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Abstract:

In this paper part of the existing Agri-Environmental Schemes (AES) of the European Union are evaluated by using data on county level instead of applying field studies. The attempt is made to disentangle the effects of AES on land management practice as well as land use on biodiversity. It is argued that subsidies as AES should promote environmental-friendly land use which, in turn, should lead to biodiversity conservation. First results show that AES promotes ecological land use rather than extensive agricultural practice. Furthermore, AES is predominantly allocated in biodiversity rich counties and not in counties with low biodiversity which should be enhanced. Furthermore, no clear evidence is so far found, that land use practice is improving the biodiversity status.

Keywords: AES effectiveness, biodiversity, policy evaluation

JEL: Q18, Q58, R14

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1. Introduction

In the last years criticism about European Agricultural Policy (CAP) has become more intense. Public discussion is mostly pointing to the fact that tax money in large sums is spent on a sector which only accounts for a small proportion of employment (2.6 of total labor force in 2001) and nearly no value adding in economic terms (0.9% of GDP in 2001) (El-Agraa 2004). In real terms, this means that € 55.0 bn are distributed among farms and agricultural related sectors as well as used for rural development in the European Union in 2008[1]. One argument for spending this high amount of money is that agriculture provides not only employment in particular in rural areas but also serves as caretaker for landscapes which in turn provides ecosystem services, environmental protection and food security to the public (see e.g. Sklenar 2007). An additional argument put forward is, that without political intervention there is a rising risk that agriculture may intensify even more leading to a further decrease of biodiversity. This causes not only potentially a valuable genetic loss (e.g. material for food crops or source for medicine) but biodiversity as such serves as insurance for ecosystem functioning, which in turn provides mankind with ecosystem services as nutrient cycling, water catchment regulation as well as aesthetic values or recreation (see Hanley/Shogren/White 2001). Furthermore, preserving diversity means to enable freedom of choice, as individuals may choose from a set of diverse alternatives (Perrings et al. 2007). Biodiversity is thereby defined as the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems" (UN 1993, p. 146). However, as this definition is not feasible for quantitative research, focus is set here on the abundance and evenness of grassland taxa.

Providing the rationale for political interventions, a question to be answered is, if the instruments chosen are effective or at least efficient according to public demand (see Baylis et al. 2008). Therefore, assessment is necessary, especially regarding the steadily increasing amount of subsidies provided by the EU for environmental issues. Agri-environmental schemes (AES) are set up to provide incentives to agriculture to implement environmentally friendly practices which in turn should enhance or at least protect biodiversity. Although, the EU demanded national evaluation of the programs and their impact on land use change, studies yield different results and are mainly conducted on the field level. Therefore, a general conclusion about the efficiency is hardly to obtain. In the paper at hand, subjects of analysis are the counties of the German federal states of Bavaria and Thuringia. Besides disentangling

[1] The CAP is the biggest expenditure stake followed by the fund for sustainable growth with €46.9 billion while for example the fund for health, consumer rights, youth, culture and media encompasses only €615 million (EC 2008)

the effects between policy instruments, agriculture and biodiversity, the analysis seeks to incorporate social-economic and geographical characteristics into the analysis. Focus is set hereby on grassland diversity and measures to enhance or influence the same.

The paper is structured as follows: After providing an overview of theoretical and empirical papers seeking to explore the relationship of biodiversity, political measures and agricultural practices (section 2); the empirical analysis conducted here is introduced (section 3). Afterwards, the implications of the first results are discussed and future research question are identified (section 4 and 5).

2. Theoretical / Empirical Background

a. Biodiversity and policy intervention

In standard economic terms, biodiversity is referred to as superior good, i.e. with increasing income a rising demand for biodiversity protection should be observable. Accepting biodiversity as socially desirable due to ecosystem services on the one hand, but having in mind the “Tragedy of the Commons” (Gordon 1954; Hardin 1968) on the other hand, political interference seems to be justified. Though, by seeking to reduce market failure, the risk of state failure is increased. Following the notions of Buchanan & Tullock (1962) and Olson (1965), policy makers are rarely benevolent, but rather utility 3aximize. Furthermore, the available information on how to intervene is in general not complete; bounded rationality is a major problem in policy making regarding environmental issues (Venkatachalam 2008). Besides these more general problems of state interventions, next to public and politicians, the interests of bureaucrats (see Niskanen 1971) and lobby groups (environmentalists as well as from the agricultural sector) are implemented in various degrees within the 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 rather in line with institutional goals. Only if the outcome of the indicator fits the goal of the institutions, funding was provided. On the side of the public sector, Hynes et al. (2008) find that special habitats (e.g., dry grassland) were favored in the distribution of subsidies, while other habitats (e.g., wet grassland) were nearly neglected by public subsidies. Furthermore, also regarding the Red List, which was implemented to conserve endangered species, evidence was found that it is misused as political instrument and driven by interests of lobby groups (Rawls/Laband 2004; Mahanty/Russel 2002). To summarize, although there is a legitimation for state intervention to set incentives to protect environmental goods, steady evaluation of the existing AES programs is necessary in order to reduce the likelihood of misallocation of public spending according to private interests instead of public ones.

b. Policy intervention (AES) and agricultural practice

So far, political reaction towards biodiversity loss is either ex-post (e.g., Red List) or ex-ante (e.g. AES). Regarding subsidies as AES, these are paid as incentive for farmers to apply environmental-friendly practice on their fields. Thus, in a second step, it should theoretically lead to a reduced biodiversity loss if not even to enhanced biodiversity abundance. However, Baylis et al. (2008) already point out that the European AES programs have a wide scope and seem to be used to reduce negative externalities of agriculture and to redistribute income instead of increasing species abundance or protect rare species and with this biodiversity in general. As the EU demanded national evaluation of the programs and their impact on land use change, a variety of field studies exists. Some authors (e.g. Kleijn et al. 2001; Feehan et al. 2005; Moonen/Bàrberi 2008) argue that due to a missing focus AES do not have any effects at all on the status of biodiversity. Others (e.g. Kleijn et al 2006; Kleijn/Sutherland 2003; Kohler et al. 2007; Merckx et al. 2009a; Roth et al. 2008; Rundlöf et al 2008), however, found that AES partly improved biodiversity. While some species seem to be favored by AES others were driven close to extinction. Thus, effects of AES seem to depend on species characterization. Regarding rare species, AES seems to have even a negative effect (Bisang et al. 2009; Konvicka et al. 2008). In contrast, regarding common species, AES seems to enhance their abundance (Mayer et al. 2008). Additionally to species' characteristics, features of the surrounding landscape may influence (Merckx et al. 2009b) or even constrain (Concepcion et al 2008; Rundlöf et al. 2008) the effectiveness of AES. However, these studies are mainly field studies which relate the observed biodiversity directly to AES. But, already Büchs et al. (2003) point to the limits of biodiversity as indicator for AES-effectiveness. Additionally, AES are used to change land use practice, thus the question about effectiveness of AES is dependent on the question whether it subsidizes existing practice and serves as income redistribution or whether it induces more biodiversity friendly land use practice. Therefore, it has to be separated between the effects of AES on agricultural practice and the impact of agricultural usage on the existing biodiversity. Referring to the first effect, for the analysis at hand, the following hypothesis is set up:

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

c. Agriculture and biodiversity

It is argued, that in the last century an intensification of agricultural production mode took place. At the same time a loss of biodiversity is recognized. As it seems obvious that both should be connected a wide range of scientific research seeks to find out what in particular connects land management practice and species' richness. While some field surveys find, e.g., a negative relationship between bird abundance and intensive agriculture (Herzon et al 2008), other were not able to find a significant effect between land use method and species richness (e.g. Clough et al. 2007; Kragten/de Snoo 2008), and rather argue that landscape elements (e.g. Burel/Baudry 2005, Sian Bates/Harris 2009), the fragmentation of the landscape (Dauber et al. 2003), the mobility of species (Merckx et al. 2009a) or the age of the grassland (Waesch/Becker 2009) is decisive for the abundance of species. Field management seems however to determine the grassland vegetation type and the species' composition (e.g. Andrieu et al. 2007; Boutin et al. 2008; Petersen et al. 2006; Taylor/Morecroft 2009). Thus, it seems that land use practice changes rather the composition of species by favoring one species over another. Or in other words: as some species seems to react positively on a land management measure (e.g. early mowing), another may be disturbed and thus react by reduced prevalence. On the one hand, due to fragmentation of the landscape such effects may be balanced out by providing diverse settlement areas for species. On the other hand, the seed bank of the grassland may also have a decisive influence on the observed species richness, especially in regards to the fact that change of species abundance seems to underlie long-term influence. So the observed practice of one season or short-term changes in land management practices, respectively, should not lead to long-term change of species abundance and thus to alterations in the observed biodiversity abundance. It may, however, have an impact on the population size of the species in the season as well on observed species composition. Therefore, the following hypothesis is set up:

