and correspondingly, in sites where arable land area occupies more than 10% of the landscape, the grasslands occupy less than 20%. This threshold phenomenon is not observed in other habitat groups (results not shown).

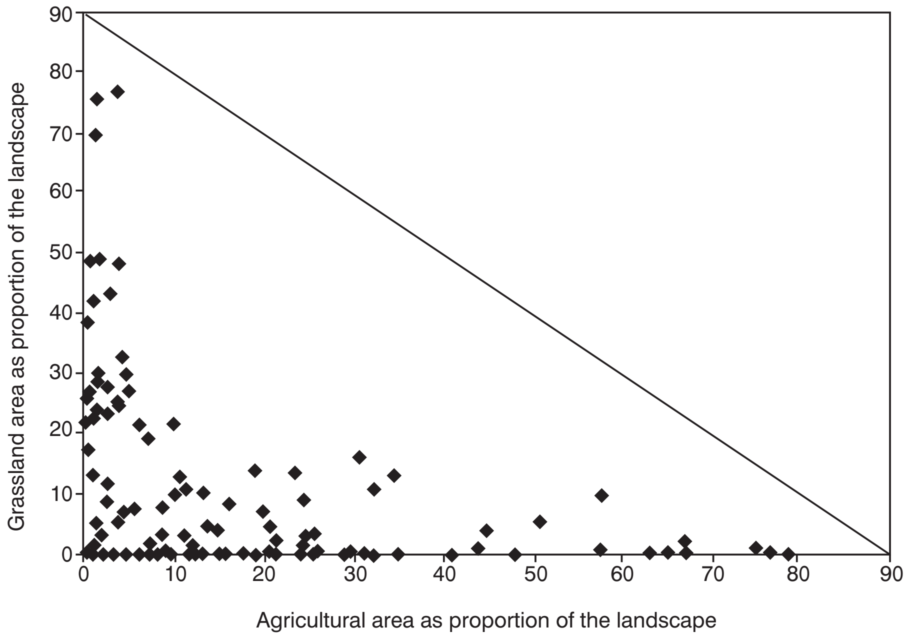

FIG. 4. The relationship between agricultural area as a proportion of the landscape to grassland area as a proportion of the landscape. The area above the diagonal is not feasible.

Agriculture and diversity of habitats: edge effects

Our second hypothesis was that the edge length of arable land in a site affects the habitat richness of this site. Our data set does not allow us to disentangle the area effects from the edge effects, because total arable land area is significantly correlated with total arable land edge length ($p < 0.001$), and mean patch size is strongly correlated with mean patch edge length ($p < 0.001$). So unsurprisingly, the rank correlation coefficients that were calculated for total arable land area deviate slightly from those for total edge length (Table 1). Equivalently, the rank correlation coefficients that were calculated for mean patch size deviate slightly from those for mean patch edge length.

Agriculture and diversity of habitats: fragmentation effects

The third hypothesis was that the fragmentation of arable land in a site affects the habitat richness of the site. We used four metrics for fragmentation: number of continuous agricultural fields (number of patches), division, mesh and split. Number of patches is correlated with total area of the site ($p < 0.001$), but not with arable land area as a proportion of the site ($p = 0.72$) or with mean patch size ($p = 0.10$). The other three metrics are correlated with area and edge significantly, but weakly (in all cases $R < 0.34$). More interestingly, the correlations between fragmentation metrics and habitat richness are different. Habitat richness is significantly but weakly correlated with number of patches ($p < 0.001$), but this might be a reflection of the stronger correlation between habitat richness and total area of the site. Habitat richness is also significantly but weakly correlated with division ($p < 0.001$), mesh ($p < 0.001$), and split ($p < 0.001$).

When analyzing the correlation between arable land fragmentation and richness of specific groups of habitat types, the results varied more (Table 1). The richness of shrublands, coastal habitat types and conservation priority habitat types is not correlated with arable land fragmentation. The richness of grasslands is weakly correlated with the division index ($p < 0.05$), but with no other. The richness of forests is weakly correlated with all fragmentation indices, except for the mesh index. And even in the case of forests, all correlation coefficients are low ($R < 0.26$), with the exception of number of patches; that might be an artifact of the relationship between forest habitat richness and total area of the site. Finally, the richness of freshwater habitat types is correlated with all arable land fragmentation indices. This correlation is even stronger than the one with area with all Spearman's rank correlation coefficients greater than 0.3 and maximum correlation with mesh.

Agriculture and conservation status

The effect of arable land on the average conservation status of the site was also examined. The results showed that conservation status is not correlated with total arable land area (R = 0.084, $p = 0.23$), but is correlated with the proportion of the site occupied by arable land (R = 0.236, $p < 0.001$), and with the arable land mean patch size (R = 0.169, $p < 0.01$), albeit weakly. Positive correlation means that as agriculture area increases, the conservation status deteriorates.

Finally, we estimated the correlation between arable land fragmentation and the conservation status of the site. All correlations were not significant, except for the division index (R = –0.293, $p < 0.001$). This weak correlation indicates that sites where agricultural land is more fragmented, the conservation status of the other habitat types is of better quality.

