# The Interdependence between Biodiversity and Socio-Economic Variables on a Local and Regional Level: Evidence for German counties

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**Abstract:**

*This paper seeks to explore possible interdependence of different biodiversity indicators with socio-economic and political factors on a county and regional level. As example the counties in Thuringia and Bavaria (Germany) are chosen in order to conduct ordinary-least square estimations as well as structural equations in order to identify possible direct and indirect effects between biodiversity as well as the loss of biodiversity. So far, results show an effect of subsidies, however this impact depends on the indicator applied and the method used. It is so far unclear, if subsidies counteract the biodiversity loss or just increases the number of species protocol to be lost in the Red List.*

**Keywords:** biodiversity indicator SEM socio-economic interdependence Bavaria Thuringia

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# 1. Introduction

Biodiversity research is a dynamic field of different interests by researchers as well as potential stakeholders. Application oriented different aspects are explored empirically, e.g. the indication or evaluation of biodiversity. The paper tries to change focus and seeks to explore possible interdependence between ecosystems and socio-economic and political aspects, respectively. Hereby, core question of research are:

1. Which influence do socio-economic and political variables have on biodiversity in grassland in a local framework?
2. Which kind of interdependence links local land use, changes of biodiversity in grassland and socio-economic/political characteristics?

To find answer to these questions, an empirical analysis for the counties of Thuringia and Bavaria, Germany, shall be conducted which examines direct relations as well as the interaction between biodiversity, land use, socio-economic factors and political interferences.

The paper is organized as follows: the next section gives the theoretical background for the empirical analysis in form of hypotheses. This is followed by the description of the used data. Preliminary results are of an ordinary least square estimation and structural equation model are described in section four.

# 2. Theoretical background

## 2.1 Biodiversity – in General

Before applying the term ‘biodiversity’, a common definition should serve as basis for the paper: “’Biological diversity’ is hereby defined as the variability among living organism 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). Thus, biodiversity in a general framework encompasses ecological diversity (e.g. landscapes, ecosystems, habitats), genetic diversity (e.g. population, chromosomes, genes), and organismal diversity (families, species, populations) (see Gaston & Spicer, 1998, p. 3). As this broad definition is not practicable in an empirical study, the concept of biodiversity here concentrates on grassland biodiversity and thereby on different taxa which indicates the biological diversity of grassland as such. Despite narrowing the term biodiversity, several possible effects can be theoretically derived. In the following different paths of interaction are presented. Before doing so, a short remark on why we care about biodiversity at all is necessary. Referring to Perrings et al. (2007) there are two major concerns driving the demand for biodiversity conservation. Firstly, diversity contributes to the overall ecosystem properties such as stability, productivity or resilience. Secondly, preserving diversity means to enable freedom of choice, as individuals may choose from a set of diverse alternatives. So, biodiversity provides mankind with different benefits: factor supply, cultural services, supporting services and regulating services (see as well Millennium Ecosystem Assessment). By conserving biodiversity ones tries so to prevent irreversible loss of genetic information may be necessary in future to realize the benefits provided to mankind.

## 2.2 Land use and biodiversity

That the mode of land use influences the level of biodiversity seems to be an unsurprising fact. However, one question at hand is still if scale of land use (large scale farming vs. small scale farming) has an impact. The argument states that large scale farming may allow more space for ‘unwished’ species to develop at the side strip or in unused corner. Due to the type of the technique applied or the relatively small loss of arable land if some is not used, side strips tend to be more frequent and thus areas with high biodiversity may develop. On the same token, small scale farming tends to use every ‘centimetre’ of the arable land and thus nearly any side strips occur, which diminishes biodiversity in general in agricultural used land. However, studies (e.g. Brose, 2003) already show that the size of the farm on its own may only have small effects. But the mode of land use (intensive vs. extensive) seems to be the important influencing factor regarding biodiversity. In respect to grassland, in general it is either used for producing hay or as grazing ground. Hereby, different intensities can be applied. Regarding hay production for instance, up to three grass cuts can be executed in a year, which represents already intensive farming. While the intensity for grazing depends on the amount of cattle on the ground and the period of grazing (e.g. changing grounds, all year one ground). Furthermore, intensive farming is mainly characterised by applying conventional modes of agriculture (e.g. fertilizer). In contrast, for the ecological way of farming it is assumed that overgrazing of the ground does not appear, thus biodiversity is conserved. Summarizing these arguments following hypotheses can be drawn:

**Hypothesis 1:** Increasing scale of farming is related to higher biodiversity

**Hypothesis 2:** The intensity of farming is negatively affecting biodiversity

## 2.3 Industrial structure, technological change and biodiversity

Regarding the industrial or labour force structure Borghesi (2002) identifies three channels of the effects of economic growth on environmental quality: (1) growth exhibit a *scale effect* on the environment (the higher the economic growth the higher the usage of natural resources as input and the higher the waste produced by industrial production which leads to environmental degradation); (2) growth has a positive effect due to a *composition effect* (increasing economic development results in structural change, which includes a turn to more clean industries); (3) *technique effect* as technological progress / innovations accompanies mostly economic growth (substitution of obsolete and dirty technologies with cleaner ones). In an evolutionary framework, the scale effect may dominate the beginning of the economic growth, but with increasing economic development, the composition and technique effect may outweigh the scale effect (Borghesi, 2002). Empirically, this relationship is shown by Grossman & Krueger (1994), who found the inverse U-shaped relation for income and air/river pollution. Harbough, Levinson & Wilson (2002), who re-examines the data, found an N-shaped relation and a high sensibility of the outcomes to changing parameters. Assuming that high environmental quality encompasses a rich biodiversity, a U-curve relationship between economic growth and biodiversity can be inferred. But also, Asufu-Adyaje (2003) finds only weak empirical evidence for the environmental Kuznets curve (EKC, U-curve relationship) by using data for biodiversity (bird species). Institutional quality and climate seems to be in his analysis the driver for the variety of biodiversity. Thus, so far, empirical results are not clear and lead to different results depending on indicator, measurement and region. However, these studies were done on a global scale. Thus, effects were often driven by differences in the economic developmental levels, institutional quality and/or population density of the countries as developing and developed countries are included at the same time (see e.g. also Freytag/Vietze/Völkl 2009).