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

d. Socio-economic influence

Agriculture is not only producing food but also serves as supplier and user of ecosystem services for the human species (Dale/Polasky 2007). Therefore, and due to the level of observation in this analysis, socio-economic influences should not be neglected. That human actions can modify the stability of the ecological fixed points is already modeled by Antoci et al. (2005) and Eichner & Pethig (2006). Additionally, in economics the effect of economy on biodiversity is mainly discussed within the framework of the Environmental Kuznets Curve (EKC), which proposes an inverse U- (or N)-shaped relation between economic growth and biodiversity loss (e.g. Harbaugh et al. 2002, Borghesi 2002, Mozumder et al. 2006). Although most studies found an impact of economic growth on biodiversity loss, the effect seems either taxa specific (Naidoo/Adamowicz 2001) or could be counteracted by ‘good’ institutions (e.g. Asafu-Adjaye 2003; Dietz/Adger 2003; Freytag et al. 2009). However, the quality of institutions is dependent on income (e.g. Rigobon/Rodrik 2005) and maybe even on public demand. The latter one in turn is also influenced by income as mentioned before, biodiversity is referred to as superior good. That means with increasing income a rising demand for biodiversity protection can be observed. Thus, while biodiversity and socio-economic variables may be negatively related due to e.g. effects of industrialization (sealing of soil or disconnecting landscapes, pollution), there may be a positive relation between biodiversity and demand for policy measures via income and ‘good’ institutions as well as income and demand for biodiversity protection. However, in the analysis at hand, only the negative direct effects of human influence on biodiversity status are concentrated on, although it is acknowledged that indirect positives effects may be observed.

e. Geographic influence

On the one hand, biodiversity in-situ depends also on topography, soil, landscape elements (e.g. Marini et al. 2007; Aviron et al. 2007). On the other hand, from a evolutionary point of view, land management practice found today is due to geographic features and biodiversity present in former times (e.g. 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 base. Furthermore, in short-term, a spatial clustering of ecological farming can be found (Parker/Munroe 2007) which has a positive effect on biodiversity enhancement (Rundlöf et al. 2008). Neighboring effects should therefore not be neglected. Thus, in order to control for such effects, geographic features needs to be included in the analysis.

To summarize, if AES is effective it should enhance the biodiversity status, especially in areas where low biodiversity can be found. Ideally, so AES should be target to alter land use method in order to incentivize biodiversity-friendly agricultural methods. Thus, in the analysis at hand, it should be explored closer in a first step what determines the level of AES and does it alter land use intensity. In a second step, land use practice is related towards biodiversity in order to see what kind of land use practice is connected with the level of biodiversity.

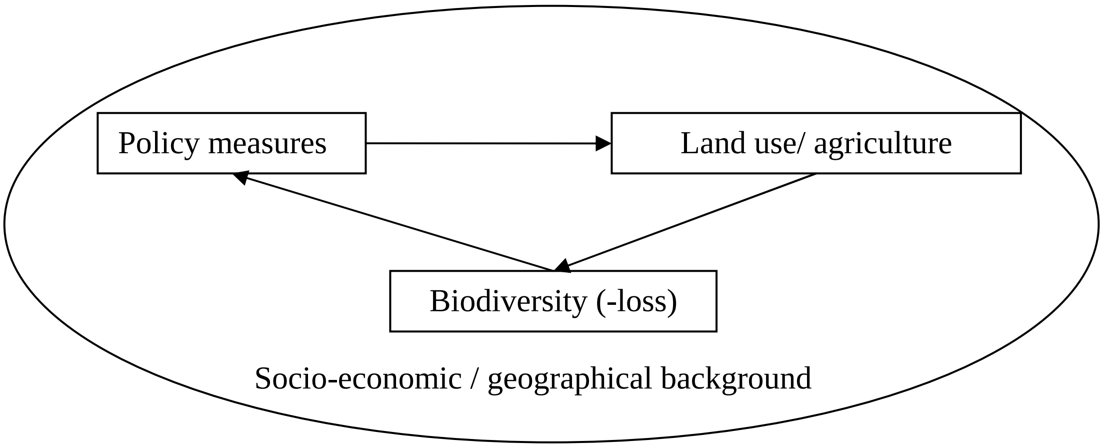

Figure 1: Systematic illustration of the analysis (own display).

3. Empirical Analysis

a. Data

To analyze the efficiency of AES several indicators on a county level for the German federal states of Bavaria and Thuringia are collected. Thereby, cities were explicitly excluded as agriculture is here seldom an important sector as well as city-biodiversity is not comparable with agri-biodiversity. Furthermore, the analysis is restricted towards grassland in order to restrict the analysis on feasible measures as data is available for different taxonomic groups as well as grassland serves well as model system in biodiversity research.

- **Biodiversity:**

In order to measure biodiversity a Shannon Diversity Index for the distribution of orchids in the counties of Bavaria and Thuringia is calculated as follows:

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

in which J denotes the number of species and P the relative density of species I in the county (i.e. P = n_i/N). Hereby, data for orchids are based on Korsch et al. (2002) for Thuringia and Schönfelder et al. (1990) for Bavaria. Although the Shannon Diversity Index performs well compared to other indices (Buckland et al 2005), it is only an evenness indicator. In order to test for robustness of the findings additional indicators are included: (1) number of typical grassland plant species relative to county’s grassland (based on Korsch et al. (2002) for Thuringia; Schönfelder et al. (1990) for Bavaria); (2) number of butterfly species relative to county’s grassland (based on Thust et al. (2006) for Thuringia, and Voith et al. (2007) for Bavaria); (3) number of grasshopper species relative to county’s grassland (based on Köhler 2001 for Thuringia and Schlumprecht/Waeber (2003) for Bavaria); and (4) relative number of typical grassland bird species weighted by the county’s grassland (based on Nicolai (1993) for

Thuringia and Bezzel et al. (2005) for Bavaria). These taxa are used as data about its distribution are comprehensive as well as they are common indicators in biodiversity research.

- **Policy:**

AES is here measured as the amount of agricultural area subsidized under the Landscape-Program KULAP C for Thuringia and the Contractual Nature Conservation Program (VNP) and Compensation Scheme for FFH-area (EA-FFH) for Bavaria in 2006. Although differences in the implementation of EU-Programs exist, both programs encompass similar measures and are as such comparable. KULAP C as well as VNP/EA-FFH promote extensive grassland usage and landscape fragmentation (by inducing e.g. field stripes or hedgerow) in areas especially highly valuable for nature conservation practice. Furthermore, they require higher nature conservation efforts than the Landscape-Program KULAP A-B, which subsidizes extensive agriculture in broader spectrum. So, although KULAP C and VNP/EA-FFH are only a small fraction of the EU-AES, it is the important one for nature conservation[2].

- **Agricultural land use:**

Agricultural intensity is here measured in relative terms as grassland ecological used as stated in the “Agrarstrukturerhebung 2007” of the Federal Statistical Office. However, the term ‘ecological agriculture’ implies that the farmer took the effort to comply to land management standards and with this registered officially under EU control (EWG regulation 2092/91). As the size of grassland managed according to this regulation is relatively small (mean 6 percent of county’s grassland), an additional measurement is applied which shall capture the size of intensively used grassland. Therefore, data from the “Agrarstrukturerhebung 2007” of the Federal Statistical Office are used to compute an intensity measure per farm. Therefore, the farm livestock typically grazing (mother cows (older than 2 years), number of sheep and number of horses, all measured in animal units) are set relatively towards the grazing area the farm is occupying. The grazing intensity measure in the following analysis applied encompasses the amount of hectares per county used with a grazing intensity (as computed before) above 1.4 livestock units per hectare. This threshold is taken from the EU subsidy programs for extensive agriculture[3].