Agricultural decline versus agricultural continuation

Our data reflect the correlation between agricultural land use spatial configuration and landscape habitat diversity at a specific moment. Data on temporal variation of this correlation are lacking. As a possible surrogate, we tried to separate our sites into two groups; one undergoing agricultural decline and abandonment and a second where agriculture continues as before. Due to lacking of chronological data on the changes of agricultural area, we used the mean patch size (i.e. the average area of continuous arable land) as a surrogate index. We assumed that sites with small mean patch size may be undergoing agricultural abandonment, an assumption supported by the fact that these sites also include abandoned agricultural areas. Sites with large mean patch size might be indicative of more constant agricultural utilization or even of agricultural intensification. Therefore, we repeated the analysis splitting our data set according to the mean patch size of each site. As shown in Table 2, sites with small mean patch size (less than 0.2 km^2) display a totally different pattern of correlations than sites with large mean patch sizes (more than 1 km^2). In the case of sites with small mean patch sizes, the only significant correlation is that habitat richness is negatively related to agricultural land as a proportion of the site. In sites with large patch sizes, this metric is not significant, while the most important indices are those of fragmentation (division, split and number of patches).

TABLE 2. Spearman's correlation coefficient (R) between each landscape metric for agricultural land and the habitat richness for sites with different Mean Patch Size (MPS) of agricultural land. The sites are distinguished into two groups; (a) sites with mean patch size less than 0.2 km^2 (these sites include abandoned agricultural fields), and (b) sites with mean patch size greater than 1 km^2 (these sites do not have abandoned agricultural fields). Statistically significant correlations ($p < 0.05$) are indicated by asterisk

Landscape metrics	MPS < 0.2 km^2	MPS > 1 km^2
Number of sites	52	71
Area metrics		
Total area	0.181	0.302*
Area proportion of the landscape	–0.389*	–0.174
Mean patch size	0.052	–0.006
Edge metrics		
Total edge	0.223	0.287*
Mean patch edge	0.044	–0.175*
Fragmentation metrics		
Number of patches	0.213	0.325*
Division	0.085	0.355*
Mesh	0.194	0.327*
Split	0.085	0.350*

DISCUSSION

Area and edge effects

We focused on the effect of spatial configuration of agriculture on landscape habitat diversity. Human hands shape arable land, and thus it has a rectangular, Euclidean, shape. As a result, arable land area is strongly correlated to the edge of cultivated fields. Therefore, we cannot disentangle the two effects, and we will discuss them jointly.

Agrochemicals used to boost productivity include pesticides and fertilizers. Several environmental problems, e.g. eutrophication, are known to be associated with surface runoff and leaching of agrochemicals (Carpenter *et al*., 1998; Gustafson & Wang, 2002; Khan & Ansari, 2005; Verhoeven *et al*., 2006). Furthermore, modern agricultural practices are based on artificial irrigation using large amounts of water and consequently affecting both groundwater and surface water levels (Ruud *et al*., 2004). The result of increased water uptake for agriculture is limiting its availability for the remaining habitats in the landscape. Modern agriculture is an intensified enterprise based upon the use of heavy, fossil fuel consuming machinery that acts as a source of pollution in areas that otherwise would not have any sources of pollution. All these effects are quantitative, and the amount of arable land in the landscape should act as a measure of the intensity of these effects. We hypothesized that sites with higher amounts and longer edges of agricultural arable land would have a stronger negative effect on the surrounding landscape habitat diversity.

Our results offer, at best, weak support for this hypothesis. The correlation between agricultural arable area (as a proportion of the total site area) and habitat richness of landscape was not significant. On the other hand, there was a significant negative correlation between arable land area (as a proportion of the total site area) and richness of forests, grasslands and priority habitat types. However, these correlations were weak with very limited explanatory and predictive ability. The example of grasslands is enlightening. Sites, where grasslands occupy large proportion of the total area and/or have high habitat richness, were characterized by limited arable land area (less than 20%). But, that does not mean that all, or even the majority of sites with low arable land area, had either large areas occupied by grasslands, or high habitat richness of grasslands. This may be due to the fact that, in most cases, areas suitable for grasslands are also suitable for agriculture, and when easily accessible, they are converted to arable land. Thus, there is a "competition" for space between grasslands and agriculture. But when the pressure from agriculture is weak, other factors take over the driving force in shaping grasslands.

Simultaneously, our results offer support against the hypothesis that agricultural area negatively affects habitat diversity. The strongest statistical correlation recorded in our study refers to the diversity of freshwater habitats. More interestingly, this correlation was positive. So, sites with higher richness in freshwater habitats had larger areas of agricultural land. This effect was predominant in the case of lakes. The correlation was weak, if we analyzed only rivers and estuaries. It is possible that some agricultural pressures may have increased habitat richness. For instance, running off of fertilizers may change the trophic status of lakes. Another possibility is that lakes have a high availability of surface water throughout the year and are usually surrounded by fertile soils, being thus preferred areas for agriculture since antiquity. So, the observed correlation between agricultural area and freshwater habitat diversity may reflect human preference for selecting arable land, rather than the effect of agriculture. In conclusion, we would suggest that in areas where agricultural activities occur over millennia (e.g. the historicity observed in our lakes), the landscape has been partially shaped by them, and thus agricultural presence is not negative to landscape habitat diversity and in this sense, agricultural preservation is recommended. This does not imply that other environmental considerations (like soil and water quality) should be ignored (Zalidis *et al*., 2004).