On a local scale however, industrial structure can be examined in more detail. Thus, if the dominant structure in the region is not industry, but e.g. eco-tourism, local actors shall have an incentive to preserve biodiversity. In addition, industrial development is mainly accompanied by an increase in settlement and traffic area (sealed land), which may counteract the proposed relationship. On the contrary, if sealed land is low and biodiversity is high, the number of eco-tourist may be high who seek recreation. This, in turn, would lead again to an incentive for conserving biodiversity, if tourism is the dominant industry.

Thus, the following hypotheses can be set up:

**Hypothesis 3:** Increasing economic growth firstly diminishes biodiversity, but ongoing it will lead to higher biodiversity again. An inverse U-curve relation shall be found.

**Hypothesis 4:** Biodiversity is depending on the dominant sector in the region. While eco-tourism conserves biodiversity, industrial production diminishes it.

Regarding the population density, however, two counteracting effects seem to be possible. Firstly, a rise in population density is closely connected with increasing sealing of soil (settlement/traffic areas). But secondly, in highly populated areas, engagement in nature conservation is less costly, as more chances in form of NGOs can be found. Thus, transaction costs may remain low. However, in the empirical analysis, population density will take over the role of a control variable.

## 2.4 Population and biodiversity

Closely related to economic development is the awareness of biodiversity within the population. Biodiversity in general is seen as superior good; this implies that increasing income is theoretically accompanied by an awareness of the population towards ‘greener’ consumption (Borghesi, 2002). With increasing income people tend to afford higher living standards and shall care more for the environment they live in. This greener demand leads to a shift in production and technologies towards a more environmentally friendly technique (see section 2.2.). Additionally, a demand for environmental policy by the government may be created (see section 2.5). In the paper at hand, a regional approach is taken. Thus, it is argued that education (although closely connected to income) as well plays an important role on its own to raise the awareness of biodiversity. To measure this awareness or preference for biodiversity conservation an approach is to take the votes for the Green Party in the “Bundestageswahl” (Federal Parliament). Votes for the program of the Green Party on this level should be less leaded by person oriented votes than concept oriented votes as it is more likely on a local base. Thus, hypotheses derived from these arguments are:

**Hypothesis 5:** Areas with highly educated persons display a high awareness of environmental issues, thus, in turn, besides engaging in biodiversity conservation, votes for green concept are not as rare as in areas with lower levels of education.

As formal education is often criticized for not displaying awareness or preferences in any kind, another measurement is to use occupation. In particular people in highly creative professions may seek biodiversity as recreation space in order to perform. Thus, creative people may in turn display a high preference for biodiversity conservation (see Florida 2006 or Runko 2004).

### 2.5 Political interference, land use and biodiversity

As section 2.2 and section 2.3 already point out, increasing income may lead to a higher demand for biodiversity conservation. Thus, it is rational for politicians to engage officially in biodiversity protection programs in order to gain votes. However, besides votes, politics also have to decide about subsidies. Theories from the field of political economy propose that money is transferred towards the section with the strongest lobby (see Müller, 2006). Regarding biodiversity, the lobbies can be found in form of NGOs (e.g. Birdwatch, Greenpeace). The question at hand would be, if subsidies are also channeled towards region with high biodiversity occurrence. A positive formulated hypothesis would be therefore:

> **Hypothesis 6:** Political interventions in form of nature conservation subsidies are target mainly towards regions with high biodiversity in order to conserve it.

Thereby, subsidies for particular nature conservation projects are assumed to be directed effectively. Points of interest here are the subsidies for the agricultural sector which infer an environmental friendly cultivation of the grassland by e.g. paying compensations for foregone income.

### 2.6. Geography, land use and biodiversity

Highly productive land should rationally be used for cropland, however, climate, altitude may play an important role as well for the decision what kind of agricultural usage and if agricultural usage at all. Furthermore, the geographic characteristics shape the biodiversity founded, so e.g. we find different species at different altitudes. Thus, geographic characteristics shape the land use as well as the observed biodiversity. So, it cannot be neglected as control factor in the analysis, but will not be the core of the analysis.

## 3. Data

To test the six hypothesis, following data is collected for all 'Land- und Stadtkreise' (in the following translated by counties) of Bavaria and Thuringia, as far as available.

### 3.1. Biodiversity

To measure biodiversity in general different practice between economy and ecology exists. While ecologist tends to measure biodiversity as observed frequency economist concentrate on the properties of biodiversity. In our study we strike the balance by using the number of species occurring (see also Baumgärtner, 2003). Hereby several forms of taxa are applied. Firstly, samples of 162 typical grassland plants and 35 typical grassland birds are examined for their occurrence in the counties. Additionally, the amount and the density of orchids to be found in a county are counted separately. Furthermore, the distributions of butterfly and grasshopper species are included. Thus, biodiversity is here approximated by the occurrence of animals and plants species important in a typical grassland ecosystem. However, these variables are only displaying the present diversity in the county. One objective of the project is as well to examine the effects of biodiversity changes on land use and political interferences. As proxy for the local loss of biodiversity, the regional Red Lists for Thuringia and Bavaria are used as indicator. In cases of extinction, the former prevalence (before 1945) is applied in order to account for the loss of the species in the county.

## 3.2 Agrarian structure

As measurement for the scale of production the size of the grassland of farms are here applied. It is assumed hereby, that farms operating on a high amount of hectares are going to bundle them together into larger areas in order to gain scale effects. Thus, areas where the majority of farms manage a larger amount of grassland (more than 50 hectares) large scale farming may be the dominant mode of farming. In addition, the size of grazing area relatively to total grassland is included in the analysis in order to define the dominant usage of the grassland farming (hay production or grazing).