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[2] In Bavaria in 2005 and 2006 VNP/EA-FFH was distributed by the Ministry for Nature Conservation, while KULAP A-B is allocated by the Ministry of Agriculture.

[3] In the EU-programs for extensive agriculture the threshold of 1.4 livestock units is applied differently by the German federal states. While some federal states use 1.4 livestock units per forage area in total irrespectively of the usage, others translate livestock units into roughage consuming livestock relatively to forage area by implementing individual translation keys. Here, the 1.4 is used as threshold although it relates grazing livestock on grazing area and not livestock in total on total forage area. In order to test for possible distortion therefore in the data the third indicator is applied.

A third indicator in order to test for robustness is the amount of livestock in the county relative to the county's grassland based as well on the data provided by the "Agrarstrukturerhebung 2007" of Federal Statistical Office.

To proxy the change in land use, the same variables are calculated from the "Agrarstrukturerhebung 2003" of Federal Statistical Office. As both surveys should be comparable, the alteration in land use is calculated as the difference of the indicators 2007 and 2003. Due to data availability issues it is decided to use these both surveys of 2003 and 2007. The one of 2005 is unfortunately not a full survey and so not representative on a county level, as the federal level is here focused on. However, the data of the AES program is dated to 2006. But, as the AES framework as such was set up for the years 2003-2006, the measurements subsidized are relatively constant over this time period which leads to the assumption that irrespectively of the amount of subsidized area the impact of the policy measures as such introduced in 2003 and continued until 2006 should be observable in the difference of land management practice between 2003 and 2007.

Additionally, the difference of arable land used in 2003 and 2007 is taken out from the "Agrarstrukturerhebung". These numbers are used in order to control for general change in agricultural land use.

- **Socio-economic control**

The settlement- and traffic area of 2004 according to the Federal Statistical Office is integrated as indicator for socio-economic influence into the analysis.

- **Geography control**

To control for geographical on-site impacts several variables are included: (1) the rate of return index for soil quality as used for tax purposes (EMZ) (obtained from the Bavarian Treasury Ministry and Thuringian Ministry of Finance); (2) the average altitude of the county according to the Bavarian State Office for Environment and the Thuringian State Office for Environment and Geology; (3) the mean monthly temperature (obtained by the German Weather Service); and (4) the mean monthly precipitation (obtained by the German Weather Service).

Clustering effects should be captured by a distance matrix, integrated in the analysis (see method section). Furthermore, it is included a dummy variable to account for specific features of the counties dominated by the Alps (1= no Alps, 0 = Alps-County) as well as a dummy variable which shall capture systematic differences between Bavaria and Thuringia

(1=Bavaria, 0 = Thuringia) in particular regarding the history of agricultural land use practice which are still prevalent nowadays.
An overview of the variables can be found in table 1 (see Appendix).

b. Method

Mapping the above mentioned data, spatial clustering already becomes obvious, for example, for the occurrence of biodiversity but also for land use practice (see Appendix: Figure 2 – Figure 7). The observed clustering may have different sources like geographical features (e.g. common landscapes, climate) or neighboring effects (spillover or contagion effects). 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 autocorrelation for most of the dependent variable spatial lag regression seems to be justified. In the analysis a spatial lag model with global autocorrelation is applied, captured by the following formula:

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

in which $\mathbb{W}$ 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). Hereby the weighting matrix is a distance matrix whereby weights are calculated as inverse of the distance between the centres of each county to the others here analyzed. Thus, the further away the counties of each other the less probably may be spillover or contagion effects and the less likely that these counties share similar landscapes. Variables which seem to be not affected strongly by distance weights and thus show only hints of local spatial autocorrelation are the changes in agricultural modes. So, for them spatial error regressions with robust standard errors are calculated in the form of:

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

In which the error term is separated into $\lambda\mathbb{W}\xi$ and ϵ, where $\lambda\mathbb{W}\xi$ captures the spatial dependence. Thus, in contrast to the spatial lag model, here no simultaneous integration of spatial dependency is taken account of but rather the coefficient is corrected for spatial correlation.

To test for multicollinearity, the variance inflation factor is calculated and regressions are dismissed with a factor above 6 (see Hill & Adkins 2001). Furthermore, robust standard errors are calculated in order to reduce the disturbance of the analysis by outliers.

In a first step of the analysis, AES should be explained statistically by land use practice. Furthermore, it is sought to relate changes in land use between 2003 and 2007 with the AES scheme of 2003-2006 (data of 2006 used). Additional control is the Bavaria-Dummy and socio-economic variables. In a second step, biodiversity is explained by land-use practice (agriculture), socio-economic control, geographic controls and the dummy for Bavaria to catch systematic differences between Thuringia and Bavaria. In case of SHDI as dependent variable, the amount of grassland in the county is used as special control. As, altitude with precipitation, temperature with the Bavarian dummy as well as the Alps-Dummy with altitude and temperature are highly correlated with each other, only the EMZ is left into the analysis reported here together with the Bavarian-Dummy and Alps-Dummy. Including the other geographic control variables into the regressions results do not change.

c. Results

Regarding AES under examination (see Table 2 and Table 3 in Appendix), results of the spatial lag regression hint to a rewarding of ecological land management under AES (positive coefficient), while grazing intensity as well as livestock per hectare as second measure for agricultural practice is not significantly connected with AES. In addition to the agricultural variables, also most of the biodiversity indicator (evenness and abundance) are positively correlated with AES measures. Considering that the indicator encompasses typical grassland taxa, further evidence is provided that AES for nature conservation favoring common species instead of rare species as our samples consisted dominantly of typical / common grassland species. Therefore, ecological agriculture is promoted rather than extensive agriculture. Thereby, the Thuringian subsidy practice does not significantly differ from the Bavarian one as in all regressions the Bavarian-Dummy showed no significant difference between Bavaria and Thuringia.

In order to explore whether AES induces changes in land management practice spatial error regressions with changes between the years 2003 and 2007 in agricultural practice as dependent variable and AES as independent are conducted. A significant positive relationship is found regarding the prospect of receiving AES in 2006 and changing land use practice between 2003 and 2007 (see Table 4 in Appendix). However, regarding the validity of the model, it should be rejected (see e.g. chi-square values). Thus, the change in land use cannot be explained by the variables so far implemented in the analysis. Furthermore, plotting these variables against each other, it becomes obvious, that there is a strong clustering of slight changes in land use and low payment of AES which drives the positive relationship between changes in land use and AES payment (see Figure 8 in Appendix). Additionally, these figures of changes in land use should be interpreted carefully, as regarding the data of the surveys of 2003 and 2007 of the ‘Agrarstrukturerhebung’, a general decrease of arable land is observable (average -404.19 ha; median -250.71 ha), hereby also the grassland usage changed with in average decline of about 101.74 ha (median -11.89 ha) for mowing and in average 52.29 ha (median -4.96 ha) for grazing. Due to these general reductions, the hectares used with high grazing intensity raised in these four years in average of about 1.1 hectare used with more than 1.4 livestock (GV) / ha (median -5.025 ha), while ecological used grassland in average stayed on the relative same level (average difference: 0.004 and median: 0.009 of ecological used grassland as proportion of total amount of grassland between 2003 and 2007). Thus, the results are very likely to be driven by external trends instead of caused by AES. This is bolstered up by the result, that the Bavarian dummy is not significant regarding grazing intensity and shows a systematic lower rate of change for Bavaria towards ecological farming, although the rate of change within four years is already low. So, no clear answer so far can be given regarding our hypothesis 1.

Further regressions are conducted to link biodiversity and the mode of land use. Hereby the diverse biodiversity indicators are implemented as dependent variable (see Table 5 and Table 6 in Appendix). First results show that regions with a high number of biodiversity either have a low rate of ecological used grassland (see e.g. plant sample or birds) or no significant relation towards ecological agriculture at all. In addition, regions with high biodiversity seem to inhabit highly intense agricultural modes measured in livestock per hectare and fraction of meadow used with grazing animal units above 1.4 per hectare. According to our hypothesis 2 it seems that so far no long-term effects of this land use are observable. Neither is an effect for ecological farming to be found. Thus, hypothesis 2 is supported.

