Agri-Environmental Schemes and Grassland Biodiversity: Another Side of the Coin

Angela Münch*

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Abstract:

In this paper, the Agri-Environmental Schemes (AES) of the European Union are evaluated on the basis of county-level data (NUTS3 region), the purpose being to disentangle the effects of AES on land-management practice from its effects on biodiversity. One of the major arguments in favour of AES subsidies is that they will promote environmental-friendly land-use, which, in turn, will lead to biodiversity conservation. However, the results of this paper reveal that AES subsidies are more focused on ecological land-use rather than extensive agricultural practice in the first place and, furthermore, the subsidies are predominantly allocated to already biodiversity-rich counties. Moreover, even if these subsidies were directed to biodiversity-poor countries, no clear evidence is found that land-use practices in situ improve the biodiversity status per-se.

Keywords: AES effectiveness, biodiversity, policy evaluation

JEL: Q18, Q58, R14

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* University of Southern Denmark, Department of Environmental and Business Economics, Niels Bohrs Vej 9, 6700 Esbjerg, Denmark, E-mail: amuench@sam.sdu.dk

1. Introduction

The European Agricultural Policy (CAP) is increasingly being criticized. Public discussion on the topic mostly revolves around the fact that a great deal of tax money—€54.6 bn[1]—was spent in 2009 on a sector that accounts for only a small proportion of employment (2.2% of total labour force in Germany) and very little value-added economic terms (0.88% of GDP in Germany) (German Federal Statistical Office). One argument in favour of spending this much money is that agriculture provides not only employment, particularly in rural areas, but also serves as caretaker for landscapes and provides ecosystem services, environmental protection, and food security (see, e.g., Sklenar 2007). Another pro-CAP argument is that without political intervention there is a great risk that agriculture will become even more intensified, leading to an even further decrease in biodiversity. The risk of loss of biodiversity is, indeed, a serious one as it involves not only the loss of valuable genetic material; biodiversity serves as insurance for ecosystem functioning, which, in turn, provides mankind with ecosystem services. "Ecosystem services" are defined here to include services such as nutrient cycling and water catchment regulation, as well as aesthetic values and recreation opportunities (see Hanley/Shogren/White 2001). Furthermore, preserving biodiversity increases freedom of choice, as in its presence individuals may choose from a set of diverse alternatives of where to live, what to eat, how to spend their time, and so forth (Perrings et al. 2007).

Assuming that there is a rationale for political interventions, the question becomes: "Are the chosen policy instruments effective?" Regular assessment is necessary to answer this question, especially in light of the fact that the subsidies are paid for by taxes. Within the EU framework of subsidies for environmental issues, Agri-Environmental Schemes (AES) are intended to provide incentives for environmentally-friendly agricultural practices, which in turn are expected to enhance or at least protect biodiversity. Although the EU demanded national evaluation of the programmes and their impact on the present flora and fauna, empirical studies to date have yielded varying results and are mainly conducted at the field level, making it difficult to arrive at any general conclusion as to the effectiveness of AES. In this work, rather than relying on field studies, a more generalized assessment of the AES is made possible by examining data from the German federal states of Bavaria and Thuringia. The study also analyses whether AES moves agriculture in the direction of biodiversity-friendly practices or instead tends to maintain existing agricultural structures. In addition to disentangling the effects of different AES- schemes on agricultural methods, and biodiversity,

[1] The CAP is part of Natural Resource policy programme of the EU. Only one policy issue has more budget available: the fund for sustainable growth at €60.1 billion, whereas, for example, the funds for citizenship (including health, consumer rights, youth, culture, and media) encompasses €651 million in total (EC 2009).

the analysis incorporates social-economic and geographical characteristics as control variables. The focus is on grassland diversity and measures to enhance or influence the same. In the next section a theoretical framework is drawn referring to a broader literature, i.e. incorporating not only scientific studies on grassland. The literature review is followed by the empirical analysis of grassland biodiversity and several AES schemes in Bavarian and Thuringian counties (NUTS3-areas, or in German: Landkreise). The obtained results will be discussed in the end of the paper before conclusions are drawn.

2. Theoretical/Empirical Background

2.1. Biodiversity and Policy Intervention

In standard economic terms, biodiversity is referred to as a superior good, i.e., with increasing income, a rising demand for biodiversity protection should be observed. Accepting biodiversity as socially desirable due to ecosystem services on the one hand, but keeping in mind the “tragedy of the commons” (Gordon 1954; Hardin 1968) on the other, political intervention seems justified, even though seeking to reduce market failure increases the risk of state failure. According to Buchanan & Tullock (1962) and Olson (1965), policymakers are rarely benevolent, but instead act to maximize their individual utility, meaning that in addition to at least ostensibly tending to social welfare, other issues, for example increasing their chances of re-election or expanding their own power/status, enter into their utility functions. Furthermore, information on how to intervene is generally not complete; bounded rationality is a major problem in policymaking regarding environmental issues (Venkatachalam 2008).

These more general problems of state intervention are complicated by the involvement and interests of bureaucrats (see Niskanen 1971) and lobbying groups (from nature conservation as well as from the agricultural sector), which have various impacts on political legislation and raise the likelihood of state failure. The findings of Bouleau et al. (2009), for example, suggest that funding for monitoring ecological indicators is not allocated according to the performance of the indicator but according to the goals of the respective institutions. Only if the outcome of the indicator fits the institutional goals funding was provided. On the public-sector side, Hynes et al. (2008) find that special habitats (e.g. dry grassland) are favoured in the distribution of public subsidies, while other habitats (e.g. wet grassland) are nearly ignored. Furthermore, regarding the US Endangered Species Act, there is empirical evidence which suggests that the listing of species are driven by the economic interests of private agents or lobbying groups within the political arena (Rawls/Laband 2004). Even the Red List data, based on a negotiation process between various actors for nature conservation tend to capture not only the loss of biodiversity (see Münch/Völkl 2011). To summarize, although there is a legitimate reason for state intervention to protect environmental goods, the AES programmes need to be evaluated regularly so as to reduce the likelihood of misallocation of public spending.

2.2. Policy measures (AES) and Agricultural Practice

To date, political reaction toward biodiversity loss is either ex-post (e.g., Red List) or ex-ante (e.g., AES). Subsidies, such as the diverse AES, are given as an incentive for farmers to engage in environmentally-friendly practices, which, theoretically, is expected to reduce biodiversity loss and possibly even enhance biodiversity abundance. However, Baylis et al. (2008) point out that the European AES, compared to their U.S. equivalents, has a wider scope than just the protection of biodiversity as the main concern appears to be the reduction of negative externalities of agriculture and redistribution of income, instead of increasing species abundance or protecting rare species. Because the EU demanded national evaluation of the programmes and their impact on biodiversity, a variety of field studies do exist. These studies generally compare agriculture modes (under/not under AES schemes) with regard to their biodiversity effects. While some authors (e.g., Kleijn et al. 2001; Feehan/Gillmor/Culleton 2005; Moonen/Bàrberi 2008) argue that, due to a lack of focus, AES does not have any effect at all on the status of biodiversity, others found positive effects on the abundance of common species in Bavaria (Mayer/Heinz/Kuhn 2008) and changes to environmentally-friendly farming in Saxony (Menge 2003) or in the Netherlands (Parra-Lópezet al. 2009). Further research (e.g., Kleijn et al. 2006; Kleijn/Sutherland 2003; Kohler et al. 2007; Merckx et al. 2009a; Roth et al. 2008), however, detects that AES only partially improves biodiversity depending on the species under examination. Some species seem to be favoured by AES; others were driven close to extinction. Thus, the effectiveness of AES appears to depend on species characterization (e.g., mobility, breeding/blossom time). In respect to rare species, AES seems even to have a negative effect on their prevalence (see e.g. Bisang/Bergamini/Lienhard 2009; Konvicka et al. 2008). In addition to species' characteristics, features of the (surrounding) landscape influence the effectiveness of AES as well (see e.g. Pywell et al. 2006, Rundlöf/Bengtsson/Smith 2008). As AES measures yields at the field level, landscape complexity is not taken into account. This approach of 'one-size-fits-all' by the programmes does not seem appropriate or efficient (see Merckx et al. 2009b; Concepcion et al. 2008; Rundlöf/Bengtsson/Smith 2008).

Most of the extant empirical work consists of field studies that relate the observed biodiversity directly to AES, sometimes even without defining further which of the scheme is considered in the analysis. As AES is intended to encourage changes in land-use practice, whether it is effective or not hinges on discovering whether it is simply subsidizing existing practice and working as a form of income redistribution (see Baylis et al. 2008) or if it is, indeed, being conducive to more biodiversity-friendly land-use practices. Therefore, a distinction needs to be made between the effects of AES on agricultural practice and the impact of agricultural usage on the existing biodiversity. Referring to the first effect, the following hypothesis is formulated:

> *H1: Policy measurements (AES) lead to an increase in environmentally-friendly agricultural practice.*

2.3. Agriculture and Biodiversity

It is argued that agricultural production intensified during the last century (see e.g. Concepcion et al. 2008). During the same time period, there has been an observed loss of biodiversity. As it seems obvious that the two are connected, a wide range of scientific research has been conducted in an effort to discover which agricultural instrument in particular connects land-management practice and species' richness. Some field surveys find, e.g., a negative relationship between species abundance and intensive agriculture in general (e.g. Herzon et al. 2008; Nickel/Hildebrandt 2003); others do not find a significant effect between land-use method and species richness (e.g., Clough/Kruess/Tscharntke 2007; Kragten/de Snoo 2008). This lack of empirical proof as to the relationship between land-practice methods and biodiversity abundance has led some scholars to emphasize various other factors as being important to the prevalence of species, including landscape elements (e.g. Baudry et al. 2000; Sian Bates/Harris 2009; Sanderson et al. 2009), landscape fragmentation (e.g. Burel/Baudry 2005; Dauber et al. 2003; Aviron et al. 2005, 2007; Haslem/Bennett 2008), species mobility (e.g. Merckx et al. 2009a), and age of the grassland (e.g. Waesch/Becker 2009; Waldhardt/Otte 2003). However, it appears that field management is the major determinant of grassland species' composition rather than species richness (e.g., Mückschel/Otte 2003; Andrieu/Josien/Duru 2007; Boutin/Baril/Martin 2008; Petersen et al. 2006; Taylor/Morecroft 2009; Humbert/Ghazoul/Walter 2009). Thus, it seems that a land-use practice change is what results in the survival of one species over another. That is, some species appear to react positively to a particular land-management measure (e.g., early mowing), whereas others may be disturbed by the very same practice, resulting in reduced prevalence. Due to fragmentation of the landscape, such effects may be balanced out by providing niches for several species. Furthermore, the seed bank of the grassland may also have an important influence on observed species richness. As seed banks store seed for many years, thus providing a rather long-term stability in the types of food available, it does not seem likely that one-season or other short-term changes in land-management practices would have much impact on long-term species richness. In particular, because geography, one major determinant of biodiversity, is given and does not alter fast, changes in biodiversity are only observable in the long-run (Burel 1993). As the analysis conducted in this work measures long-term species abundance (see data section), the following relationship between biodiversity and agricultural practice is expected:

H2: Agricultural land-use should have no observed long-term effect on biodiversity abundance.