Besides these more practical differentiations between the modes of farming, a further variable is introduced in the analysis: ecological farming. As ecological farming is mainly conducted on a smaller scale than conventional farming, the analysis includes not just the land used for ecological farming but also the number of farms.

Due to the history of agriculture in the former GDR, large scale farming is more frequent in Thuringia than in Bavaria. So, while the Bavarian farms structure may be represented well by grouping 50-200 hectares, a part of the Thuringian farms have still more than 200 hectare grassland. A Bavarian Dummy is introduced to capture possible structural problems of the data.

## 3.3 Industrial structure & technological change

One proxy used for the level of economic development is the available income per capita (GDP relative to population). In order to integrate the industrial structure and take account for technological change, the rate of unemployed people and people employed in production are used. The proportion of settlement and traffic area is incorporated as proxy for sealed surface.

To examine the possible impact of tourism on biodiversity, the number of offered beds (as supply side factor) relatively to the number of overnight stays (demand side factor) is here applied as proxy: capacity utilization.

## 3.4 Population

The hypothesis about population is based on education. Education here is presented by the proportion of academics in the county. As measurement for informal education the proportion of the creative class shall serve. Here it is assumed, that people in professions where creativity is necessary, may also be aware of environmental degradations. To proxy the demand for environmental conservation, the votes for and the members of the 'Green' party are integrated. To minimise the risk, that the concept instead of a person is voted for, the level of 'Bundestagswahl', second voice is applied.

## 3.5 Political measures

One of the core interests in this project is the influence of political measures on biodiversity and land use and vice versa. Therefore, it is sought to included EU subsidies regarding nature conservation (e.g. VNP, EA-FFH, KULAP C) as well as EU-programs aiming on agricultural production (e.g. KULAP A,B; EA – disadvantaged areas) into the analysis[1]. However, so far, data was only available for KULAP C in Thuringia and VNP and EA-FFH in Bavaria for the years 2005 and 2006. These data is as such comparable as the same nature conservation measures are supported in Bavaria under the guidelines of VNP and EA-FFH while Thuringia grouped these measures at this time under KULAP C. Both federal states although introduced KULAP A,B measures for extensive farming, however, so far only figures for Thuringia accessible. Thus, this EU-guideline is not included so far.

## 3.6 Landscape / Geography

In order to take account for the natural characteristics of the area which influences the land use and the founded biodiversity severable variables are used. So, the average yearly precipitation for each county as well as the average temperature shall indicate the climate, as it is expected that some climate is favorable for grassland biodiversity. Furthermore, the average altitude of the county is used to take account for differences in biodiversity due to mountainous or flare landscapes. Climate and altitude is strongly connected with each other as

[1] For a more detailed description of included subsidies see table 4, appendix.

well as with quality of soil, which in turn influences the found biodiversity as well. To proxy the quality of the soil so-called 'Ertragsmesszahlen' (EMZ) as used for taxation purposes is applied. Although, this measurement is composed of indicators for grassland and cropland, to untangle this indicator for grassland only was not possible.

As our biodiversity indicators are the number of species found in the county, a control variable 'biotopes' is introduced. It can be expected that some county display a high degree of biodiversity due to the reason that they possess a high amount of biotopes, which are protected. Thus, the measure biodiversity is just a kind of 'storage room', but not influenced directly by agricultural land use in the county as such. Another proxy would also be 'undisturbed areas', however, data for Thuringia and Bavaria underlie different definitions and are as such not comparable.

A comprehensive list of all variables in the analysis can be found in the appendix (table 1, in German).

# 4. Analysis

Regarding the data closely, it becomes quickly clear that there is interdependency between the variables, especially regarding population and industrial structure or biodiversity and land use and geography. But, as every variable shows an aspect of factors to be integrated in the analysis the reduction of variables seems to be not the optimal method. However, in a first step variable will be reduced in order to perform an ordinary least square estimation (OLS) to proxy direct effects of socio-economic factors on several biodiversity indicators. In a second step, a Structure Equation Modelling (SEM) approach is chosen to detect direct and indirect effects at the same time and so to examine possible interdependencies. This approach combines factor analysis and regression analysis by using latent variables. However, in order to use the latter approach all variables need to be standardized, which needs to be kept in mind by interpreting the results.

## 4.1 Direct effects

The direct influences on biodiversity shall be examined by using OLS estimation. Hereby different models were performed in order to test robustness of estimations. Model 1 (Model 2 -6, respectively) is the standard model with as less variables included as possible in order to rule out multicolinearity. In Model 7 (Model 8-12, respectively) the Bavarian Dummy is introduced to count for systemic differences between Bavarian and Thuringian characteristics which may influence the analysis. In Model 13 (Model 14-18, respectively) the variable 'squared income' is added in order to take account for a possible u-shape relationship between biodiversity and income as proposed by the EKC-theory. All models are executed for the sample of plants, butterflies, grasshoppers, orchids and orchids density as well as for number of species of these taxa in the local Red List in order to measure biodiversity change.

Table 2 (see Appendix) shows the results of the OLS estimation. One first remark is that each indicator seems to be explained different characteristics. Furthermore, most dependent variables are significant positive related with subsidies, i.e. KULAP C/VNP. However birds seem to display specific characteristics as they favor less precipitation, but are not affected by subsidies. Regarding the question about large scale farming vs. small scale farming, only butterfly and orchid density react positively significant towards larger scale farming (50-200 ha), otherwise no significant robust correlation can be shown. Hereby, both, butterfly and orchid tend to be negatively associated with intense agriculture.

Referring to the Bavarian Dummy, only the biodiversity indicators grasshoppers, birds, orchids show a significant negative relationship which points to systematic differences between both federal states. Otherwise results remain unchanged. Changing the variable 'income' to 'squared income' does not change the results significantly. Only the sample of grassland plants seems to be explained by 'income' in the shape of a U-curve. Otherwise, none of the other biodiversity indicator are affected significant by the income variable.