Referring to the geographic control variables, biodiversity abundance is significantly positive related with the soil quality (EMZ), which can be expected. The landscape of Alps (see Alps-Dummy) is negatively related with the evenness of orchids, i.e. that the likelihood of finding orchids is higher in the Alps than in the other landscapes of Thuringia or Bavaria. Furthermore, the Bavaria dummy is as well significant for the other biodiversity indicators (plant/ha; butterfly/ha; grasshopper/ha; bird/ha) which indicates a significant systematic difference between Bavarian and Thuringian biodiversity level, whereby in Bavaria a lower abundance of taxa are found than in Thuringia’s landscapes. Taking additionally our model specification towards spatial autocorrelation (rho, sigma, lambda), one clear finding is that geographical features as well as neighborhood or distance and socio-economic background matters. The way the latter ones matters is thereby, however, a counterintuitive result (significant positive relationship between biodiversity abundance and settlement area) which shall be subject of future research.

4. Discussion

So far conducted empirical analysis unveils that the present AES schemes for nature conservation rewards ecological land use. However, no causality can be drawn so far by the existing dataset; in other words, it might be that AES is just compensating farmers for using ecological methods already in practice instead of incentivizing it. Thus, these farmers may have applied ecological methods irrespectively of the AES. The subsidy provided under this scheme may just influence positively the cost-effectiveness structure (see also Matzdorf/Lorenz 2009). Furthermore, in case AES promotes ecological land use, there is still a lack of empirical evidence in county level studies (here) as well as field studies that ecological agriculture positively affect biodiversity conservation and enhancement. An additional line of criticism towards AES is put forward by Kleijn & Sutherland (2003). They found in their comparisons of the effect of AES measures across Europe, that the schemes are taken up mainly in areas with historically high extensive agriculture and high biodiversity, but rather seldom in areas with low biodiversity occurrence or/and intensive farm practices. In the analysis at hand, it is also found that regions with a high number of common species are supported rather than regions with low rates of biodiversity which may improve. So far, regarding field study results evidence for a positive effect of AES is dependent on the species or/and on its characterization. Thus, the general picture would lead to the conclusion that different land use practices are leading to various outcomes in the meaning that some species will be favored and some will be neglected if not even disadvantaged. This would lead to the general conclusion that a subsidy framework as AES in general is not able to enhance biodiversity as such, but rather needs to be focused. However, to set focus leads unavoidable to the questions which species to preserve and what is a species valid in monetary terms (see Weitzman 1998; Metrick/Weitzman 1998) or if landscape fragmentation measure are more effective in conserving/enhancing biodiversity than environmental-friendly agriculture. Thus, AES schemes should rather incentives hedges or field stripes than ecological land use in general. This latter argument may also explain why we find a positive connection of biodiversity abundance, agricultural practice and AES. Our AES indicator consists predominantly of measures incentivizing the creation of landscape elements. Thus, further research needs to focus if this positive relation still holds if rare species or AES with broader spectrum (in particular KULAP B) are subject of analysis.

To conclude, so far, first results show a positive impact of AES on promoting ecological land use (however not on extensive land use). Regarding the induced change of agricultural practice, it seems difficult to lead to alteration. In particular, if one examines the rate of changes in agricultural usage between 2003 and 2007, nearly no difference is observable within these four years. A ‘stickiness ‘ of land use mode seems to be prevalent, which is also already pointed out by Ohl et al. (2008), who model cases where the payment scheme requires overcompensation of the land users to be effective. This in turn means that increasing the level of AES may be effective in promoting ecological land use, but may not be efficient or socially justified. However, as political interventions and compensation in the agricultural sector is common for years now, an open question remains what may have happened without AES.

Furthermore, it seems that intensive agriculture is prevalent in biodiversity rich regions which also yield high in terms of soil quality. Taking together the low rate of change in agricultural practice and the prevalent biodiversity abundance, it seems that although AES promotes ecological agriculture, no observable effect in biodiversity conservation is measurable in terms of biodiversity enhancement. Additionally, biodiversity is here measured in terms of common species. The effect of AES on rare species shall be subject to further research.

5. Literature

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Appendix

Table 1: Overview of variables

Abbreviation	Description	Descriptive statistic
AES	Fraction of grassland subsidized under the EU – Scheme of KULAP C in Thuringia and VNP/EA-FFH in Bavaria in 2006 in hectare (see Figure 4) *Source: Bavarian Ministry for Environment; Thuringian Ministry for Administration*	Min: 0 Max: 0.4965087 Mean: 0.0954739 Std. Dev.: 0.1049986
Alps-Dummy	Dummy with 1 for counties not dominated by the Alps (78) and 0 for counties dominated by the Alps (10)	
Altitude	Mean altitude of the county in 2009 *Source: Bavarian State Office for Environment and the Thuringian State Office for Environment and Geology*	Min: 183.421 Max: 1122.596 Mean: 479.1243 Std. Dev.: 174.7127
Bavaria-Dummy	Dummy variable with 1 for county in Bavaria and 0 for county in Thuringia	
Bird / ha	Number of common grassland bird species to be found in the county of a sample of 35 typical grassland bird species, i.e. birds breeding in grassland or nourish crucially in grassland per county relative to the county's grassland *Source: Bavaria: Bezzel et al (2005), Status 1996-1999; Thuringia: Nicolai (1993), Status 1978-1982*	Min: 0.0003238 Max: 0.0146862 Mean: 0.0032178 Std. Dev.: 0.0026382
Butterfly / ha	Number of common butterfly species to be found in the county of a sample of 113 (Thuringia) / 143 (Bavaria) relative to the county's grassland *Source: Bavaria: Voith/Bolz/Wolf (2007); Status up from 1971; Thuringia: Thust et al. (2006), Status 1991-2002*	Min: 0.0009469 Max: 0.0305994 Mean: 0.0070573 Std. Dev.: 0.0054039
Difference ecological farming	Difference between percent of grassland used ecological in 2007 to percent of grassland used ecological in 2003 (see Figure 6) *Source: Agrarstrukturerhebung 2003 and 2007*	Min: -0.0378244 Max: 0.2635651 Mean: 0.0097231 Std. Dev.: 0.0324056
Difference grazing intensity	Difference between grassland area used with an grazing intensity above 1.4 of livestock (mother cows older than 2 years, horses and sheep) per hectare grazing land per farm in 2007 to grassland fraction used in 2003 with grazing intensity above 1.4 *Source: Agrarstrukturerhebung 2003 and 2007*	Min: -0.3403888 Max: 0.4358477 Mean: 0.0162364 Std. Dev.: 0.1098049
Difference GV/ha	Difference between total livestock in the county per ha grassland in 2007 in livestock units / hectare and the same in 2003 *Source: Agrarstrukturerhebung 2007*	Min: -1.958156 Max: 0.2463398 Mean: -0.2798045 Std. Dev.: 0.2993919
Ecological grassland	Fraction of grassland used under ecological standards of the EWG regulation 2092/91in 2007 (see Figure 5) *Source: Agrarstrukturerhebung 2007*	Min: 0.0014686 Max: 0.2701515 Mean: 0.0644847 Std. Dev.: 0.0480358
EMZ	Ertragsmesszahl – number given by tax authority in order to evaluate the potential quality (profit) of the soil in 2007 *Source: Bavarian Treasury Ministry and Thuringian Ministry of Finance*	Min: 28.51 Max: 63.39 Mean: 42.96352 Std. Dev.: 8.358405