2.4. Socioeconomic Influence

Agriculture not only produces food but is also a supplier (and user) of ecosystem services for humans (Dale/Polasky 2007). Therefore, and due to the level of observation in this analysis, socioeconomic influences should not be ignored. That human action can modify the stability of ecological fixed points is modelled by Antoci et al. (2005 a, b) and by Eichner & Pethig (2006). While Antoci et al. (2005 a, b) show that human interference, in order to preserve one species, leads to changes in the original features of the natural dynamics, Eichner & Pethig (2006b) request a social planner, as otherwise all land will be used economically by mankind and none left for nature.

Another discussion in economics is the relevance of the environmental Kuznets curve (EKC), which proposes an inverse U- (or N-) shaped relationship between economic growth and biodiversity loss (e.g., Harbaugh et al. 2002; Mozumder/Berrens/Bohara 2006). Although most studies find an impact of economic growth on biodiversity loss, the effect seems either taxa specific (Naidoo/Adamowicz 2001) or counteracted by “good” institutions, i.e. effective policy interventions (e.g. Asafu-Adjaye 2003; Dietz/Adger 2003). Hence, biodiversity and socioeconomic variables may be negatively related due to, e.g., effects of industrialization (covered soil, disconnecting landscapes, or pollution), which needs to be taken into account in the empirical analysis.

2.5. Geographic Impact

Biodiversity in-situ depends on topography, soil, and landscape elements (e.g., Marini et al. 2007; Aviron et al. 2007). Furthermore, agricultural practice also depends on the landscape (Deffontaine/Thenail/Baudry 1995). So, for example, organic farming practices tend to occur in spatial clusters, the location of which is determined by geographic features (Parker/Munroe 2007). From an evolutionary point of view current land-management practice can be even traced back to geographic features and biodiversity of former times. So, for example, evidence is already provided that the foundation for nowadays land-use and observed biodiversity was laid already in the Iron Age (see Olsson/Hibbs 2005; Norton et al. 2009). Thus, geographical features seem to influence land-management practice as well as species abundance on a long-term basis. Therefore, it is often argued in the literature that AES shall account for landscape features on implementation scale as well as allocation criteria (see e.g. Kantelhardt/Osinski/Heissenhuber 2003; Aviron et al. 2007; Lindborg et al. 2008).

To summarize, if AES is effective it should enhance biodiversity status, especially in areas of low biodiversity. Ideally, AES should be implemented in such a way that alterations in land-use are of a long-term nature and encourage ‘biodiversity-friendly' agricultural methods. Thus, in a first step, the analysis at hand investigates which factors determine the allocation of AES. Second, it is examined whether AES alters land-use intensity. In a third step, land-use practice is related to biodiversity in order to discover what kind of land-use practice is connected with the level of biodiversity. Figure 1 is a graphic representation of the analytical framework within which the empirical analysis will occur. Due to data restriction (cross-section analysis) possible endogeneity will not be analysed in detail, but shall be kept in mind as it may interfere the results.

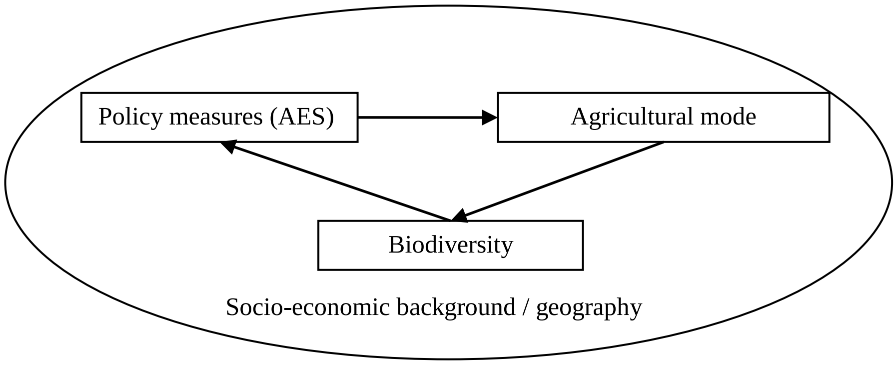

Figure 1: Systematic Illustration of the Analysis
Source: Own Illustration

3. Empirical Analysis

3.1. Data

To analyse the efficiency of AES, several indicators at the county level (NUTS3-areas or in German: Landkreise) for the German federal states of Bavaria and Thuringia are collected. Cities are excluded as agriculture plays little if any role in such locations. Moreover, biodiversity in cities tend to be higher in respect to species richness than in rural areas (see e.g. Wania/Kühn/Klotz 2006). Thus, distortion in the analysis may result. The study is restricted to grassland because distribution maps are available for different taxonomic groups of this ecosystem. Additionally, grassland serves well as a model system in biodiversity research.

3.1.1. Biodiversity

To measure biodiversity, the Shannon Diversity Index (*SHDI*) for the distribution of orchids in the counties of Bavaria and Thuringia is calculated first, as follows:

$$SHDI = -\sum_{i=1}^{J}(P_i \times \ln P_i)$$

Where J denotes the number of species and P the relative density of species i in the respective county (i.e., $P = n_i/N$). Data on the distribution of orchid species are based on maps obtained from Korsch, Westhus & Zündorf (2002) for Thuringia and from Schönfelder, Bresinsky & Ahlmer (1990) for Bavaria. Although the Shannon Diversity Index performs well compared to other indices (see Buckland et al. 2005), it is only an evenness indicator, and does not capture species abundance (see Jost 2009). To test the robustness of the findings and account for species richness, an additional indicator is included: *biodiversity*. This variable is a latent variable bundling the following observed variables with the help of a main component analysis[2,3]: (1) the number of typical grassland plant species (based on maps obtained from Korsch, Westhus & Zündorf (2002) for Thuringia and from Schönfelder, Bresinsky & Ahlmer (1990) for Bavaria); (2) the number of common butterfly species (based on maps obtained from Thust, Kuna & Rommel (2006) for Thuringia and from Voith, Bolz & Wolf (2007) for Bavaria); (3) the number of common grasshopper species (based on maps obtained from Köhler (2001) for Thuringia and from Schlumprecht & Waeber (2003) for Bavaria); (4) number of typical grassland bird species (based on maps obtained from Nicolai (1993) for Thuringia and from Bezzel et al. (2005) for Bavaria); and (5) the number of common orchid

[2] Using each of the variables separately leads to the same results. Therefore, all variables are bundled into one latent variable, as no information loss is to be suspected.
[3] The loading can be found in Table 4 (Appendix).

species (based on maps obtained from Korsch, Westhus & Zündorf (2002) for Thuringia and from Schönfelder, Bresinsky & Ahlmer (1990) for Bavaria). The focus is on species common to both regions, and thus species specific to, for example, the Alps are excluded. Furthermore, all variables are related to the size of grassland (hectares) within the county. The indicators here used, SHDI and biodiversity, capture either evenness in species distribution or species richness, but not diversity intactness. Hence, the interdependency between taxonomic groups cannot be integrated due to data availability. Limits in the efficiency of this type of indicator, as pointed out by, e.g., Büchs et al. (2003), are acknowledged. As several taxonomic groups are integrated into the analysis, distortion in the findings due to species characteristics (e.g., species mobility; see Hansson 1997) shall be ruled out. Regarding statistical power, ecological relevance, and ease of communication these indicator have proven to perform better than species intactness indices or multivariate community intactness indices (see Lamb et al. 2009).

3.1.2. Policy

Each EU member state possesses the sovereignty over the implementation of subsidy schemes within the EU-framework. In Germany the 2nd pillar of the CAP is split in the areas: 'guarantee' and 'special needs of the federal states of the former GDR'. These areas are again only frameworks for the federal states which are regulating their agricultural policy sovereign. So, all 16 German Federal States can decide on a diverse set of policy instruments to incorporate into their agricultural policy to meet the EU-goals and German programme guidelines. This patchwork of frameworks and guidelines and different levels of regulations creates a heterogeneous subsidy landscape within Germany, which shall account for regional differences in natural and agricultural features but makes an empirical analysis for Germany in total impossible due to the lack of comparability (Hartmann et al. 2006).

Within the guideline for the subsidy section 'guarantee' one also finds the Agri-Environmental Schemes, can be classified as follows (based on Hartmann et al. 2003): (1) *Mainly production-oriented instruments (AES-P)*: shall promote environmentally-friendly production methods independent of the area to operate on, local nature protection targets or actual environmental issues. So, a general decrease in production intensity and the preservation of genetic resources of traditional agricultural crop and livestock is targeted. These measures mainly serve abiotical resource protection (e.g. reduction of emissions) and can be further broken down to instruments in respect to total farm operations (e.g. ecological farming), to parts of the farm operations (branch of the farm is targeted, e.g. grassland extensification measures), to production methods/single crops (e.g. biological pest control), or to protect genetic resources (e.g. protection of domestic endangered livestock); (2) *Mainly nature conservation-oriented instruments (AES-N)*: shall promote environmentally-friendly production methods for specific fields in order to protect species, biotopes or landscapes. Thus, nature conservation goals are dominant, but production is not forbidden and/or traditional production methods shall be preserved (e.g. usage of traditional orchards). Agricultural knowledge and labour shall explicitly serve as caretaker for the environment. Both general schemes therefore imply different levels of restriction and compensation for nature conservation in the agricultural land management.

In this study, the counties of Bavaria and Thuringia are chosen due to not only data availability for biodiversity and AES, but also because the subsidies schemes are comparable. The empirical analysis incorporates therefore as *production-oriented AES (AES-P)* the subsidies paid (in Euros) in 2006 to the farmers under the schemes KULAP A/B in Bavaria and Thuringia. To measure *AES-N*, subsidies paid (in Euros) under the schemes KULAP C in Thuringia and VNP/EA-FFH respectively in Bavaria in 2006 are included. These data are as such comparable as the nature conservation measures which were supported in Bavaria under the guidelines of VNP/EA-FFH (contractual nature conservation efforts) were grouped in Thuringia at this time under the scheme KULAP C.[4] However, within the data subsidies specific for grassland management cannot be disentangled from other measures, e.g. for cropland, hedgerows or domestic animals. These figures display the total amount of subsidies paid under the respective general scheme. However, one opportunity to analyse the effect of grassland measures directly is given by using the number of grassland hectares under KULAP C in Thuringia and VNP/EA-FFH in Bavaria in 2006. This variable will be named *AES-G* in the following. Thus AES-G is the part of the AES-N programme which is only applicable to grassland. However, the same is not possible for KULAP A/B due to data constraints.