In order to examine the dependency of biodiversity loss with socio-economic variables, the same models are conducted for relative red list taxa (see also table 2, Appendix). Here as well, subsidies are explaining significantly positively the occurrence of red list species regarding the plant sample, butterflies and grasshoppers.

The loss of biodiversity seems to be reduced by increasing grazing area according to the estimates for the plant sample and butterflies. On the other hand, butterflies and birds in the Red List appear to react positively on large-scale farming, while the loss of orchids tend to be related to large scale farming and settlement, respectively.

## 4.2 Indirect effects & dynamics

In a second step a structural equation model (SEM) is applied in order to identify indirect effects (see also Backhaus et al., 2006):

Figure 1 (see Appendix) shows the preliminary results of the SEM if the number of species is implemented. Figure 2 displays results if relative loss of biodiversity (Red List Species) is used as variable. Regarding the number of species; politics seems to influence significantly the structure of agriculture besides geography. However, a significant impact of politics on biodiversity is not founded here. It seems that the industrial structure has a more (negative) crucial impact here on biodiversity. Regarding the Red List data, as well, industrial structure has a negative significant impact on biodiversity loss. However, it seems that amount of species in the Red List decreases with increasing education and votes of the population for ‘Green’ concepts.

According to our hypotheses, results so far remain unclear or depend on the used biodiversity indicator, respectively. Increasing scale of farming leads to higher biodiversity (Hypothesis 1) measured as number of butterfly species or orchid density, while at the same time it seems to increase also the loss of butterfly and bird species referring to the red list figures, but not the number of orchid’s species. Regarding the area used for ecological farming tends to be not related to the number of species in the Red List or biodiversity found. However, evidence for the EKC (Hypothesis 3) measured by biodiversity indicator remains weak or even is not displayed by the estimations. Same holds for the impact of the dominant sector in the region, or education and evaluation of biodiversity (Hypothesis 4 & 5).

Regarding hypothesis 6, results are left for interpretation. Although all biodiversity indicators are positively correlated with the political interventions same holds for Red List figures

## 5. Conclusion

The aim of the analysis presented in this paper is to examine empirically on a local and regional level the influence of socio-economic and political variables on biodiversity and change in biodiversity in grassland. Therefore different concepts are introduced which may explain theoretically the interdependency between the variables examined. In order to identify direct influences different models in form of OLS estimation are conducted. Indirect effects and potential dynamics shall be examined by a structure equation model. However, preliminary results, although robust, are puzzling and need further research. While governmental interventions are significant, the underlying reasons are still not obvious, same holds for the significant relation towards large scale farming. What is shown, however, is the importance of careful biodiversity indicator choice. Each indicator points to different results.

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# Appendix

## Table 1: Overview of variables

| Shortcut | Description | Source for Bavaria | Source for Thuringia |
|---|---|---|---|
| Academics | Percentage of employees with academic degrees in 2005 | Initiative Neue Soziale Marktwirtschaft | Initiative Neue Soziale Marktwirtschaft |
| Altitude | Average altitude of the county | Bayerisches Landesamt für Umwelt (Hangen) | TLUG (Voerkel) |
| Bavaria Dummy | Dummy variable with: Bavaria 1, Thuringia 0 | | |
| Biotope | Area classified as biotopes (i.e. under FFH protection) | FIS-Natur, Flachland-biotopkartierung Bayern; Stand 12.12.2007 | TLUG, Stand 31.12.2005 |
| Birds | Number of typical 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 | Völkl & Bavarian Ministry for Environment | Nicolai (1993) Atlas der Brutvögel Ostdeutschlands |
| Birds – Red List | Number of typical grassland bird species in the regional Red List relative to total number of typical grassland bird species found in the county | Red List Bavaria 2003 | Red List Thuringia 2003 |
| Butterflies | Number of butterfly species to be found in the county of a sample of 113 (Thuringia) / 143 (Bavaria) | Völkl & Bavarian Ministry for Environment | Thust/Kuna/Rommel: Naturschutzreport 23, (2006) Status 1991-2002 |
| Butterflies – Red List | Number of butterfly species in the regional Red List relative to total number of butterfly species in the county | Red List Bavaria 2003 | Red List Thuringia 2003 |
| Creative Class | Fraction of persons employed in knowledge intensive occupations of total population in 2004 | Fritsch/Stützer; based on Data of IAB and Künstler- & Sozialkasse 2004 | Fritsch/Stützer; based on Data of IAB and Künstler- & Sozialkasse 2004 |
| Ecological area | Fraction of agricultural area used for ecological farming in 2005 | Genesis | TLS |
| Employed Production | Fraction of social insurance paying employees in the production sector per total number of social insurance paying employees per county on 30.06.2007 | Genesis | TLS |
| EMZ | Ertragsmesszahl – number given by tax authority in order to evaluate the potential quality (profit) of the soil | Bayerisches Landesamt für Steuern (Hirsch) | LFD (Rötscher) |
| Grass 5-20 | Number of farms managing between 5ha and 20ha grassland in 2007 | FDZ | FDZ |
| Grass 20-50 | Number of farms managing between 20ha and 50ha of grassland in 2007 | FDZ | FDZ |