Grasshopper / ha	Number of common grasshopper species to be found in the county of a sample of 52 (Thuringia) / 75 (Bavaria) relative to the county's grassland *Source: Bavaria: Schlumprecht/Waeber (2003), Status up from 1986; Thuringia: Köhler (2001), Status 1980-2000*	Min: 0.0007699 Max: 0.035531 Mean: 0.0068792 Std. Dev.: 0.0057529
Grassland	Area used as grassland in percentage of arable land in 2007 *Source: Agrarstrukturerhebung 2007*	Min: 0.0353329 Max: 0.9829401 Mean: 0.3373512 Std. Dev.: 0.2371396
Grazing intensity	Relative meadow area used with an grazing intensity above 1.4 of livestock (mother cows older than 2 years, horses and sheep) per hectare grazing land per farm in 2007 in hectare *Source: Agrarstrukturerhebung 2007*	Min: 0.013897 Max: 0.6801471 Mean: 0.3540001 Std. Dev.: 0.1868906
GV / ha	Total livestock in the county per ha grassland in 2007 in livestock units/ha *Source: Agrarstrukturerhebung 2007*	Min: 1.114386 Max: 10.21687 Mean: 3.283913 Std. Dev.: 1.902524
Plant / ha	Number of common grassland plants to be found in the county of a sample of 162 typical grassland plant species relative to the county's grassland (see Figure 3) *Source: Bavaria: Schönfelder et al. (1990), Status 1945-1986; Thuringia: Korsch et al. (2002), Status 1990-2001*	Min: 0.0023127 Max: 0.0682804 Mean: 0.0171315 Std. Dev.: 0.0126553
Precipitation	Average of monthly mean of precipitation in millimeter for the years 1961-1990 for Bavaria and 1971-2000 for Thuringia *Source: DWD*	Min: 519.6856 Max: 1890.13 Mean: 894.9913 Std. Dev.: 280.609
Settlement area	Fraction of settlement and traffic area of total county area on 31.12.2004 (see Figure 7) *Source: Federal Statistical Office*	Min: 4.4 Max: 18.2 Mean: 9.883887 Std. Dev.: 2.474867
SHDI	Shannon diversity index for orchids (Status 1945-1983 in Bavaria; 1990-2001 in Thuringia) (see figure 1) *Based on data provided by: Schönfelder et al. (1990) for Bavaria (Status 1945-1983); Korsch et al. (2002) for Thuringia (Status 1990-2001)*	Min: 1.658228 Max: 2.986591 Mean: 2.450119 Std. Dev.: 0.338997
Temperature	Average of monthly mean of the daily temperature in degree Celsius for the years 1961-1990 for Bavaria and 1971-2000 for Thuringia *Source: DWD*	Min: 6.777442 Max: 86.4082 Mean: 61.98211 Std. Dev.: 27.38653

*Please note: Number of observations are always 88.

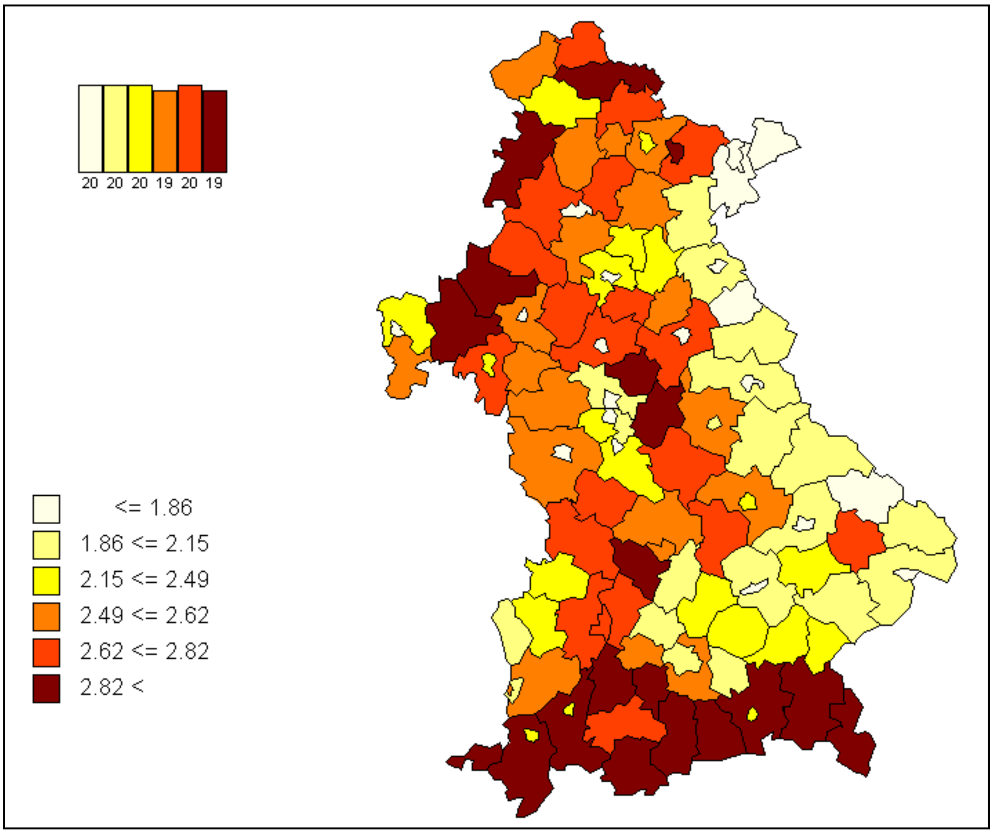

Figure 2: SHDI for Orchids on a county level in Thuringia and Bavaria

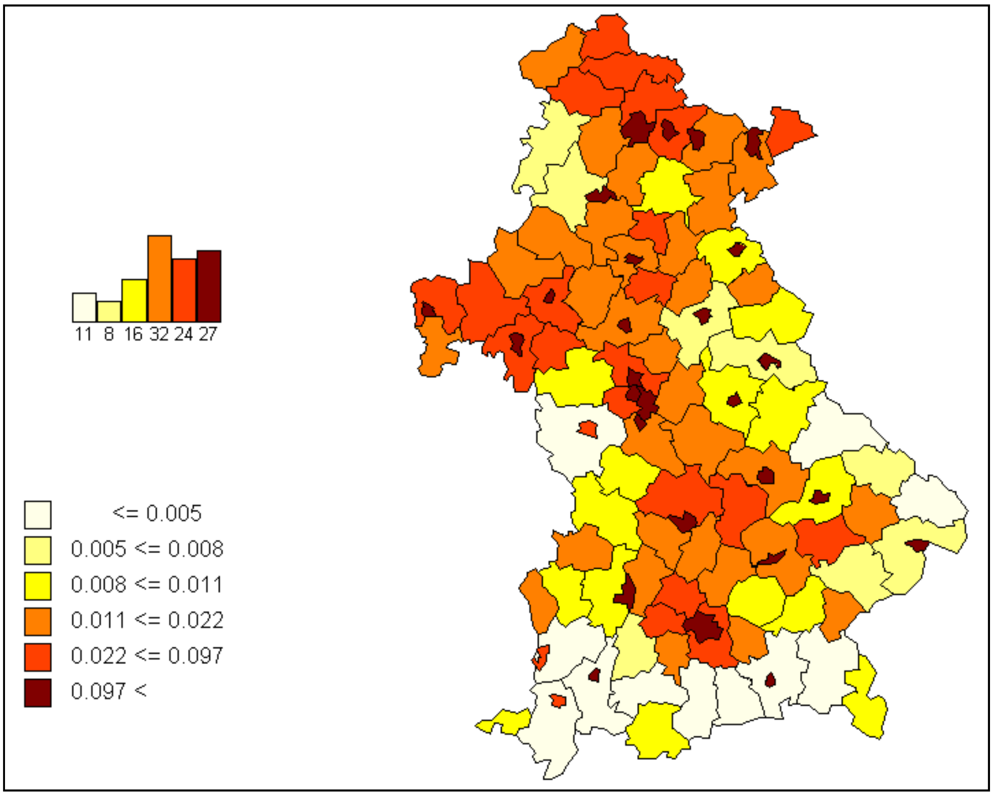

Figure 3: Distribution of typical grassland plant species per hectare grassland on a county level for Bavaria and Thuringia