In order to test if AES induced changes in agricultural practice, though, the payments of 2006 are taken. The difference in AES of 2002/03 and 2006/07 (the timespan covered by the German agricultural survey) is not considered based on the following arguments: (1) there were major shifts in AES between 2003/2004 and 2006/2007. To compare, therefore, the payments of the schemes seem not feasible; (2) responsibilities of authorities for the specific programmes changed over time and with this the application process for the farmers;[5] (3) data

[4] Please see Table 7 (Appendix) for an overview of the AES-schemes and their respective measures.

[5] So, e.g. in Bavaria until 2006 AES-N was distributed by the Ministry for Nature Conservation, while AES-P was allocated by the Ministry of Agriculture. In 2007, the responsibility for AES-N was taken over by the Ministry of Agriculture, which is now issuing AES-P and AES-N.

is not available which would allow to accommodate these alterations. Consequently, it is assumed that agricultural management starts to orient themselves already one to two years before towards the fulfilling of the 2006 criteria. As a result overall changes in the agricultural practice between 2003 and 2007 may be reflected in the AES criteria in 2006.

3.1.3. Agricultural Land-Use

To measure the agricultural mode the fraction of *grassland organically used* as reported in the German agricultural survey 2007 (Agrarstrukturerhebung) of the Federal Statistical Office is here integrated. The term "ecological agriculture" implies that the farmer made an effort to comply with land-management standards and by doing so is registered officially according to the council regulation (EEC) 2092/91. This regulation implies to abandon the usage of any kind of chemicals (e.g. artificial fertilizer or pesticides) and genetic modified materials. However, it does not regulate the intensity of the land-use. Furthermore, the size of grassland managed according to this standard is relatively small (mean 6% of a county's grassland). Hence, an additional indicator for agricultural intensity is employed: *grazing intensity* which shall capture the size of intensively used grazing area. Data from the German agricultural survey 2007 are used to compute an intensity measure per farm. The farm livestock typically kept outdoors on grassland (sucker cows (older than two years), number of sheep, and number of horses, measured in livestock units (LU)) are measured relative to the farm's pasture area. This intensity measure is then used to calculate the number of hectares per county occupied with a grazing intensity above 1.4 and 2.0 livestock units per hectare (LU/ha), respectively. In the EU-AES programmes, the threshold for "environmentally-friendly agriculture" is 1.4 LU/ha. However, this number is not derived uniformly in the German federal states. Some federal states use 1.4 LU/ha related to total forage area, regardless of the usage; others, using various and again non-uniform methods, translate livestock units into roughage consuming livestock relative to forage area (RLU/ha). Therefore, in the analysis the thresholds of 1.4 and 2.0 LU/ha are used respectively.

To proxy the change in land-use, the same variables are calculated from the German agricultural survey 2003 of the Federal Statistical Office. As both surveys should be comparable, according to the Federal Statistical Office, the alteration in land-use is calculated as the difference in the indicators between 2003 and 2007. Data for the AES programmes are from 2006, but as the AES framework was set up for the years 2003–2006, the measurements subsidized are relatively constant over this time period, giving rise to the assumption that regardless of the extent of the subsidized area, the impact of the policy measures introduced in

2003 and continued until 2006 should be observable in the difference in land-management practice between 2003 and 2007. Thus, in this analysis, change in land-use is the situation in agricultural practice before and after the AES scheme 2003–2006.

Additionally, the difference in total grassland area between 2003 and 2007 is derived from the German agricultural surveys. These figures are used to proxy general changes in land management.

3.1.4. Socio-Economic Control

To avoid statistical problems such as multicollinearity, the socioeconomic control is limited to the variable of settlement and traffic area in 2008 according to the Federal Statistical Office. This figure captures well the effects of economic development like covered soil, disconnected landscapes or pollution. Additionally, the variable is highly correlated (on a 70–80% level) with population density and GDP per capita in the county. In order to measure change, the difference in settlement and traffic area between 31.12.2004 and 31.12.2008 are integrated into the analysis on land-use change.

3.1.5. Geographic Control

To control for geographical impacts, again several variables are bundled together as one and termed *geograph*y. Based on a main component analysis, *geography* includes the following variables: (1) the average altitude of the county according to the Bavarian State Office for Environment and the Thuringian State Office for Environment and Geology; (2) the mean monthly temperature (obtained from the German Weather Service); (3) the mean monthly precipitation (obtained from the German Weather Service); and (4) an Alps dummy, which takes the value 0 for counties dominated by the Alps and 1 for those with no Alps so as to control for specific features of the Alps landscape.[6]

As an additional geographic indicator serves a proxy for soil quality as used for tax purposes (EMZ) (obtained from the Bavarian Treasury Ministry and Thuringian Ministry of Finance).

Clustering effects should be captured by an inversed distance matrix, which is integrated in the analysis (see methods section). Furthermore, a dummy variable is introduced to capture systematic differences between Bavaria and Thuringia (1 = Bavaria, 0 = Thuringia), particularly those differences related to historical land-use practices that are still prevalent today.

[6] The loading can be found in Table 5 (Appendix).

An overview of the variables and their statistical properties is provided in Table 6 (Appendix).

3.2. Method

When mapping the above mentioned data, it is immediately obvious that spatial clustering is occurring, not only in the matter of biodiversity but also for land-use practice (see Figure 4 – Figure 7, Appendix). The observed clustering could be due to various factors, such as common geographical features (e.g., landscape or climate) or neighbouring effects (e.g., spillover or contagion). Based on the fact that global Moran's I as well as Geary's C, both tests for spatial autocorrelation, point to significant global spatial correlation for most of the dependent variables (see Table 8 & Table 9, Appendix). Moreover, diagnostic tests for spatial correlation indicate the usage of Spatial Lag Regression (see Anselin et al. 1996, Ward/Gleditsch 2008). In the analysis, a Spatial Lag Model with global autocorrelation is applied, captured by the following formula:

$$y = \mathbb{X}\beta + \rho\mathbb{W}y + \varepsilon \text{ with } \varepsilon \sim N(0, \sigma^2 \mathrm{I})$$

where $\mathbb{W}$ denotes a weighting matrix and y the spatially lagged dependent variable additional to $\mathbb{X}$, the observed characteristics of the county, and the coefficients β & ρ (following Anselin 2001). The weighting matrix is a distance matrix whereby weights are calculated as the inverse of the distance between the centre of one county to the ones of the other counties. Thus, the farther away the counties are from each other, the less probable are spillover or contagion effects and the less likely it is that these counties share similar landscapes. Variables that do not appear to be strongly affected by distance weights, and also do not show only small hints of local spatial autocorrelation, are the changes in agricultural modes.[7] So, for these variables, Ordinary Least Square (OLS) regressions with robust standard errors are calculated in the form of:

$$y = \mathbb{X}\beta + \varepsilon \text{ with } \varepsilon \sim N(\mu, \sigma^2)$$

To check for multicollinearity, the correlation matrix and the variance inflation factor is calculated. Variables correlating above 0.6 are not integrated together into the regression as well as regressions with a variance inflation factor above six (see Hill/Adkins 2001) are removed from the interpretation section. Furthermore, robust standard errors are calculated to reduce the effects of outliers and address statistical issues such as heteroskedasticity of the data. As the regression encompasses those variables bundled by main component analysis, all

[7] One exception is the variable 'difference in ecological farming' which shows some hints of global autocorrelation (see Moran's I). However, as Geary's C does not support the global autocorrelation ratio, it seems not be justified to use a spatial regression method in this case.

variables in the regressions are standardized (mean = 0; standard deviation = 1) to assure the comparability of the data.

In the first step of the analysis, AES is related to land-use practice. The variables SHDI and biodiversity are included to investigate whether AES allocation is related to biodiversity abundance or not. Socioeconomic variables as well as geographic features are controlled so as to capture whether particular regions are favoured by AES. In a second step, explanations for changes in land-use between 2003 and 2007, as well as general changes in agriculture for this time period, are sought by means of the AES scheme of 2003–2006 (2006 data). Socioeconomic and geographic controls are implemented as well as the Bavarian dummy. The third analysis concentrates on the abundance of biodiversity and whether land-use practice is present in 2007, which may be supported by AES, or whether socioeconomic controls and geographic variables explain the difference in species richness and evenness. A dummy variable is included to catch systematic differences between Thuringia and Bavaria.

3.3. Results

In a first step, the correlation matrix of the variables in the estimations is examined in more detail. One variable which highly correlates with geography is AES-P. Thus, area with higher precipitation (0.80), lower temperature (-0.82), or on a higher elevation (0.82) tend to be favoured by AES-P. Areas with a high proportion of grassland (0.91) also have a higher chance of obtaining AES-P. Furthermore, grassland dominates areas with higher altitude (correlation of grassland with Alps-Dummy: 0.74, with average altitude: 0.85). This correlation already points to possible endogeneity in the model as geography may; for example, influence agricultural practice as well as biodiversity, while agricultural management has an impact on biodiversity as well. Moreover, subsidies shall be allocated according to the biodiversity in-situ (dependent as well on geography). But subsidies also intend to change land management and this, in turn, may affect the found biodiversity. Due to data constraints and lack of verifiable instruments, these impacts cannot be totally ruled out, but shall be careful considered in the following regressions.

In a second step, the spatial lag model, which shall give hints on the drivers for regional differences in the allocation of AES schemes, is calculated. Results can be found in Table 1. Except favouring geographic characteristics, AES-P is also found to be significantly more distributed in areas with larger fractions of organic grassland farming, with lower grazing intensity and lower potential of agricultural yields (see coefficient of EMZ), respectively. Moreover, more rural areas tend to be targeted by AES-P as settlement and traffic area show a negative significant effect. However, the local biodiversity (evenness and species richness) cannot be significantly related towards the allocation of AES-P.