| | | | |
|---|---|---|---|
| Grass 50-200 | Number of farms managing between 50ha and 200ha of grassland in 2007 | FDZ | FDZ |
| Grasshoppers | Number of grasshopper species to be found in the county of a sample of 52 (Thuringia) / 75 (Bavaria) | Völkl & Bavarian Ministry for Environment | Köhler G: Naturschutzreport 17 (2001) |
| Grasshoppers – Red List | Number of grasshoppers species in the regional Red List relative to total number of grasshoppers species in the county | Red List Bavaria 2003 | Red List Thuringia 2003 |
| Grassland | Area used as grassland in 2007 | FDZ | FDZ |
| Grazing 0.8 | Number of livestock units (sheep, breeding cows and horses) per farm per ha grassland under 0.8 | FDZ | FDZ |
| Grazing 2.0 | Number of livestock units (sheep, breeding cows and horses) per farm per ha grassland above 2.0 | FDZ | FDZ |
| Income | Available income of private households (including private non-profit organisations) per inhabitant in 2005 | Statistik Regional | Statistik Regional |
| Member Green Party | Members of the Green Party in local organizations at 31.12.2007 | Bündnis 90/ Grüne | Bündnis 90/ Grüne |
| Orchid density | Density of orchid distribution per county | Verbreitungsatlas Schönfelder/Bresinsky (1990) Status 1945-1983 | Verbreitungsatlas Korsch/Westhus/Zündorf (2002) Status 1990-2001 |
| Orchids | Number of orchid species to be found in the county of a sample of 40 (Thuringia) / 74 (Bavaria) | Völkl & Bavarian Ministry for Environment | Verbreitungsatlas Korsch/Westhus/Zündorf (2002) Status 1990-2001 |
| Orchids – Red List | Number of orchid species in the regional Red List relative to total number of orchid species in the county | Red List Bavaria 2003 | Red List Thuringia 2003 |
| Plants | Number of typical grassland plants to be found in the county of a sample of 162 typical grassland plant species | Verbreitungsatlas Schönfelder/Bresinsky (1990) Status 1945-1983 | Verbreitungsatlas Korsch/Westhus/Zündorf (2002) Status 1990-2001 |
| Plants – Red List | Number of grassland species in the regional Red List relative to total number of grassland species in the county | Red List Bavaria 2003 | Red List Thuringia 2003 |
| Precipation | Average yearly precipitation | DWD 1961-1991 | DWD 1971-2001 |
| Settlement area | Fraction of settlement and traffic area of total county area on 31.12.2004 | Genesis | TLS |
| Subsidies | Subsidies payed for nature conservation from the federal ministry | VNP, EA 2006 for grassland Bayerisches Landesamt für Umwelt (Völkl/Radlmair) | Kulap C 2006 grassland programs TLVwA (Rottleb) |
| Temperature | Average yearly temperature | DWD 1961-1990 | DWD 1971-2000 |
| Tourist. utilisation | Overnight stays divided by offered beds in the county in 2005 | Statistik Regional | Statistik Regional |
| Unemployed | Average unemployment rate in 2007 | Genesis | TLS |
| Votes Green Party | Votes (2. Vote) for the Green Party in ‘Bundestagswahl’ 2005 (Election of Federal Parliament) | Statistik Regional | Statistik Regional |

## Table 2: OLS results for Biodiversity occurrence & Red List

| | Plant sample | | | Red List plant sample | | |
|---|---|---|---|---|---|---|
| **Variable** | **model1** | **model7** | **model13** | **model19** | **model24** | **model29** |
| Eco area | -0.252 | -0.206 | -0.314 | -0.209 | -0.144 | -0.144 |
| Grass 20-50 | 0.000 | 0.000 | -0.000 | 0.000* | 0.000 | 0.000 |
| Grass 50-200 | 0.000 | 0.000 | 0.000** | 0.000 | 0.000 | 0.000 |
| Grazing 0.8 | -0.000 | -0.000 | -0.000* | -0.000** | -0.000 | -0.000 |
| Grazing 2.0 | -0.000 | -0.000 | -0.000 | 0.000*** | 0.000** | 0.000** |
| Tourist utilisation | -0.000 | 0.000 | -0.000 | -0.000 | 0.000 | 0.000 |
| Settlement area | -0.002 | -0.002 | -0.003 | 0.001 | 0.000 | 0.000 |
| Income | -0.000 | -0.000 | 0.000** | 0.000 | -0.000 | -0.000 |
| sqIncome | | | -0.000** | | | 0.000 |
| Votes Green Party | 0.011** | 0.012** | 0.011** | 0.000 | 0.001 | 0.001 |
| Creative Class | 0.086 | 0.099 | 0.203 | 0.031 | 0.050 | 0.049 |
| Subsidies | 0.342*** | 0.334*** | 0.339*** | 0.146*** | 0.135*** | 0.135*** |
| Precipation | -0.000 | -0.000 | -0.000 | 0.000** | 0.000 | 0.000 |
| Bavaria Dummy | | 0.022 | -0.024 | | 0.031*** | 0.031*** |
| _cons | 0.815*** | 0.842*** | 0.378* | 0.001 | 0.040 | 0.042 |
| N | 54 | 54 | 54 | 54 | 54 | 54 |
| r2 | 0.466 | 0.474 | 0.527 | 0.637 | 0.706 | 0.706 |
| r2_a | 0.310 | 0.303 | 0.357 | 0.531 | 0.610 | 0.600 |