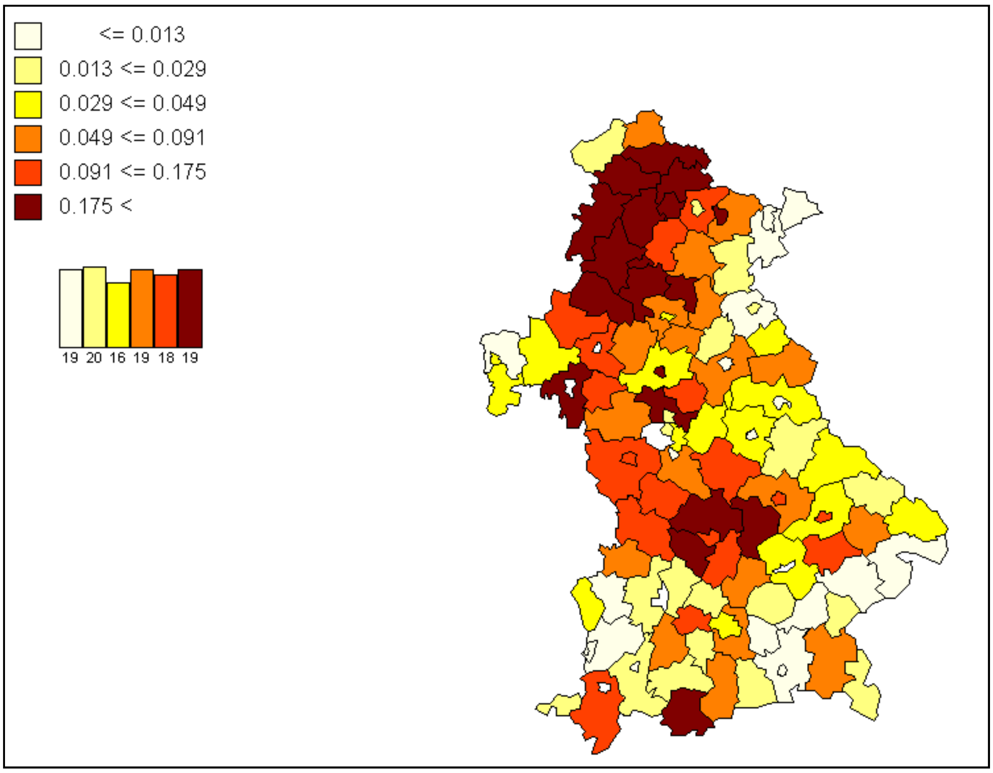

Figure 4: Distribution of subsidized grassland under KULAP C or VNP/EA-FFH relative to total grassland in the respective county

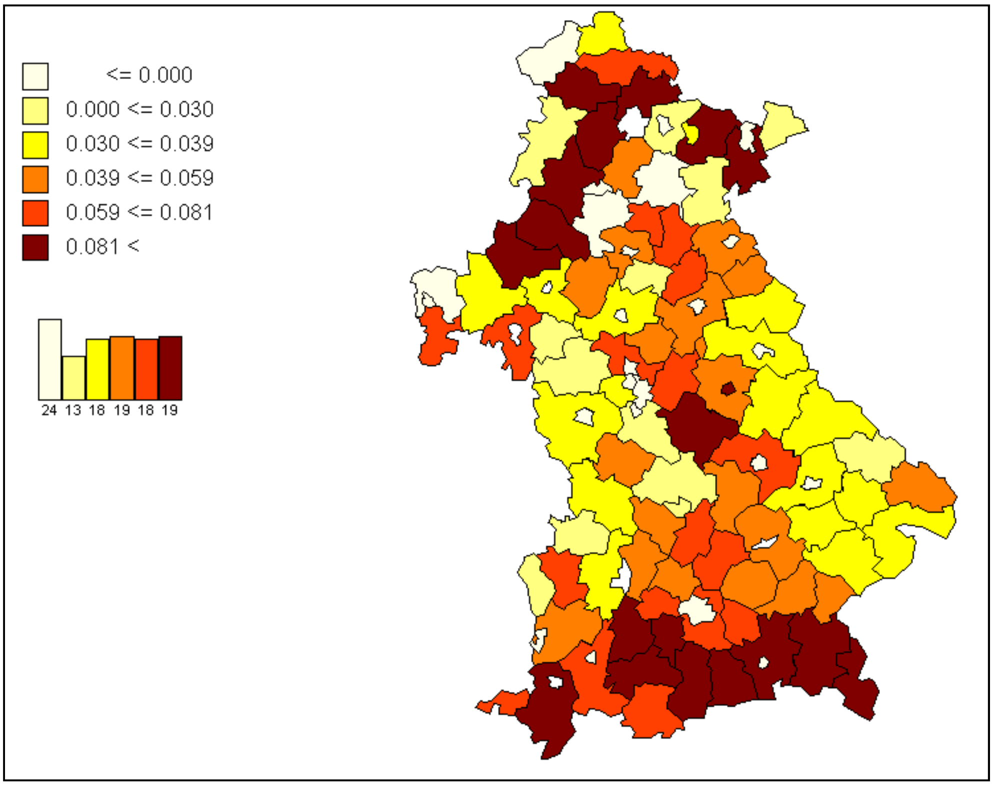

Figure 5: Distribution of ecological used grassland as proportion of total grassland on a county level