	AES-P	AES-P	AES-N	AES-N	AES-G	AES-G
SHDI	0.0205	0.0334	**0.254*** **	**0.237*** **	**0.252*** **	**0.251*** **
	(0.0714)	(0.0731)	(0.0859)	(0.0886)	(0.0773)	(0.0778)
Biodiversity	-0.00622	-0.0410	-0.0652	-0.0367	**0.258*** **	**0.275*** **
	(0.0596)	(0.0604)	(0.0981)	(0.112)	(0.0969)	(0.0956)
Organic Grassland	**0.228*** **	**0.231*** **	0.0824	0.0860	**0.245***	**0.248***
	(0.0454)	(0.0454)	(0.121)	(0.123)	(0.137)	(0.136)
Grazing Intensity 1.4	**-0.322*** **		**0.271** **		0.209	
	(0.0783)		(0.107)		(0.147)	
Grazing Intensity 2.0		**-0.309*** **		**0.190** **		**0.241** **
		(0.0750)		(0.0836)		(0.115)
Settlement Area	**-0.221** **	**-0.207** **	0.0314	0.0196	**-0.160***	**-0.186***
	(0.0858)	(0.0845)	(0.0967)	(0.101)	(0.0931)	(0.0949)
Geography			0.171	0.112	-0.0133	-0.0199
			(0.176)	(0.166)	(0.198)	(0.173)
EMZ	**-0.393*** **	**-0.369*** **	**-0.261** **	**-0.291** **	-0.0610	-0.0773
	(0.0582)	(0.0605)	(0.118)	(0.119)	(0.121)	(0.111)
Bavaria Dummy	**1.207*** **	**1.201*** **	**-1.414*** **	**-1.285*** **	-0.509	-0.534
	(0.172)	(0.171)	(0.433)	(0.435)	(0.470)	(0.414)
Constant	-0.937***	-0.932***	1.139***	1.036**	0.404	0.424
	(0.124)	(0.124)	(0.401)	(0.410)	(0.374)	(0.341)
rho	0.852***	0.862***	0.398	0.375	0.578	0.587*
	(0.145)	(0.136)	(0.461)	(0.478)	(0.358)	(0.356)
sigma	0.513***	0.519***	0.774***	0.784***	0.780***	0.775***
	(0.0503)	(0.0518)	(0.134)	(0.130)	(0.101)	(0.0967)
Observations	88	88	88	88	88	88
varRatio	0.701	0.690	0.390	0.374	0.370	0.377
Wald	34.29	39.97	0.744	0.616	2.610	2.724
Chi²	146.2	140.7	22.56	19.17	44.41	42.36
p	0	0	2.04e-06	1.19e-05	0	7.61e-11
ll	-67.38	-68.55	-102.4	-103.6	-103.4	-102.9
sqCorr	0.735	0.728	0.395	0.378	0.385	0.392

Table 1: Results of Spatial Lag Regression with AES as Dependent Variable
Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; All variables are standardized.

Contrary to AES-P, AES-N targets significantly areas with species evenness (SHDI), irrespectively of species abundance. Moreover, AES-N appears to support agricultural intensity. This result is counterintuitive and shall be subject to discussion later on. Similar to AES-P, AES-N also is allocated in areas with lower average agri-productive soil. The socio-economic structure and geography, however, do not significantly explain the variance in distribution of AES-N. Restricting the analysis towards the grassland hectares under AES-N, results change in that way that not only species evenness seems to be a decisive factor for the allocation of AES-N, but also species abundance shows a significant effect. Thus, distribution of AES-G tends to focus on areas rich in common species and evenly distributed species composition, respectively. Considering the agricultural practice which raises the chance of receiving subsidies under AES-N, areas with a higher fraction of grassland operated with a grazing intensity above 1.4LU/ha and 2.0 LU/ha, respectively, are significantly supported. However, the grazing intensity of 1.4 LU/ha do not significantly raise the likelihood of falling under the AES-G schemes, i.e. nature conservation in grassland. This result shall also be taken up again in the following discussion.

Additionally, it is revealed that AES-P is predominantly used in Bavaria, while AES-N seems to be the instrument of choice in Thuringia. As this effect is not displayed for AES-G, it looks as if instruments for nature conservation in grassland are comparable for both federal states. These systematic differences between the usage of AES-P and AES-N in Bavaria and Thuringia may be traced back to subsidy programmes aiming at alteration in cropland management. As cropland is not integrated into the analysis, it is refrained from further examination here.

The model specification towards spatial autocorrelation (rho, sigma) shows a spatial clustering of subsidy receiver (see Figure 8 - Figure 10, Appendix). High subsidy-receivers tend to be near each other. For biodiversity and geography such a positive relationship is found as well. As the coefficients in the regression, are only significant for AES-G and biodiversity, it appears that these clusters are geographically not overlapping. Contrariwise, if this spatial autocorrelation is caused by landscape features, than the significant spatial dependency within the allocation of AES may be interpreted as evidence that AES favours certain landscapes and is not equally taken up by the agricultural sector.

To explore whether AES induces changes in land-management practice, Ordinary-Least-Square Regressions on the changes between the years 2003 and 2007 in agricultural practice as the dependent variable and the three AES as independent variables are conducted (see Table 2). Regarding the results and the validity of the model, with the variable at hand, changes in agricultural land-use cannot be explained. AES (all three variables) seem not to be related to alteration in agriculture we observed between 2003 and 2007. However, these changes in land-use should be interpreted cautiously. According to the data from the German agricultural surveys of 2003 and 2007, a general decrease in the amount of arable land occurred during this period within these counties (mean: -520.712 ha; Std. Dev. 956.18), and there was also a slight decline in grassland fraction (mean: -0.2%; Std. Dev. 0.011). These general developments show a low impact on the agricultural land-use mode. The number of hectares with high grazing intensity (more than 2 livestock (LU)/ha) remained at average level during these four years (mean 0.0095; Std. Dev. 0.085), as did the fraction of organically used grassland (mean: 0.009; Std. Dev. 0.032). Thus, if alteration in land-use occurred, the results are very likely driven by external trends instead of caused by any of the subsidy schemes. Hence, no support can be found for Hypothesis 1 stating that the subsidy schemes will incentivize changes in the agricultural sector towards environmentally-friendly land management methods. None of the coefficients of the AES schemes on changes in land-use practice is significant. However, this "non-result" seems to be caused by the "stickiness" of agricultural practice, i.e., hardly any change in respect to intensity is observable. If there is change, other factors, not included in the analysis, appear to drive this alteration in land-use practices.

	Diff_Grazing Intensity 1.4	Diff_Grazing Intensity 1.4	Diff_Grazing Intensity 2.0	Diff_Grazing Intensity 2.0	Diff_ Organic Grassland	Diff_ Organic Grassland
AES-P	-0.0402		0.0514		0.0323	
	(0.117)		(0.110)		(0.120)	
AES-N	0.0346		0.0791		0.204	
	(0.151)		(0.0946)		(0.193)	
AES-G		-0.180		0.106		0.411
		(0.143)		(0.109)		(0.254)
Diff_Grassland	-0.0425	-0.0635	-0.0534	-0.0640	-0.298	-0.259
	(0.224)	(0.220)	(0.117)	(0.114)	(0.277)	(0.243)
Biodiversity	0.130	0.213	0.0377	0.0333	-0.188	-0.323
	(0.222)	(0.224)	(0.199)	(0.203)	(0.191)	(0.225)
SHDI	0.00231	0.0309	0.0958	0.0694	0.0172	-0.0213
	(0.101)	(0.108)	(0.109)	(0.111)	(0.0884)	(0.0897)
EMZ	-0.195	-0.175	0.126	0.115	0.325	0.239
	(0.196)	(0.160)	(0.156)	(0.135)	(0.340)	(0.258)
Diff_Settlement	0.0763	0.0687	0.199	0.218	-0.126	-0.0798
	(0.133)	(0.136)	(0.153)	(0.155)	(0.0912)	(0.0779)
Geography		0.104		0.119		-0.103
		(0.149)		(0.0956)		(0.118)
Bavaria	0.146	-0.0914	-0.153	-0.210	-0.377	-0.287
Dummy	(0.333)	(0.340)	(0.334)	(0.312)	(0.361)	(0.325)
Constant	-0.118	0.0737	0.123	0.170	0.305	0.231
	(0.285)	(0.306)	(0.267)	(0.250)	(0.360)	(0.326)
Observations	88	88	88	88	88	88
R^2	0.040	0.069	0.056	0.067	0.224	0.325
F (8, 79)	0.230	0.454	0.642	0.860	1.505	2.203

Table 2: OLS-Estimates with Change in Agricultural Practice as Dependent Variable
Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; All variables are standardized.

A more detailed examination of the alteration in grassland usage between 2003 and 2007 is only possible in a descriptive way. Due to data restriction based on privacy issues, data aggregation can be only conducted on the federal state level (Bavaria/Thuringia) and administrative regional level (NUTS2-areas, in German: Regierungsbezirke). Regarding the shift between 2003 and 2007 in grassland fraction area which is used with a grazing intensity above 1.4 LU/ha and 2.0 LU/ha, respectively, a mixed picture is drawn, if changes are split up between conventional farming and organic farming. While in Bavaria in total, the area used above the threshold is increased, in Thuringia only conventional farming downsized the area operated with high grazing intensity within the four years. The increase in pasture with grazing intensity above 2.0 LU/ha in Thuringia is, contrariwise, caused by organic farming (see Figure 2).

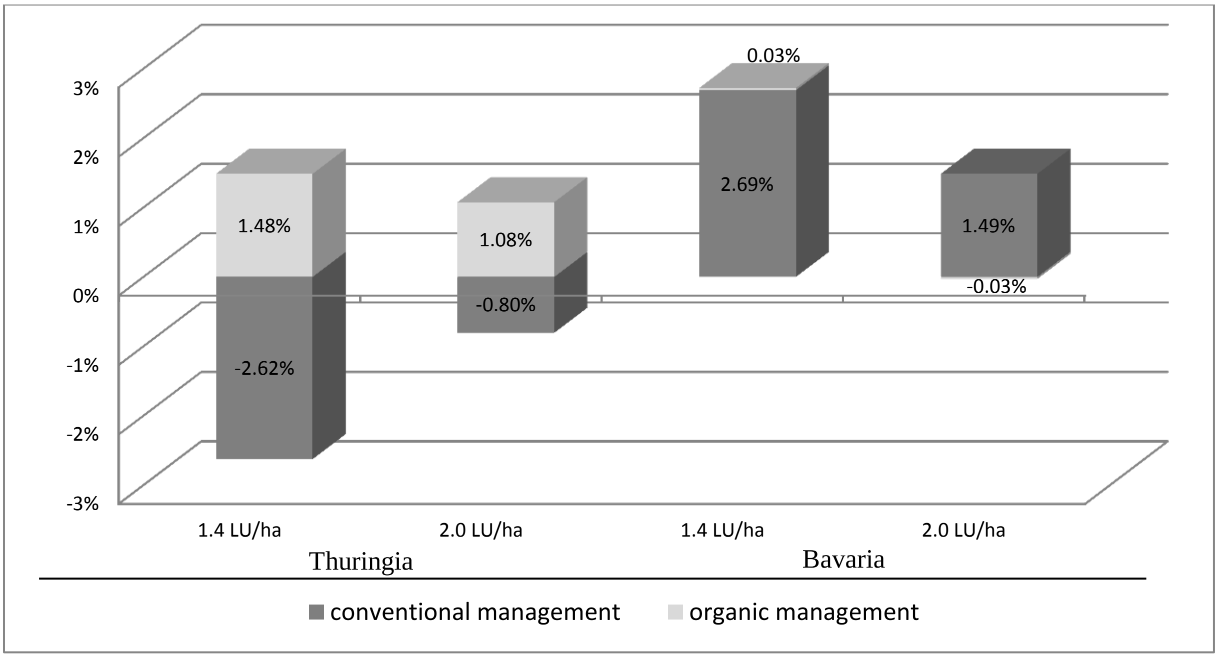

Figure 2: Difference of Grazing Intensity in Bavaria/Thuringia (2003-2007) (in %)

Please note: Differences are split up between conventional and organic grassland usage. Grazing intensity is measured as portion of pasture used above 1.4 LU/ha and 2 LU/ha; Source: German agricultural survey.