legend: * p<.1; ** p<.05; *** p<.01

| | Butterflies | | | Red List butterflies | | |
|---|---|---|---|---|---|---|
| **Variable** | **model2** | **model8** | **model14** | **model20** | **model25** | **model30** |
| Eco area | 0.366 | 0.431 | 0.571 | 0.082 | 0.414 | 0.436 |
| Grass 20-50 | 0.000 | -0.000 | -0.000 | 0.000 | -0.000 | -0.000 |
| Grass 50-200 | 0.001** | 0.002** | 0.001* | 0.001** | 0.001** | 0.001** |
| Grazing 0.8 | -0.000 | -0.000 | 0.000 | -0.001 | -0.000 | -0.000 |
| Grazing 2.0 | -0.001*** | -0.001** | -0.002** | -0.000 | -0.001*** | -0.001*** |
| Tourist utilisation | 0.000 | 0.000 | 0.000 | -0.000 | 0.000 | 0.000 |
| Settlement area | -0.019*** | -0.020*** | -0.019** | -0.006 | -0.011** | -0.011** |
| Income | -0.000 | -0.000 | -0.000* | -0.000 | -0.000** | -0.000 |
| sqIncome | | | 0.000 | | | 0.000 |
| Votes Green Party | 0.020* | 0.021* | 0.022** | 0.017* | 0.021*** | 0.021*** |
| Creative Class | -0.624 | -0.606 | -0.740 | -0.509 | -0.414 | -0.435 |
| Subsidies | 0.620*** | 0.609*** | 0.604*** | 0.409*** | 0.353*** | 0.353*** |
| Precipation | 0.000 | -0.000 | -0.000 | 0.000 | -0.000 | -0.000 |
| Bavaria Dummy | | 0.031 | 0.090 | | 0.158*** | 0.167*** |
| _cons | 0.802*** | 0.841*** | 1.442*** | 0.346*** | 0.542*** | 0.636** |
| N | 54 | 54 | 54 | 54 | 54 | 54 |
| $R^2$ | 0.705 | 0.706 | 0.717 | 0.525 | 0.642 | 0.643 |
| $R^2$ adj. | 0.618 | 0.611 | 0.615 | 0.386 | 0.526 | 0.515 |

legend: * p<.1; ** p<.05; *** p<.01

| Variable | Grasshoppers<br>model3 | model9 | model15 | Red List grasshoppers<br>model21 | model26 | model31 |
|---|---|---|---|---|---|---|
| Eco area | 0.175 | -0.035 | -0.091 | -0.436 | -0.063 | -0.022 |
| Grass 20-50 | -0.000* | -0.000 | -0.000 | 0.000* | 0.000 | 0.000 |
| Grass 50-200 | 0.001 | 0.001 | 0.001 | -0.000 | -0.000 | -0.000 |
| Grazing 0.8 | 0.001 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| Grazing 2.0 | -0.001** | 0.000 | 0.000 | 0.001*** | 0.000 | 0.000 |
| Tourist utilisation | -0.000 | -0.000 | -0.001 | -0.001* | -0.000 | -0.000 |
| Settlement area | -0.016** | -0.012** | -0.013** | -0.005 | -0.010** | -0.010* |
| Income | -0.000* | -0.000 | 0.000 | 0.000*** | 0.000 | -0.000 |
| sqIncome | | | -0.000 | | | 0.000 |
| Votes Green Party | 0.011 | 0.009 | 0.008 | -0.006 | -0.002 | -0.001 |
| Creative Class | -0.026 | -0.086 | -0.033 | 0.149 | 0.256 | 0.217 |
| Subsidies | 0.382** | 0.417** | 0.419** | 0.303** | 0.241** | 0.239* |
| Precipation | -0.000** | -0.000 | -0.000 | 0.000 | -0.000 | -0.000 |
| Bavaria Dummy | | -0.100** | -0.123** | | 0.178*** | 0.195*** |
| _cons | 1.019*** | 0.895*** | 0.657 | 0.114 | 0.335*** | 0.510 |
| N | 54 | 54 | 54 | 54 | 54 | 54 |
| $R^2$ | 0.668 | 0.693 | 0.695 | 0.605 | 0.728 | 0.729 |
| $R^2$ adj. | 0.571 | 0.594 | 0.586 | 0.490 | 0.639 | 0.632 |

legend: * p<.1; ** p<.05; *** p<.01

| Variable | Birds<br>model4 | model10 | model16 | Red List birds<br>model22 | model27 | model32 |
|---|---|---|---|---|---|---|
| Eco area | -0.041 | -0.332 | -0.299 | 0.076 | 0.206 | 0.179 |
| Grass 20-50 | -0.000 | -0.000 | -0.000 | -0.000 | -0.000** | -0.000* |
| Grass 50-200 | 0.001 | 0.001 | 0.001 | 0.001** | 0.001** | 0.001** |
| Grazing 0.8 | 0.001 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| Grazing 2.0 | -0.000 | 0.001 | 0.001 | -0.000 | -0.001 | -0.001 |
| Tourist utilisation | 0.001 | 0.000 | 0.000 | -0.000 | -0.000 | -0.000 |
| Settlement area | -0.001 | 0.004 | 0.004 | 0.009 | 0.008 | 0.007 |
| Income | -0.000 | -0.000 | -0.000 | 0.000 | 0.000 | 0.000 |
| sqIncome | | | 0.000 | | | -0.000 |
| Votes Green Party | -0.000 | -0.003 | -0.003 | -0.014 | -0.013 | -0.013 |
| Creative Class | -0.047 | -0.131 | -0.163 | -0.709 | -0.672 | -0.646 |
| Subsidies | 0.080 | 0.129 | 0.127 | 0.092 | 0.071 | 0.072 |
| Precipation | -0.000*** | -0.000*** | -0.000*** | -0.000** | -0.000*** | -0.000*** |
| Bavaria Dummy | | -0.139*** | -0.124** | | 0.062 | 0.050 |
| _cons | 1.092*** | 0.919*** | 1.064*** | 0.492*** | 0.569*** | 0.453 |
| N | 54 | 54 | 54 | 54 | 54 | 54 |
| $R^2$ | 0.712 | 0.763 | 0.764 | 0.517 | 0.536 | 0.537 |
| $R^2$ adj. | 0.627 | 0.686 | 0.679 | 0.376 | 0.385 | 0.371 |