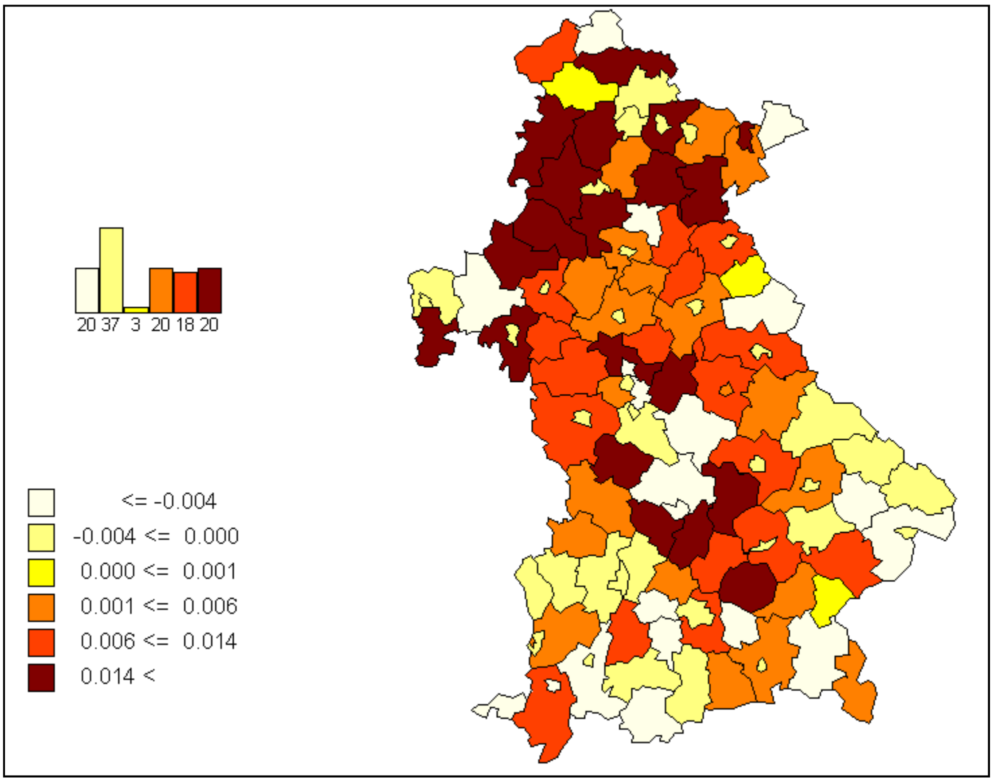

Figure 6: Difference of ecological grassland in 2007 towards 2003

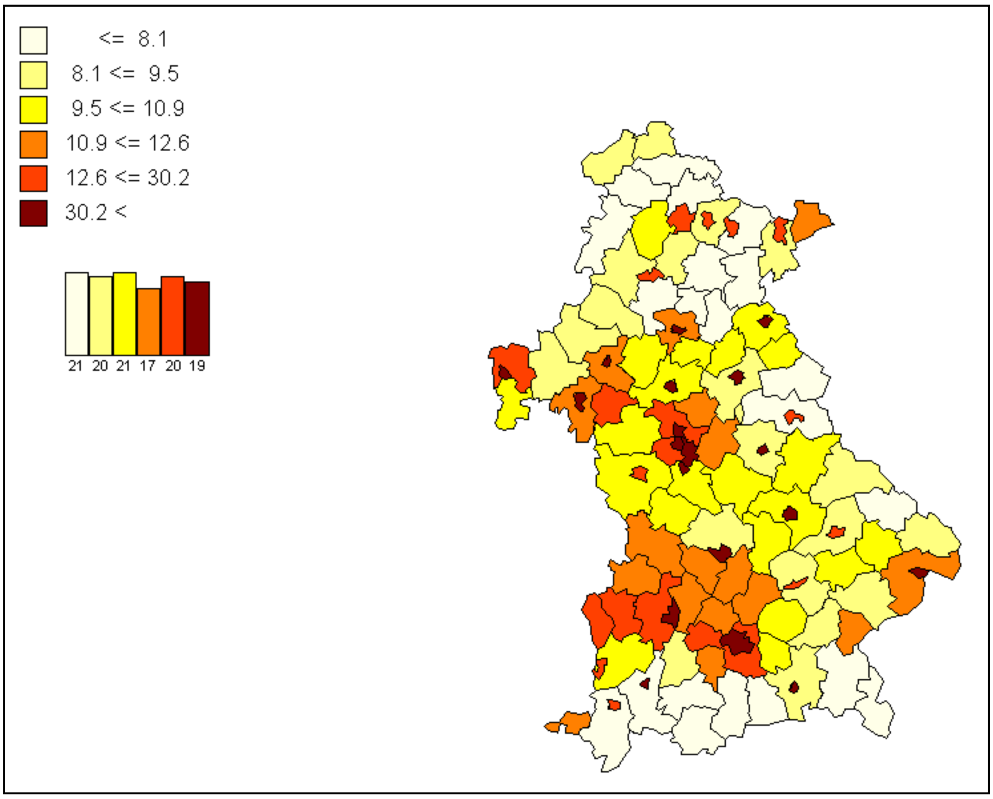

Figure 7: Distribution of settlement and traffic area as proportion of county size

	AES	AES	AES	AES	AES	AES	AES	AES	AES	AES
SHDI	**0.0942*** **					**0.107*** **				
	(0.0250)					(0.0246)				
Plant / ha		**2.465*** **					**1.973** **			
		(0.752)					(0.970)			
Butterfly / ha			**6.589*** **					**5.876** **		
			(1.885)					(2.320)		
Grasshopper / ha				**5.202*** **					**4.135***	
				(1.900)					(2.395)	
Bird / ha					**11.29*** **					**8.738***
					(3.946)					(5.135)
Ecological grassland	**0.503***	**0.676** **	**0.656** **	**0.675** **	**0.679** **					
	(0.301)	(0.290)	(0.285)	(0.289)	(0.292)					
Grazing intensity						0.0891	0.0522	0.0565	0.0578	0.0614
						(0.0984)	(0.108)	(0.104)	(0.107)	(0.108)
Grassland	-1.47e-06					-1.20e-06				
	(1.05e-06)					(1.02e-06)				
Settlement area	-0.00558	**-0.01000** **	**-0.00921** **	**-0.00796***	**-0.00933** **	-0.00570	-0.00893*	-0.00882**	-0.00732	-0.00832*
	(0.00426)	(0.00454)	(0.00432)	(0.00424)	(0.00445)	(0.00418)	(0.00478)	(0.00443)	(0.00448)	(0.00478)
Alps-Dummy	0.0550	0.0440	0.0450	0.0431	0.0451	0.00732	-0.00891	-0.00915	-0.0115	-0.0113
	(0.0459)	(0.0342)	(0.0326)	(0.0343)	(0.0342)	(0.0551)	(0.0540)	(0.0521)	(0.0538)	(0.0540)
Bavaria-Dummy	-0.0340	-0.0116	-0.00333	-0.00391	-0.00607	-0.0761	-0.0558	-0.0464	-0.0512	-0.0545
	(0.0335)	(0.0356)	(0.0368)	(0.0372)	(0.0371)	(0.0500)	(0.0558)	(0.0553)	(0.0570)	(0.0575)
Constant	-0.169	0.00987	-0.00527	-0.00917	0.00418	-0.126	0.115*	0.0999	0.101	0.112*
	(0.112)	(0.0702)	(0.0694)	(0.0705)	(0.0715)	(0.102)	(0.0640)	(0.0635)	(0.0652)	(0.0648)
rho	0.574	0.714***	0.680**	0.713***	0.706***	0.566	0.720***	0.691**	0.720***	0.717***
	(0.354)	(0.258)	(0.286)	(0.260)	(0.266)	(0.355)	(0.253)	(0.277)	(0.254)	(0.257)
sigma	0.0838***	0.0859***	0.0843***	0.0861***	0.0863***	0.0860***	0.0904***	0.0887***	0.0905***	0.0908***
	(0.00940)	(0.0103)	(0.00990)	(0.0104)	(0.0103)	(0.0109)	(0.0118)	(0.0116)	(0.0118)	(0.0117)
Observations	88	88	88	88	88	88	88	88	88	88
Wald	2.631	7.676	5.646	7.505	7.054	2.551	8.111	6.243	8.038	7.769
p	1.96e-08	1.00e-07	8.49e-08	2.88e-06	1.49e-06	5.84e-08	3.76e-05	7.34e-05	0.000307	0.000151
chi2	31.53	28.37	28.69	21.90	23.16	29.42	16.99	15.72	13.03	14.35
ll	92.87	90.43	92.11	90.23	89.98	90.70	85.90	87.69	85.78	85.54

Table 2: Spatial Lag Regression with AES as dependent variable and present agricultural practice as independent variable (to be continued)

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

VARIABLES	**AES**	**AES**	**AES**	**AES**	**AES**
SHDI	**0.107*** **				
	(0.0250)				
Plant / ha		**2.564** **			
		(1.083)			
Butterfly / ha			**7.210*** **		
			(2.607)		
Grasshopper / ha				**5.133** **	
				(2.581)	
Bird / ha					**11.35***
					(5.819)
GV / ha	0.00329	-0.00550	-0.00645	-0.00436	-0.00489
	(0.00502)	(0.00549)	(0.00584)	(0.00538)	(0.00584)
Grassland	-1.25e-06				
	(1.07e-06)				
Settlement area	-0.00537	**-0.00960***	**-0.00900***	-0.00735	**-0.00876***
	(0.00424)	(0.00510)	(0.00460)	(0.00461)	(0.00512)
Alps-Dummy	0.0318	0.0177	0.0215	0.0152	0.0178
	(0.0406)	(0.0294)	(0.0285)	(0.0298)	(0.0299)
Bavaria-Dummy	-0.0560	-0.0352	-0.0238	-0.0294	-0.0309
	(0.0378)	(0.0451)	(0.0455)	(0.0469)	(0.0479)
Constant	-0.145	0.111*	0.0932	0.0905	0.105*
	(0.104)	(0.0590)	(0.0579)	(0.0585)	(0.0593)
rho	0.568	0.686**	0.638**	0.691**	0.681**
	(0.356)	(0.283)	(0.321)	(0.281)	(0.289)
sigma	0.0864***	0.0903***	0.0885***	0.0906***	0.0909***
	(0.0106)	(0.0111)	(0.0107)	(0.0111)	(0.0110)
Observations	88	88	88	88	88
Wald	2.547	5.870	3.950	6.068	5.564
p	1.16e-07	2.32e-05	4.29e-05	0.000327	0.000189
chi2	28.08	17.91	16.74	12.91	13.94
ll	90.26	86.07	88.00	85.78	85.56

Table 3: Spatial Lag Regression with AES as dependent variable and present agricultural practice as independent variable (continued)

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 4: Ordineary-Least-Square-Estimation with change in agricultural practice as dependent variable and AES as independent variable

VARIABLES	Difference grazing intensity	Difference ecological farming	Difference GV / ha
AES	-0.0894	0.109***	-0.197
	(0.0986)	(0.0357)	(0.273)
Difference in grassland	-2.27e-05	5.27e-06	
	(1.86e-05)	(4.26e-06)	
Difference in arable land			-3.87e-05
			(3.75e-05)
Settlement area	0.000524	4.19e-05	0.00690
	(0.00445)	(0.000625)	(0.0139)
EMZ	-0.00166	0.000131	-0.0148*
	(0.00136)	(0.000263)	(0.00761)
Alps-Dummy	0.0232	0.00258	-0.183
	(0.0346)	(0.00820)	(0.131)
Bavaria-Dummy	-0.0108	-0.0176***	0.0944
	(0.0238)	(0.00515)	(0.106)
Constant	0.0766	0.00652	0.372
	(0.0541)	(0.00954)	(0.242)
Lambda	-2.497**	-4.888***	-0.0742
	(1.214)	(1.410)	(1.550)
Sigma	0.100***	0.0234***	0.252***
	(0.0114)	(0.00543)	(0.0397)
Observations	88	88	88
Wald	4.231	12.01	0.00229
LL	74.68	196.9	-3.539
LM	1.424	3.215	0.00287