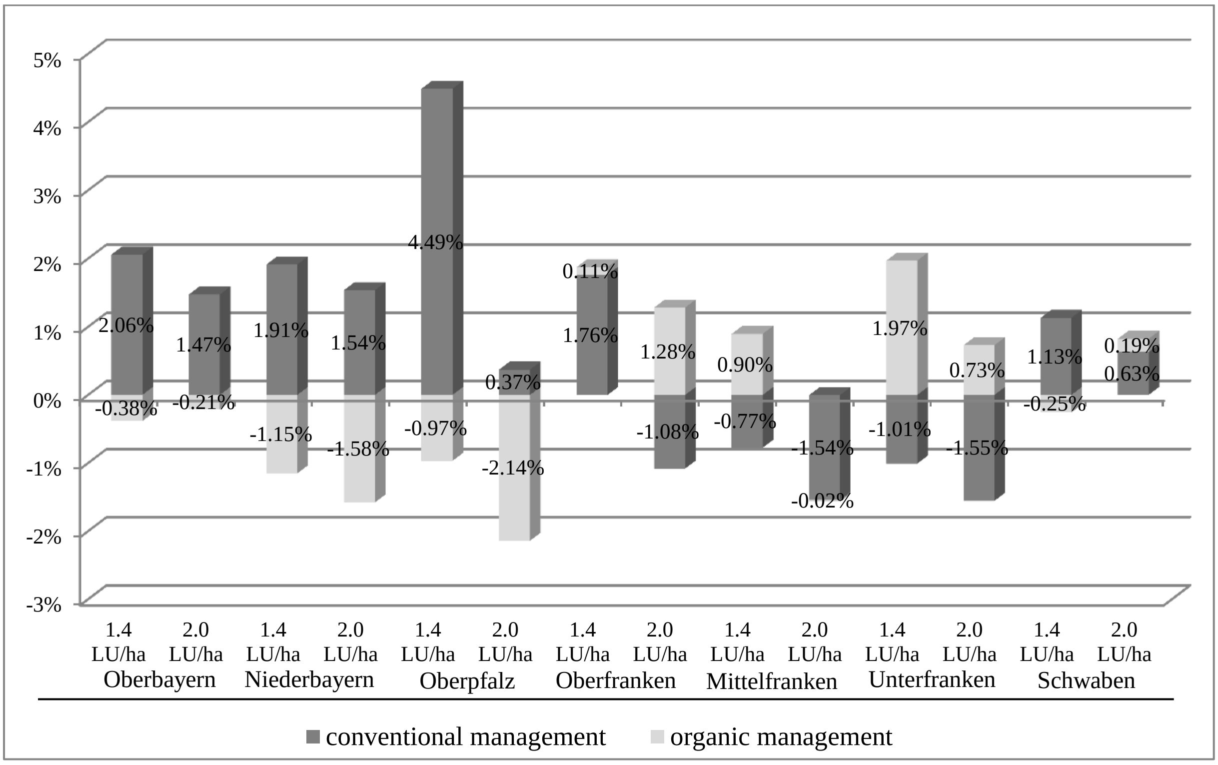

Figure 3: Difference of Grazing Intensity in Bavarian Regions (2003-2007) (in %)

Please note: Differences are split up between conventional and organic grassland usage. Grazing intensity is measured as portion of pasture used above 1.4 LU/ha and 2 LU/ha; Source: German agricultural survey.

Exploring the differences on the administrative regional level in Bavaria (see Figure 3) the picture is even more heterogeneous. In Oberbayern (around Munich), Niederbayern and Oberpfalz intensively used grazing area by conventional agriculture is enlarged, while intensively used grazing area by organic farming is lessened (for both intensity indicator). In contrast thereto, in Oberfranken organic farming intensified their pasture usage, while for the conventional management there seems to be a shift from 2.0 LU/ha grazing intensity towards 1.4 LU/ha. Unterfranken and Mittelfranken, the total diminishment of grazing pressure on pasture is driven by a large extent by conventional farming and shows a similar pattern to Thuringia (increase of organic intensive grazing, decrease of conventional intensive grazing), while in Schwaben a more general rise in intensively used grazing area is to be observed (conventional and organic pasture management). Considering neighbourhood effects on this level of aggregation, it becomes obvious that adjoining federal states display similar patterns of alterations. A Northwest-Southeast pattern is observable.

VARIABLES	SHDI	SHDI	Biodiversity	Biodiversity
Organic Grassland	**0.167****	**0.167****	-0.119	-0.123
	(0.0830)	(0.0832)	(0.0930)	(0.0951)
Grazing Intensity 1.4	**-0.221***		0.142	
	(0.134)		(0.122)	
Grazing Intensity 2.0		-0.210		0.0360
		(0.140)		(0.117)
Settlement Area	-0.152	-0.138	0.213	0.224
	(0.111)	(0.117)	(0.144)	(0.139)
EMZ	0.126	0.141	**0.364*****	**0.347*****
	(0.0989)	(0.0945)	(0.130)	(0.129)
Geography	-0.00196	0.0280	0.00185	-0.0610
	(0.117)	(0.112)	(0.132)	(0.119)
Bavaria Dummy	0.456	0.438	**-0.780***	**-0.637***
	(0.337)	(0.354)	(0.402)	(0.373)
Constant	-0.366	-0.351	0.617*	0.501
	(0.298)	(0.313)	(0.345)	(0.315)
rho	0.782***	0.783***	0.779***	0.767***
	(0.208)	(0.206)	(0.201)	(0.212)
sigma	0.880***	0.882***	0.749***	0.756***
	(0.0611)	(0.0591)	(0.105)	(0.106)
Observations	88	88	88	88
varRatio	0.157	0.155	0.390	0.383
Wald	14.08	14.40	14.97	13.11
Chi²	33.8	31.06	35.66	39.24
p	6.12e-09	2.50e-08	2.35e-09	3.75e-10
ll	-114.6	-114.7	-100.4	-101.1
sqCorr	0.221	0.220	0.433	0.423

Table 3: Spatial Lag Regression with SHDI & Biodiversity as Dependent Variable
Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Additional regressions are conducted to link biodiversity and the mode of land-use, in which the biodiversity indicators are implemented as dependent variables (see Table 3). Results show no significant or weak relationship between species abundance and the mode of agricultural land-use (neither organic/conventional nor intensity) which in turn is in accord with Hypotheses 2. However, the distribution of orchid species does seem to be connected positively with organic land-use. Thus, instead of enhancing biodiversity, organic farming might lead to evenness of species distribution.

As to the geographic control variables, biodiversity abundance is significantly positively related to soil quality (EMZ), while the other geographic control shows no effect. The Bavaria dummy is also significant for the biodiversity indicators, implying a significant systematic difference between Bavarian and Thuringian species abundance levels; fewer common taxonomic groups are found in Bavaria than in Thuringia. Besides the regional effects, spatial correlation is detectable for the occurrence and distribution of species.

4. Discussion

The Thuringian strategy, as stated by Roth & Schwabe (2003), was in the starting period of the AES-schemes to instrumentalize extensive land-use, copses, hedgerows, and other landscape elements. Regarding the measures taken up in 2006, this strategy still appears to lead them their way. For Bavaria, unfortunately no such strategy statement is found. However, regarding our results and the criteria of AES-P, subsidizing organic agricultural seems to be the AES instrument in practice. However, no inferences of causality can be made; it might be that AES-P is simply compensating farmers for using organic methods already in practice instead of providing incentives to begin such practices. In other words, these farmers might have applied organic or extensive methods irrespective of an AES subsidy and, thus, the subsidy may simply be positively influencing their cost effectiveness (see also Matzdorf/Lorenz 2010). The latter impression is strengthened by the heterogeneous picture observed in analysing the composition of intensively used pasture. No clear effect of organic agriculture and reduced agricultural intensity is observable. The alterations in land-use tend to be driven by other factors, not integrated into this analysis. AES schemes do not give the impression to incentivize changes towards environmentally-friendly farming practice as such.

Another line of criticism of AES is made by Kleijn & Sutherland (2003), who find, in their comparison of the effects of AES measures across Europe, that the schemes are mainly implemented in areas with historically high extensive agriculture and high biodiversity, but seldom in areas with low biodiversity occurrence or/and intensive farm practices. The results of this analysis are partly in accord, finding that regions with a high number of common species are supported by AES-G, rather than regions with low biodiversity that could be improved. While the allocation of AES-N in general can be at least explained by the distribution of species, the granting of AES-P seems not to be dependent either on species richness or on species distribution.

To date, field study results provide evidence that a positive effect of AES is dependent on the species and/or its characterization. Thus, the general picture being painted shows that different land-use practices lead to various outcomes, meaning that some species are favoured and some neglected, possibly even harmed. This, in turn, leads to the general conclusion that the subsidy framework of AES in its current form is not able to enhance biodiversity, but needs to be more focused and long-term orientated. However, becoming more focused will lead to inevitable and difficult questions as to which species should be preserved, how species can be (or whether they even should be) valued monetarily (see Weitzman 1998; Metrick/Weitzman 1998; Polasky/Solow/Broadus 1993), and whether landscape fragmentation measures are more effective in conserving/enhancing biodiversity than environmentally-friendly agriculture. In other words, the question still to be answered directs to whether AES schemes should be aimed towards encouraging hedges or field stripes rather than towards organic land-use in general. Thus, further research needs to discover if the positive relation continues to hold when rare species and landscape fragmentation are subjects of analysis.