Fragmentation effects

The other spatial characteristic of agricultural arable land we examined, was fragmentation. Agricultural fields need to be accessible by roads. The fields along with the transport infrastructure form a network of human land uses that effectively fragments the natural habitats. Fragmentation is known to be one of the major threats to ecological systems and biodiversity (Olff & Ritchie, 2002; Fahrig, 2003; Fagan *et al*., 2005; Kallimanis *et al.,* 2005, 2006). The fragmentation of the natural habitat becomes greater as the dispersion of agricultural fields in the landscape becomes greater, and thus the transport network is more extended. So, we hypothesized that the dispersion and fragmentation of agricultural land may act as a measure of this effect and thus the sites with greater fragmentation will have lower habitat richness in the surrounding landscape. Our results do not offer support to this hypothesis. Fragmentation of agricultural activity, in general, had no negative effect on habitat diversity. On the contrary, it had a positive effect on the habitat diversity of forests and freshwater habitats. Usually, habitat fragmentation is examined jointly with habitat loss, and is found detrimental for biodiversity. We separated the two effects by examining the area effects independently of the fragmentation effects. Our findings indicate a need to reconsider the general perception of fragmentation, *per se*, negatively affecting the habitat diversity.

Other considerations

One possible explanation of why we observe no severe effects is that we are looking only at a snapshot in time. A habitat type in a specific site might be declining in area and it may even become extinct in the foreseeable future, but is still present. Vellend *et al.* (2006) and Helm *et al*. (2006) reported examples of plant species persisting in a site even though they are doomed to go extinct. The conservation status is indicative of the quality of the habitat and it might be considered as an indicator of its sustainability. The analysis of this indicator suggests that agriculture was weakly, if at all, correlated with the average conservation status of the site. The examination of the agriculture in relation to the conservation status of each Natura 2000 site would be of higher value and more objective, if the following prerequisites were fulfilled: a) conservation status was not based exclusively on the judgment of the expert at site level, and b) conservation status of the site was derived from assessment at the mapping polygon level for each habitat type, as now are the guidelines by the European Commission (Dimopoulos *et al*., 2005a).

Another confounding factor may be the dynamics of agriculture. Agricultural landscapes in Europe presently are under two different and opposing pressures. On the one hand, we observe agricultural intensification and homogenization of the landscape (Stoate *et al*., 2001; Robinson & Sutherland, 2002), while on the other hand, in marginal lands we observed the opposite trend of agricultural decline and abandonment (Strijker, 2005). Our data reflect the conditions recorded at a single moment in time. So, in some sites, the agricultural configuration may represent a remnant of the past, while in others, a recently utilized area. The two different driving forces of landscape formation may have opposing effects on habitat diversity and thus obscure the effect we are trying to discern. In order to discriminate the two cases, we used mean patch size as an indicator. Sites with small fields are undergoing abandonment, as witnessed by the presence of abandoned agricultural land, while sites with large mean patch sizes are more likely characteristic of conventional or even intensified agriculture (hence the absence of abandoned fields). Indeed, this distinction led to totally different correlations. In areas with small fields (agricultural abandonment), habitat richness was negatively correlated with agricultural area as a proportion of the site. On the other hand, in areas with large fields, habitat richness is more strongly determined by fragmentation, and to a lesser degree, positively affected by total area and edge length. So, the two activities leave a totally different fingerprint on the effect of agriculture on habitat diversity.

One final caveat; the areas we investigated were not a random sample of the Greek territory. They form a network of sites identified for their high environmental quality, and several are currently protected under the Greek law. Though they have been used for agriculture for prolonged periods of time, they retained their high ecological value, and perhaps some other features of the area ameliorate the effects of agriculture.

Our results suggest that agriculture does not have a negative effect on landscape habitat diversity. At least this holds for the case of Greek protected areas, especially given that in Greece 58% of the total agricultural land is not irrigated and thus not intensively cultivated (GSNSSG, 2006). Therefore, we believe that the agri-environmental schemes will be proved more efficient and beneficial for conservation, if they focus firstly on the level of species, ecosystem functions, soil and water quality and secondly on the landscape habitat level.

Summarizing, agricultural land uses are very common in the proposed Greek Natura 2000 network. The presence of agricultural land does not seem to affect the potential for an area to be of high biodiversity value. In general, agriculture seems to have a weak effect on the habitat diversity of the surrounding landscape, with the exception of freshwater habitats. Surprisingly, freshwater habitat richness is correlated with agricultural land in a positive way. Only grasslands seem to be in "competition" with agriculture for space. Even in the case of grasslands, the effect on grassland habitat diversity is weak. We believe that the conservation of the landscape habitat diversity needs not rely on restriction of agriculture.

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