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

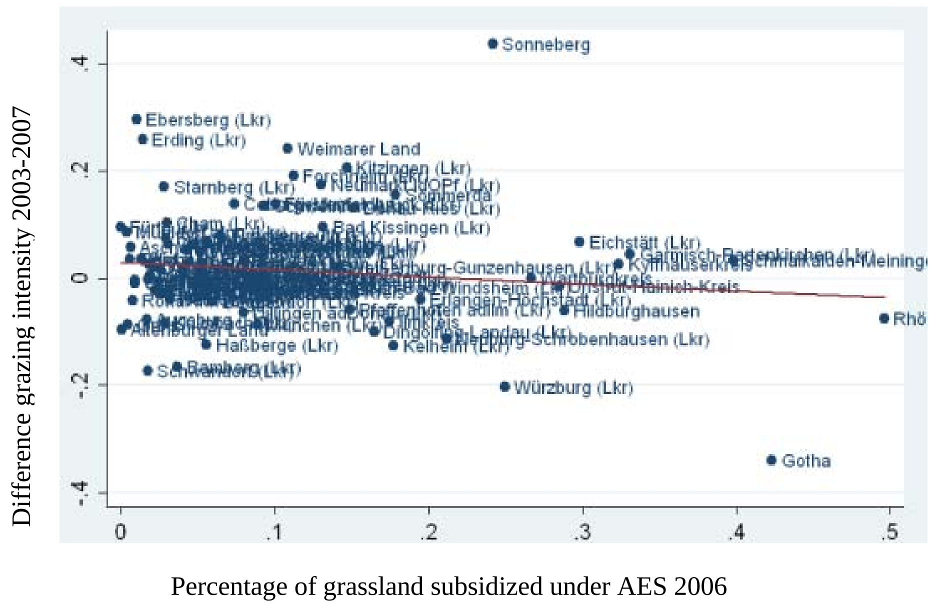

Figure 8: Scatter plot of difference in grazing intensity and AES

VARIABLES	SHDI	SHDI	SHDI	Plant / ha	Plant / ha	Plant / ha	Butterfly / ha	Butterfly / ha	Butterfly / ha
Ecological grassland	0.924			**-0.0392***			-0.0122		
	(0.573)			(0.0238)			(0.0105)		
Grazing intensity		-0.152			**0.0187***			0.00576	
		(0.263)			(0.0104)			(0.00400)	
GV / ha			**-0.0544*****			**0.00292*****			**0.00103****
			(0.0208)			(0.000995)			(0.000498)
Grassland	-3.14e-06								
	(2.14e-06)								
Settlement area	-0.0165	-0.0118	-0.0188	**0.00181*****	**0.00167*****	**0.00213*****	**0.000502***	0.000457	**0.000616****
	(0.0150)	(0.0155)	(0.0159)	(0.000617)	(0.000647)	(0.000583)	(0.000268)	(0.000293)	(0.000264)
EMZ	0.00466	0.00513	**0.0129*****	**0.000510*****	**0.000509*****	8.87e-05	**0.000235*****	**0.000235*****	8.62e-05
	(0.00381)	(0.00385)	(0.00447)	(0.000195)	(0.000194)	(0.000161)	(8.73e-05)	(8.73e-05)	(6.52e-05)
Alps-Dummy	**-0.352*****	**-0.290****	**-0.242****	-0.000400	-0.00487	-0.00395	-0.000404	-0.00177	-0.00174
	(0.0951)	(0.128)	(0.0996)	(0.00293)	(0.00430)	(0.00312)	(0.00129)	(0.00172)	(0.00139)
Bavaria-Dummy	0.0199	0.00532	0.0214	**-0.00884****	**-0.0118****	**-0.0101*****	**-0.00392*****	**-0.00484*****	**-0.00444*****
	(0.108)	(0.114)	(0.105)	(0.00373)	(0.00475)	(0.00319)	(0.00152)	(0.00178)	(0.00128)
Constant	0.834	0.777	0.642	-0.0248**	-0.0261**	-0.0185**	-0.00949**	-0.00991**	-0.00697**
	(0.605)	(0.582)	(0.634)	(0.0112)	(0.0106)	(0.00873)	(0.00406)	(0.00386)	(0.00285)
rho	0.759***	0.766***	0.741***	0.695***	0.696***	0.737***	0.813***	0.814***	0.837***
	(0.228)	(0.223)	(0.243)	(0.269)	(0.269)	(0.243)	(0.173)	(0.173)	(0.155)
sigma	0.294***	0.297***	0.289***	0.00952***	0.00942***	0.00878***	0.00412***	0.00410***	0.00390***
	(0.0199)	(0.0202)	(0.0193)	(0.00114)	(0.00115)	(0.000909)	(0.000555)	(0.000568)	(0.000423)
Observations	88	88	88	88	88	88	88	88	88
Wald	11.04	11.83	9.307	6.689	6.716	9.223	22.13	22.19	29.24
p	0	0	0	1.59e-10	6.71e-11	0	2.41e-07	1.20e-07	5.45e-08
chi2	59.69	50.42	56.30	40.91	42.60	49.60	26.67	28.01	29.55
ll	-18.02	-19.04	-16.33	284.0	285.0	291.1	357.3	357.7	362.1

Table 5: Spatial Lag Regression with Biodiversity Indicators as dependent variable (to be continued)

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

VARIABLES	Grasshopper / ha	Grasshopper / ha	Grasshopper / ha	Bird / ha	Bird / ha	Bird / ha
Ecological grassland	-0.0183			**-0.00882***		
	(0.0130)			(0.00533)		
Grazing intensity		**0.00769***			0.00320	
		(0.00464)			(0.00200)	
GV / ha			**0.00115*****			**0.000594*****
			(0.000446)			(0.000201)
Settlement area	**0.000482***	0.000422	**0.000608****	**0.000341*****	**0.000316****	**0.000406*****
	(0.000254)	(0.000271)	(0.000236)	(0.000122)	(0.000129)	(0.000114)
EMZ	**0.000246****	**0.000245****	7.96e-05	**0.000111*****	**0.000111*****	2.56e-05
	(0.000101)	(0.000100)	(8.22e-05)	(4.13e-05)	(4.18e-05)	(3.30e-05)
Alps-Dummy	-0.000249	-0.00197	-0.00148	-0.000253	-0.000904	-0.000930
	(0.00117)	(0.00181)	(0.00122)	(0.000570)	(0.000829)	(0.000587)
Bavaria-Dummy	**-0.00508*****	**-0.00622*****	**-0.00548*****	**-0.00225*****	**-0.00268*****	**-0.00247*****
	(0.00196)	(0.00237)	(0.00168)	(0.000771)	(0.000958)	(0.000655)
Constant	-0.00828*	-0.00912**	-0.00605*	-0.00486**	-0.00535***	-0.00367**
	(0.00468)	(0.00436)	(0.00367)	(0.00197)	(0.00185)	(0.00146)
rho	0.770***	0.773***	0.789***	0.779***	0.777***	0.813***
	(0.208)	(0.205)	(0.197)	(0.198)	(0.200)	(0.175)
sigma	0.00431***	0.00429***	0.00408***	0.00191***	0.00191***	0.00176***
	(0.000595)	(0.000612)	(0.000562)	(0.000243)	(0.000252)	(0.000205)
Observations	88	88	88	88	88	88
Wald	13.69	14.22	16.08	15.51	15.13	21.68
p	1.10e-08	1.54e-08	6.09e-10	8.65e-11	8.44e-11	0
chi2	32.65	32.01	38.29	42.10	42.15	51.09
ll	353.5	353.9	358.2	425.2	425.1	432.0

Table 6: Spatial Lag Regression with Biodiversity Indicators as dependent variable (continued)

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1