One result, which is puzzling, is that subsidy schemes for nature conservation (AES-N) promote agricultural methods with high grazing intensity. As the thresholds, 1.4 LU/ha and 2.0LU/ha, yield significant results, it can either be interfered that the thresholds for extensive farming are still too low or that the variable grazing intensity captures further characteristics of the agriculture and not only the intensity of land-use. Hence, the solution to the first issue would be raising the threshold over 2.0 LU/hectare, and this positive relation should vanish. However, it is here claimed that a higher threshold does not capture extensive agriculture anymore, but rather shows a further weak point of AES schemes. This is that by introducing AES, thresholds were adapted to agricultural practice in place. Hence, instead of setting up standards to be fulfilled for environmentally-friendly farming and inducing therewith changes in agriculture, AES only compensates farmers for on-going-practices and reduction of general subsidies.

Considering the second issue, it cannot be entirely ruled out that ‘grazing intensity’ may measure further structural features of agriculture than the pure intensity of pasturing. This impression is strengthened by the fact that both grazing intensity measures are correlated on a 60 percentage level (positively) with the fraction of cutting area in the county. One interpretation is that in this area, the livestock here assumed to be mainly grazing outside (sheep, sucker cows, horses), are actually kept inside. However, this livestock still creates a kind of grazing pressure, instead on pasture meadows. As this interpretation cannot be ruled out entirely, it shall be kept in mind before proposing alterations of AES.

5. Conclusion

In conclusion, the results of this study show that AES has only a weak impact on promoting change in land-use. Predominantly AES-G is paid in biodiversity abundant regions while for the allocation of AES-P biodiversity is not considered at all. Furthermore, there is still no empirical evidence from county-level studies (as conducted here) or from field studies which kind of agricultural method positively affects biodiversity conservation and enhancement. Additionally, actually changing agricultural practices seem to be more difficult. In particular, hardly any change in agricultural usage can be observed between 2003 and 2007. There appears to be a certain “stickiness” to land-use mode that is hard to overcome, at least in the short term, a finding in agreement with Ohl et al. (2008), who show that payment schemes need to overcompensate land-users before they will be effective. This finding implies that increasing the level of AES subsidies may be effective in promoting organic land-use; however, whether doing so would be efficient is questionable. It does need to be kept in mind, however, that political intervention in and compensation to the agricultural sector have been on-going even before the Common Agricultural Policy (CAP) of the EU (since 1957) and thus it is impossible to know how the world would have been different without them, including AES.

Furthermore, it appears that intensive agriculture is prevalent in biodiversity rich regions, which are also rich in terms of soil quality. Taking together the low rate of change in agricultural practice and the prevalent biodiversity abundance, one could be justified in concluding that although AES-P and AES-G do promote organic agriculture, they have no observable effect on biodiversity conservation. However, in this study, biodiversity is measured in terms of common species; the effect of AES on rare species is still to be discovered.

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Appendix

Table 4: Factor Loadings of the Main Component Analysis for the Variable "Biodiversity"

	Biodiversity
Z-Value(Plants/ha)	0.988
Z-Value(Butterflies/ha)	0.982
Z-Value(Grasshoppers/ha)	0.985
Z-Value(Birds/ha)	0.985
Z-Value(Orchids/ha)	0.966

Explained variance: 96.299%.

Table 5: Factor Loadings of the Main Component Analysis for the Variable "Geography"

	Geography
AlpsDummy	-0.860
Z-Value (Altitude)	0.967
Z-Value (Temperature)	-0.866
Z-Value (Precipation)	0.962

Explained variance: 83.757%.

Please note: The observed variable ‚EMZ' did not score high within the factor analysis and thus is not included in the latent variable ‚geography'

Table 6: Overview of Variables

Abbreviation	Description / *Source*	Descriptive statistics
AES-G	Fraction of grassland (hectares) subsidized under the EU-Scheme of KULAP C in Thuringia and VNP/EA-FFH in Bavaria in 2006 *Bavarian Ministry for Environment;* *Thuringian Ministry for Administration*	Min: 0.0000 Max: 0.4965 Mean: 0.0955 Std.Dev. 0.1050 N: 88
AES-N	Subsidies paid under the EU-Scheme of KULAP C in Thuringia and VNP/EA-FFH in Bavaria in 2006 per hectare arable land in the county (in Euros/hectare) *Bavarian Ministry for Nutrition, Agriculture & Forestry;* *Thuringian Ministry for Administration*	Min: 0.0738 Max: 66.4813 Mean: 7.4365 Std.Dev. 10.4619 N: 88
AES-P	Subsidies paid under the EU-Scheme of KULAP AB in Thuringia and Bavaria in 2006 per hectare arable land in the county (in Euros/hectare) *Bavarian Ministry for Nutrition, Agriculture & Forestry;* *Thuringian Ministry for Administration*	Min: 11.2807 Max: 198.6867 Mean: 61.3996 Std.Dev. 39.5170 N: 88
Alps	Dummy with value of 1 for counties dominated by the Alps (10) and 0 for counties not dominated by the Alps (78)	

Altitude	Mean altitude of the county in 2009 (in meters) *Bavarian State Office for Environment;* *Thuringian State Office for Environment and Geology*	Min: 183.42 Max: 1122.60 Mean: 479.12 Std.Dev. 174.71 N: 88
Bavaria	Dummy variable with value of 1 for county in Bavaria and 0 for county in Thuringia	
Birds/ha	Number of grassland bird species out of a sample of 35 typical grassland bird species, i.e., birds breeding in grassland or nourishing crucially in grassland to be found in the county relative to the county's grassland *Bavaria: Bezzel et al (2005), Status 1996-1999;* *Thuringia: Nicolai (1993), Status 1978-1982*	Min: 0.0003 Max: 0.0147 Mean: 0.0032 Std.Dev. 0.0026 N: 88
Butterflies/ha	Number of butterfly species to be found in the county out of a sample of 98 common species relative to the county's grassland (if only Bavaria is considered: full sample of 143 species) *Bavaria: Voith/Bolz/Wolf (2007); Status up from 1971;* *Thuringia: Thust/Kuna/Rommel (2006), Status 1991-2002*	Min: 0.0011 Max: 0.0361 Mean: 0.0079 Std.Dev. 0.0060 N: 88
Cutting Area	Fraction of grassland used predominantly as cutting area (grass is cutted for forage production) *German agricultural survey 2007*	Min: 0.51074 Max: 0.98997 Mean: 0.90344 Std.Dev. 0.10 N: 88
Diff_Arable Land	Difference of arable land (in ha) in 2007 & 2003 *German agricultural survey 2003 and 2007*	Min: -4339.00 Max: 4188.00 Mean: -520.71 Std.Dev. 956.19 N: 88
Diff_Cutting Area	Difference between fraction used as cutting area in 2003 and 2007 *German agricultural survey 2003 and 2007*	Min: -0.07417 Max: 0.11564 Mean: 0.00120 Std.Dev. 0.02 N: 88
Diff_Ecological Grassland	Difference between fraction of grassland used ecologically in 2007 to fraction of grassland used ecologically in 2003 *German agricultural survey 2003 and 2007*	Min: -0.0378 Max: 0.2636 Mean: 0.0100 Std.Dev. 0.0326 N: 88
Diff_Grassland	Difference between fraction of arable land used as grassland in 2007 & 2003 *German agricultural survey 2003 and 2007*	Min: -0.0567 Max: 0.0338 Mean: -0.0021 Std.Dev. 0.0115 N: 88
Diff_Grazing Area	Difference between grassland fractions used as grazing area in 2007 and 2003 *German agricultural survey 2003 and 2007*	Min: -2858.93 Max: 1543.37 Mean: -70.67 Std.Dev. 452.78 N: 88
Diff_Grazing Intensity 1.4	Difference between fraction of grazing area used with a grazing intensity above 1.4 livestock units (sucker cows older than 2 years, horses, and sheep) per hectare grazing land per farm in 2007 to fraction of grazing area used in 2003 with grazing intensity above 1.4 LU/ha *German agricultural survey 2003 and 2007*	Min: -0.3404 Max: 0.4358 Mean: 0.0162 Std.Dev. 0.1098 N: 88

Diff_Grazing Intensity 2.0	Difference between fraction of grazing area used with a grazing intensity above 2 livestock units (sucker cows older than 2 years, horses, and sheep) per hectare grazing land per farm in 2007 to fraction of grazing area used in 2003 with grazing intensity above 2 LU/ha *German agricultural survey 2003 and 2007*	Min: -0.1404 Max: 0.2512 Mean: 0.0095 Std.Dev. 0.0851 N: 88
Diff_LU/ha	Difference between total livestock in the county per ha grassland in 2007 in livestock units/hectare and the same in 2003 *German agricultural survey 2003 and 2007*	Min: -0.1657 Max: 0.0229 Mean: -0.0533 Std.Dev. 0.0328 N: 88
Diff_Settlement	Fraction of settlement and traffic area of total county area on 31.12.2008 compared to the one on 31.12.2004 *Federal Statistical Office*	Min: 0.0006 Max: 0.0113 Mean: 0.0031 Std.Dev. 0.0016 N: 88
Ecological Grassland	Fraction of grassland used under ecological standards of the EWG regulation 2092/91 in 2007 *German agricultural survey 2007*	Min: 0.0015 Max: 0.2702 Mean: 0.0645 Std.Dev. 0.0480 N: 88
EMZ	Ertragsmesszahl—number given by tax authority in evaluating the potential quality (profit) of the soil in 2007 *Bavarian Treasury Ministry;* *Thuringian Ministry of Finance*	Min: 28.51 Max: 63.39 Mean: 42.96 Std.Dev. 8.36 N: 88
Grasshoppers/ha	Number of grasshopper species to be found in the county out of a sample of 51 common species relative to the county's grassland (if only Bavaria is considered: full sample of 75 species) *Bavaria: Schlumprecht/Waeber (2003), Status up from 1986;* *Thuringia: Köhler (2001), Status 1980–2000*	Min: 0.0005 Max: 0.0208 Mean: 0.0044 Std.Dev. 0.0036 N: 88
Grassland	Area used as grassland as percentage of arable land in 2007 *German agricultural survey 2007*	Min: 0.0353 Max: 0.9829 Mean: 0.3374 Std.Dev. 0.2371 N: 88
Grazing Area	Fraction of grassland used predominantly as meadow/pasture etc. *German agricultural survey 2007*	Min: 0.01003 Max: 0.48926 Mean: 0.09656 Std.Dev. 0.10 N: 88
Grazing Intensity 1.4	Fraction of grazing area used with a grazing intensity above 1.4 livestock units (sucker cows older than 2 years, horses, and sheep) per hectare grazing land per farm in 2007 *German agricultural survey 2007*	Min: 0.0139 Max: 0.6801 Mean: 0.3540 Std.Dev. 0.1869 N: 88
Grazing Intensity 2.0	Fraction of grazing area used with a grazing intensity above 2 livestock units (sucker cows older than 2 years, horses, and sheep) per hectare grazing land per farm in 2007 *German agricultural survey 2007*	Min: 0.0098 Max: 0.5910 Mean: 0.2619 Std.Dev. 0.1664 N: 88