legend: * p<.1; ** p<.05; *** p<.01

| Variable | Orchids model5 | model11 | model17 | Red List orchids model23 | model28 | model33 |
|---|---|---|---|---|---|---|
| Eco area | 0.992 | 0.441 | 0.515 | -0.728 | -0.229 | -0.218 |
| Grass 20-50 | -0.000 | -0.000 | -0.000 | 0.000** | 0.000 | 0.000 |
| Grass 50-200 | 0.001 | 0.000 | 0.000 | -0.001** | -0.001** | -0.001** |
| Grazing 0.8 | 0.001 | 0.000 | 0.000 | 0.000 | 0.001** | 0.001** |
| Grazing 2.0 | -0.002*** | -0.000 | -0.000 | 0.003*** | 0.001*** | 0.001*** |
| Tourist utilisation | 0.001 | 0.000 | 0.000 | -0.001 | -0.000 | -0.000 |
| Settlement area | -0.017* | -0.009 | -0.008 | 0.016** | 0.009* | 0.009* |
| Income | -0.000* | -0.000 | -0.000 | 0.000** | -0.000 | -0.000 |
| sqIncome | | | 0.000 | | | 0.000 |
| Votes Green Party | 0.026** | 0.020* | 0.020* | -0.012 | -0.007 | -0.007 |
| Creative Class | 0.117 | -0.042 | -0.113 | 0.598 | 0.742** | 0.731* |
| Subsidies | 0.356 | 0.448** | 0.445** | 0.117 | 0.033 | 0.033 |
| Precipation | -0.000 | 0.000 | 0.000 | 0.000** | 0.000 | 0.000 |
| Bavaria Dummy | | -0.262*** | -0.230*** | | 0.237*** | 0.242*** |
| _cons | 0.761*** | 0.435*** | 0.754 | 0.200 | 0.496*** | 0.544** |
| N | 54 | 54 | 54 | 54 | 54 | 54 |
| $R^2$ | 0.704 | 0.791 | 0.793 | 0.845 | 0.932 | 0.932 |
| $R^2$ adj. | 0.617 | 0.723 | 0.718 | 0.800 | 0.910 | 0.908 |

legend: * p<.1; ** p<.05; *** p<.01

| Variable | Orchid density model6 | model12 | model8 |
|---|---|---|---|
| Eco area | -10.304 | 84.393 | 48.013 |
| Grass 20-50 | 0.118* | 0.096 | 0.094 |
| Grass 50-200 | 0.869** | 0.948** | 0.980** |
| Grazing 0.8 | 1.071* | 1.196* | 1.140* |
| Grazing 2.0 | 0.347 | 0.048 | 0.095 |
| Tourist utilisation | -0.112 | -0.021 | -0.042 |
| Settlement area | -6.870 | -8.297 | -8.633* |
| Income | -0.001 | -0.005 | 0.012 |
| sqIncome | | | -0.000 |
| Votes Green Party | 13.209 | 14.312* | 13.989 |
| Creative Class | -77.192 | -49.911 | -15.021 |
| Subsidies | 317.265*** | 301.432** | 302.848** |
| Precipation | 0.009 | -0.016 | -0.013 |
| Bavaria Dummy | | 45.038 | 29.593 |
| _cons | 24.751 | 80.880 | 75.452 |
| N | 54 | 54 | 54 |
| $R^2$ | 0.747 | 0.753 | 0.754 |
| $R^2$ adj. | 0.673 | 0.673 | 0.666 |