LU/ha	Total livestock in the county registered as farm animal per hectare arable land in 2007 *German agricultural survey 2007*	Min: 0.2178 Max: 1.6483 Mean: 0.8355 Std.Dev. 0.3498 N: 88
Orchids/ha	Number of orchid species to be found in the county out of a sample of 34 common orchid species relative to the county's grassland *Bavaria: Schönfelder/Bresinsky/Ahlmer (1990), Status 1945-1986; Thuringia: Korsch/Westhus/Zündorf (2002), Status 1990-2001*	Min: 0.0003 Max: 0.0096 Mean: 0.0020 Std.Dev. 0.0016 N: 88
Plants/ha	Number of common grassland plants to be found in the county out of a sample of 162 typical grassland plant species relative to the county's grassland *Bavaria: Schönfelder/Bresinsky/Ahlmer (1990), Status 1945-1986; Thuringia: Korsch/Westhus/Zündorf (2002), Status 1990-2001*	Min: 0.0023 Max: 0.0683 Mean: 0.0171 Std.Dev. 0.0127 N: 88
Precipitation	Average of monthly mean of precipitation in millimeters for the years 1961–1990 for Bavaria and 1971–2000 for Thuringia *DWD (German Weather Service)*	Min: 519.69 Max: 1890.13 Mean: 894.99 Std.Dev. 280.61 N: 88
Settlement Area	Fraction of settlement and traffic area of total county area on 31.12.2008. *Federal Statistical Office*	Min: 0.0451 Max: 0.1865 Mean: 0.1019 Std.Dev. 0.0256 N: 88
SHDI	Shannon Diversity Index for orchids *Based on data provided by: Schönfelder/Bresinsky/Ahlmer (1990) for Bavaria (Status 1945-1983); Korsch/Westhus/Zündorf (2002) for Thuringia (Status 1990-2001)*	Min: 1.6582 Max: 2.9866 Mean: 2.4501 Std.Dev. 0.3390 N: 88
Temperature	Average of monthly mean of the daily temperature in degrees Celsius for the years 1961–1990 for Bavaria and 1971–2000 for Thuringia *DWD (German Weather Service)*	Min: 5.2323 Max: 8.8372 Mean: 7.5747 Std.Dev. 0.7157 N: 88

*Please note: Number of observations = 88.

Table 7: Allocation Guidelines of AES in Thuringia & Bavaria

Bavaria	**Thuringia**
KULAP A/B	
A 1.1: Ecological farming (max. 2.0 livestock units per hectare; if more than 50 percent of the farmland is grassland, than at least 0.5GV/HFF, i.e. at least 0.5 livestock units per hectare main forage area) A 2.1: Extensification of cropland with at least five different crops per year A 3.8: Winter greening (if more than 50 percent of the farmland is grassland, than at least 0.5GV/HFF, i.e. at least 0.5 livestock units per hectare main forage area; max. 2.0 livestock units per hectare does not apply)	A1: Ecological farming A4: Controlled integrated gardening A7: Controlled integrated crop production A8: Diversification of crops A9: Blossom areas within set-asides B1: Extensification of grassland (max. 1.4 RGV/ HFF, i.e. 1.4 roughage consuming livestock units per hectare main forage area) B2: Extensification of grassland (pasture) B3: Extensification of meadow conditional to cutting times B4: Conversion of cropland into grassland

VNP/EA-FFH	KULAP-C
Cropland: 1: Abandonment of mechanic-thermal weed clearance, undersown crops, fertilization, and chemical pesticides 2: Fallow land with self-greening (esp. beaver habitats) *Meadow:* 1: Restricted use by complying with cutting times 3: Fallow land (esp. beaver habitats) Further, the abandonment of fertilizer (may incl. liquid manure and mineral fertilization) and pesticides *Pasture:* 1: Extensive grazing with sheep/goats/horses 2: Extensive permanently grazing with cattle 3: Extensive upland grazing with cattle *For All:* Extended labour and mechanical efforts	C1: Extensification of side stripes in cropland C2: Set-asides for 10 years or 20 years C3: Pasturing of biotopes (according to standards of the FFH-guideline) C4: Cutting of biotopes conditional to times (according to standards of the FFH-guideline) C5: Preservation of traditional orchards C6: Maintenance of hedgerows and areas around water reservoirs C7: Abandonment of side stripes within cropland C8: Breeding of endangered species C9: Maintenance of ponds
Based on information sheet provided by StMELF	*Based on AgrarberichtThuringen 2007 (Report on the Agricultural Sector in Thuringia 2007)*

Figure 4: Map of SHDI for Orchids in Thuringia/Bavaria

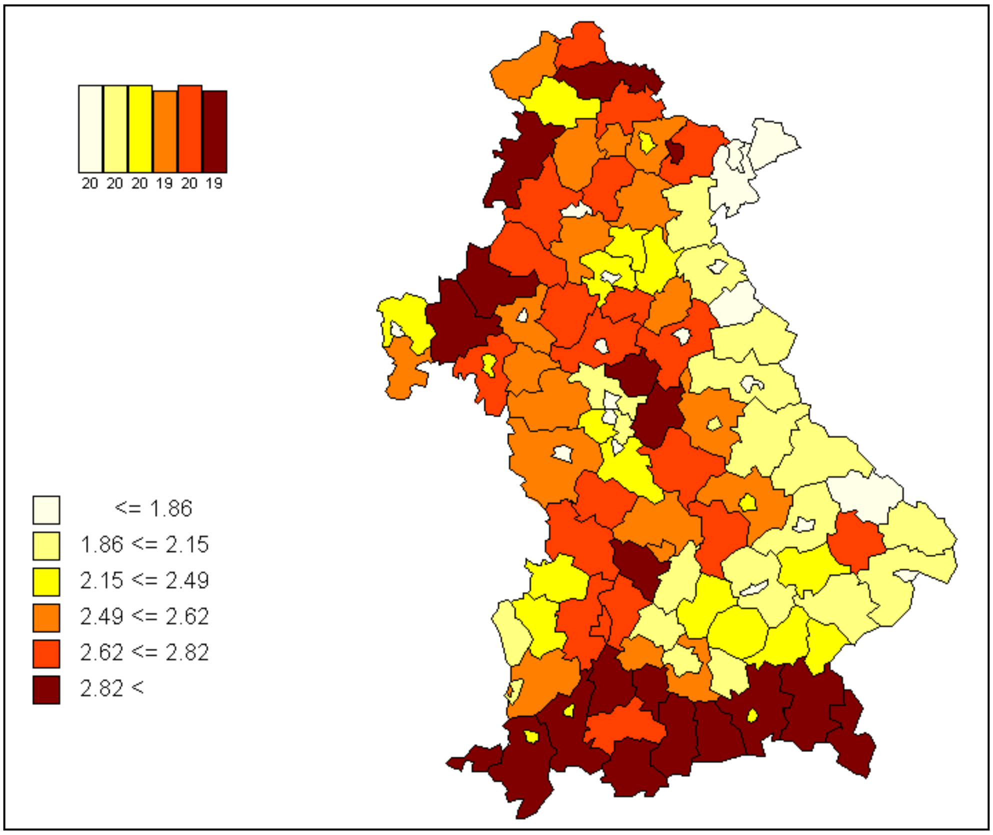


Figure 5: Map of Grassland Subsidized under KULAP-C & VNP/EA-FFH

Map for Thuringia & Bavaria (numbers are grassland subsidizied (ha) relative to total grassland in the county (AES-G))

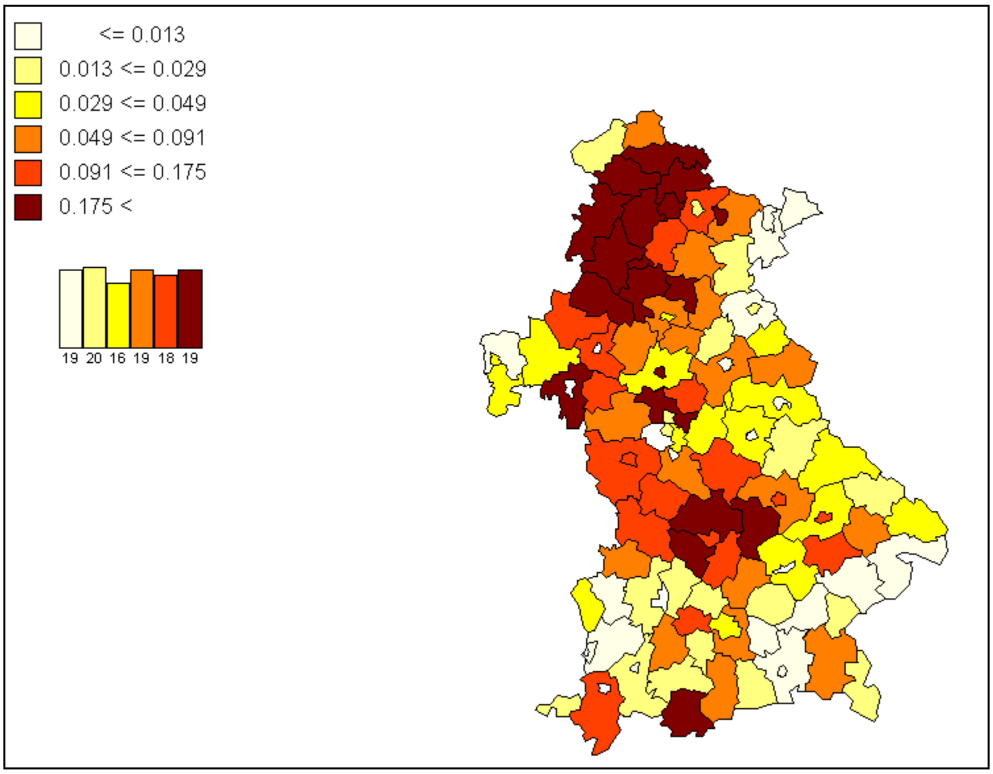


Figure 6: Map of Ecologically Used Grassland

(relative to total grassland in the county)

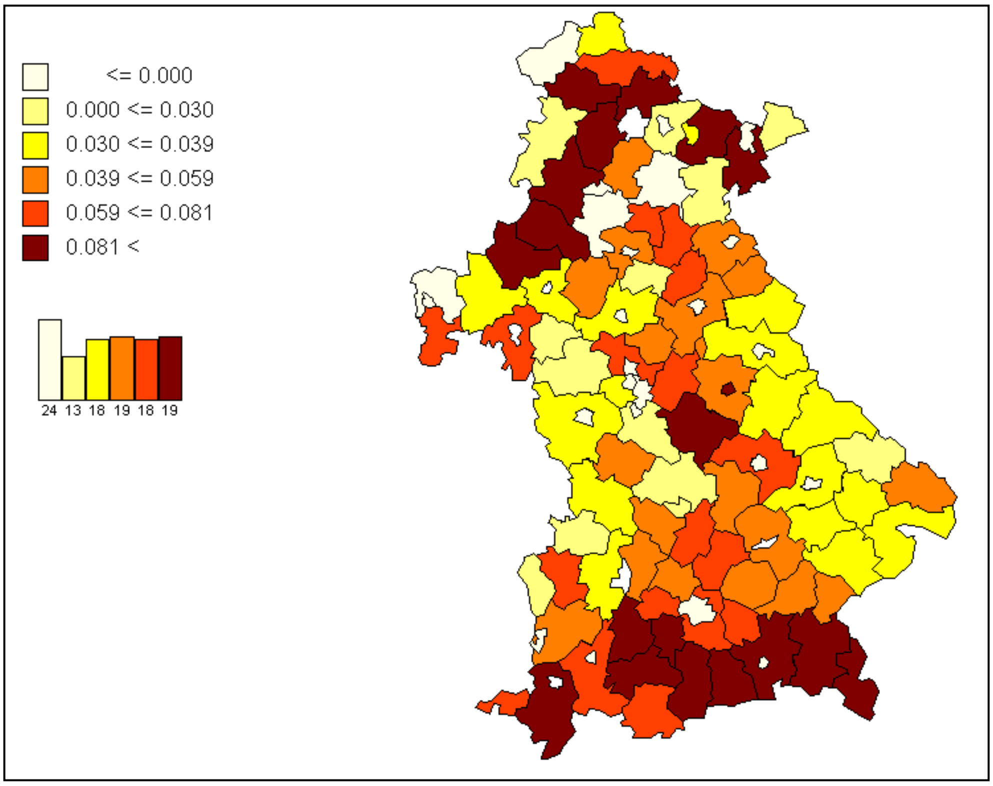


Figure 7: Map of Alterations of Ecological Used Grassland (2003-2007)

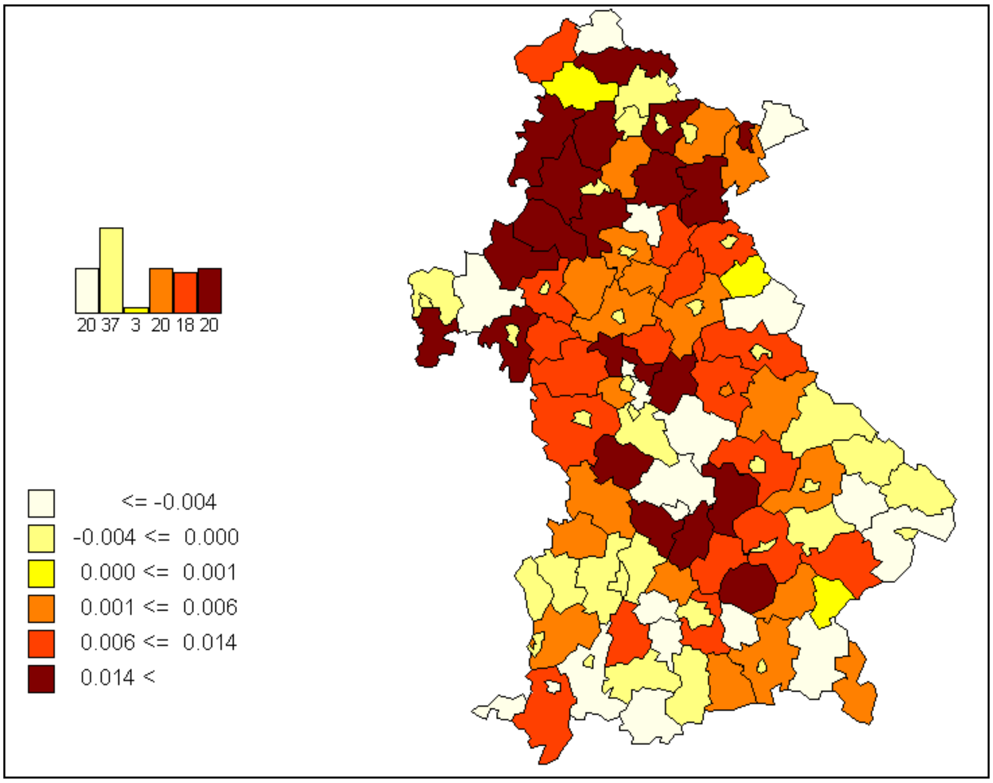


Table 8: Moran's I for Dependent Variables

Variables	I	E(I)	sd(I)	z	p-value*
SHDI	0.061	-0.011	0.013	5.680	0.000
Biodiversity	0.079	-0.011	0.012	7.340	0.000
AES-G	0.098	-0.011	0.013	8.719	0.000
AES-P	0.100	-0.011	0.013	8.843	0.000
AES-N	0.082	-0.011	0.012	7.942	0.000
Diff_ecological Grassland	0.036	-0.011	0.009	5.200	0.000
Diff_Grazing Intensity 1.4	-0.026	-0.011	0.013	-1.121	0.262
Diff_Grazing Intensity 2.0	-0.006	-0.011	0.013	0.457	0.648

*2-tail test

Table 9: Geary's C for Dependent Variables

Variables	c	E(c)	sd(c)	z	p-value*
SHDI	0.916	1.000	0.015	-5.600	0.000
Biodiversity	0.897	1.000	0.023	-4.477	0.000
AES-G	0.881	1.000	0.020	-6.000	0.000
AES-P	0.834	1.000	0.018	-9.012	0.000
AES-N	0.901	1.000	0.029	-3.379	0.001
Diff_ecological Grassland	0.940	1.000	0.047	-1.284	0.199
Diff_Grazing Intensity 1.4	1.044	1.000	0.020	2.237	0.025
Diff_Grazing Intensity 2.0	1.021	1.000	0.017	1.192	0.233

*2-tail test

Figure 8: Moran's Scatter Plot for AES-P

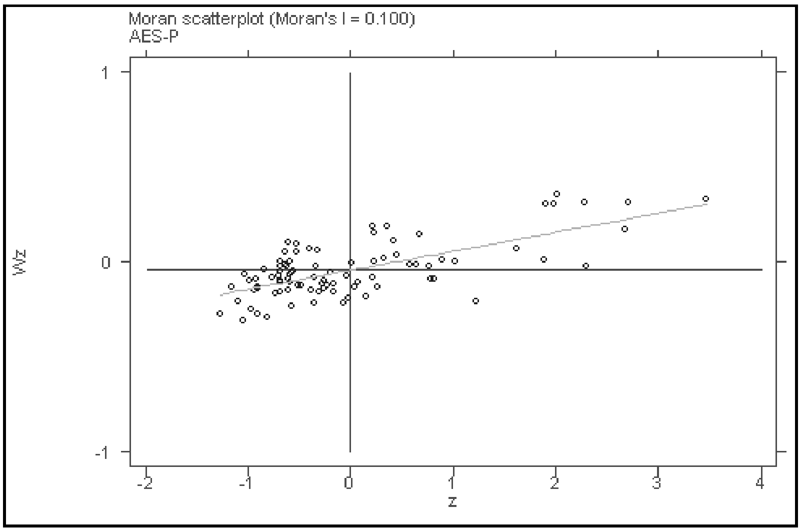


Figure 9: Moran's Scatter Plot for AES-N

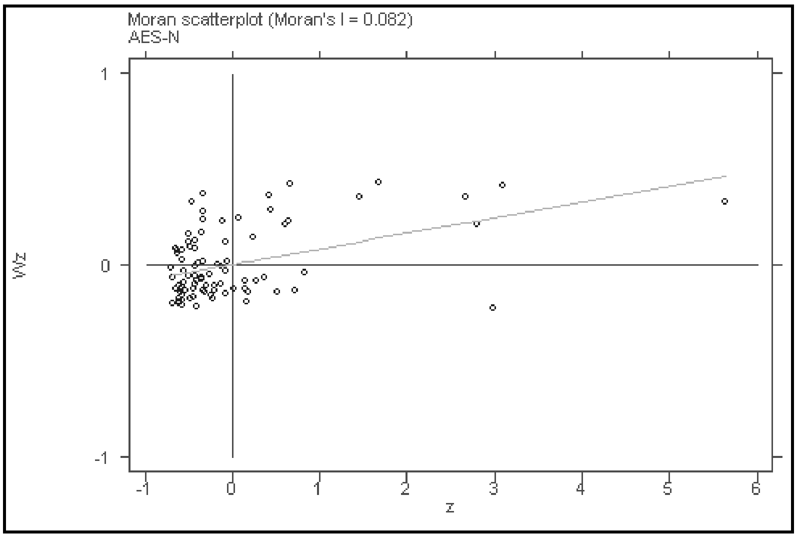
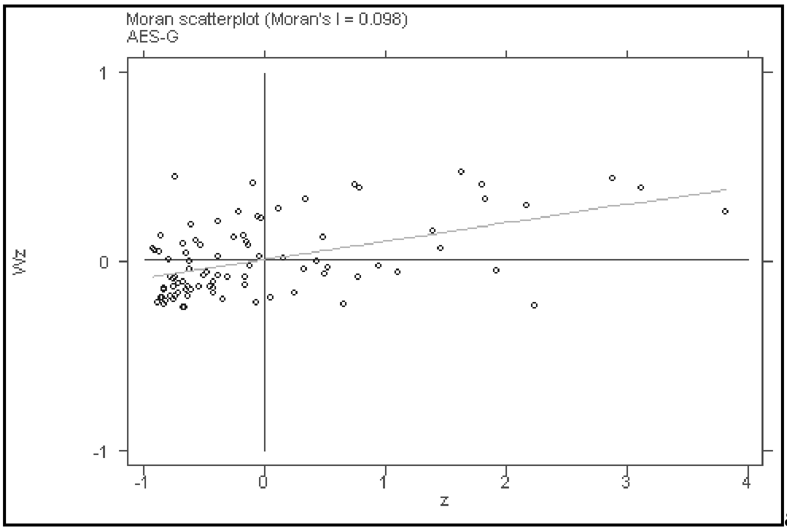


Figure 10: Moran's Scatter Plot for AES-G



a