legend: * p<.1; ** p<.05; *** p<.01

**Figure 1: SEM for biodiversity occurrence**

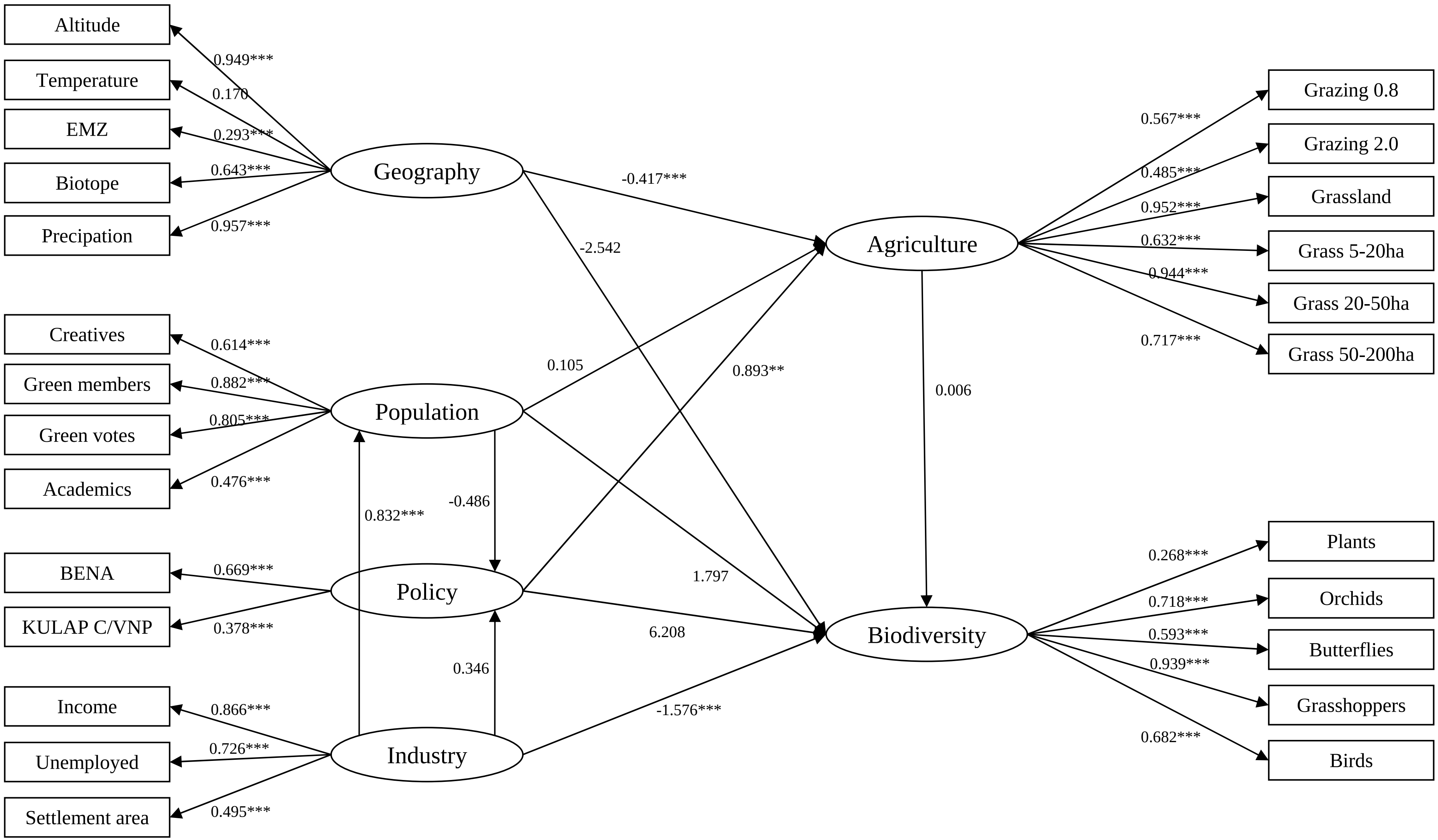
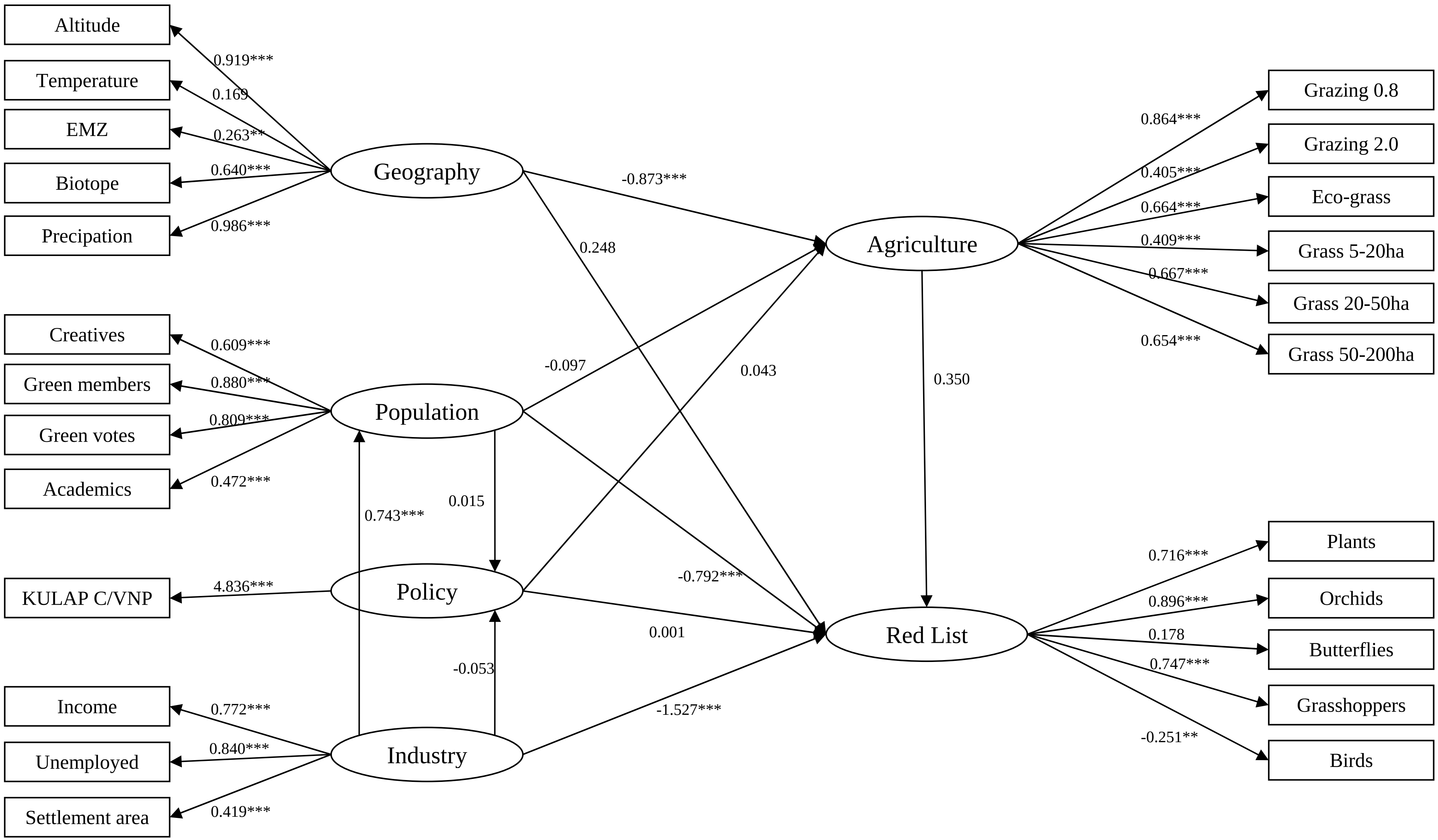


**Figure 2: SEM for biodiversity loss**



### Table 4: Overview of governmental subsidy programs for agriculture (used here)

| **Name** | **Brief description** |
|---|---|
| Ertragsausgleichzahlung benachteiligte Gebiete (BENA)<br>*Compensation payments for disadvantaged areas* | Payments in order to sustain agriculture in remote areas; see also concept of ‘agriculture as gardener’: here number of farms falling under this guideline |
| Kulturlandschaftsprogramm (KULAP A,B, C)<br>*Landscape program* | Payments to land user to pursuit a wished land use. In particular Kulap C aims on extensive land use in areas regarded as worth to protect while Kulap A & B seeks to motivate extensive land use only. |
| Vertragsnaturschutzprogramm (VNP)<br>*Contractual nature conservation program* | Land user and nature conservation agency form a contract voluntarily on nature conservational usage of grassland for at least 5 years |