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Report on the suitability of continental scale indicators for reflecting biodiversity of organic/low input farming systems, proposition of a monitoring system at the continental scale

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Report on the suitability of continental scale indicators for reflecting biodiversity of organic/low input farming systems, proposition of a monitoring system at the continental scale

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Content

1. Introduction

In Deliverable 4.2 a continental analysis has been conducted in order to estimate the frequency and localisation (spatial distribution) of the 12 organic/low-input case study regions which we examined. The conclusion at this stage is that we pretty well cover the major farming types in Europe. Still, the data will not allow a quantitative estimation of the biodiversity values in those regions because of the small sample size. Based on the continental analysis and on the findings from the CS, a monitoring system for biodiversity in European farming is proposed. It contains indications on the sampling design (spatial, temporal). Several options are considered and tested with respect to the relationship between benefit (how informative the system would be) and the costs involved.

2. Approaches and data for a European sampling scheme

According to Brandt and Bunce (2002), the first aim in any survey is the efficient acquisition of data. One way of optimizing data collection is to use a stratification to integrate datasets and efficiently distribute samples. According to Lakhani (1981) as variability within the sampling frame is not known when designing a survey for large areas, the sampling effort can be optimised if the populations are stratified according to the environmental factors that influence the site characteristics and therefore also influence the variables of interest. Stratification may improve sampling efficiency as it improves the precision of the estimates and the cost effectiveness of the surveys. It also allows the production of estimates for broader areas (regional and national areas) from a limited number of samples and allows the results to be quantified with statistical descriptions of confidence. Sampling ecological data has been carried out by "stratifying across space and averaging to infer underlying processes and mechanism" (Liebhold and Gurevitch, 2002).

According to Jongman et al. (2006) objective stratifications can produce results based on quantitative information with minimal personal bias. Boundaries may be arbitrary, but they are defined through clear decision rules and therefore reproducible. Stratifications are a useful approach for getting insight into environmentally diverse areas. To analyse diversity in patterns and processes it is necessary to determine which areas and situations are comparable and what generalisation is possible. Knowing that environmental data are scale dependent and obey to a hierarchy of interaction between types of variables, in order: climate, geomorphology, geology, soil, vegetation / land cover and fauna is the ecological basis to produce an environmental stratification for sampling.

Statistical methods must be used to relate the sample to the larger population and to make inferences (Perry et al. 2000). Sampling from a clearly defined population, defined by a statistically objective way, allows measures of the errors associated with the population estimates to be expressed as the degree of confidence that can be placed in the results (Bunce et al. 1996). "From a statistical point of view, the core of spatial inventory is first of all sampling. For spatial inventory, sampling is done in space at one time. For monitoring, it is done in time, either at a single location (temporal sampling), or at multiple locations (space-time sampling)" (De Gruijter, 2000).

For upscaling in BioBio two approaches are possible:

1. A sample set of farms will be based on random sampling units spread over environmentally homogeneous populations to efficiently estimate the population parameters from the sample data.
2. A sample set of farms will be selected from the population of farms within a given administrative unit (e.g. district, NUTS region). If needed, the population of farms may be stratified according to farming types / farm typology (nested approach).

If the farm and the farming practice is the main driver of the differences in biodiversity between regions and the environmental conditions are secondary then the stratification should be based on farming areas (FADN). As farmers share a lot of their approaches within the region (practice, intensity, farm size) it is practical and appropriate to use farming administrative units as a starting point. The other approach is to use the NUTS regions as an entrance as this is generally used in Europe for administrative and statistical reasons. Soil data and climate data are available at NUTS level. This means that we can take the FADN regionalisation as a starting point (Figure 2) or the NUTS level (Figure 3) depending on available and accessible data.

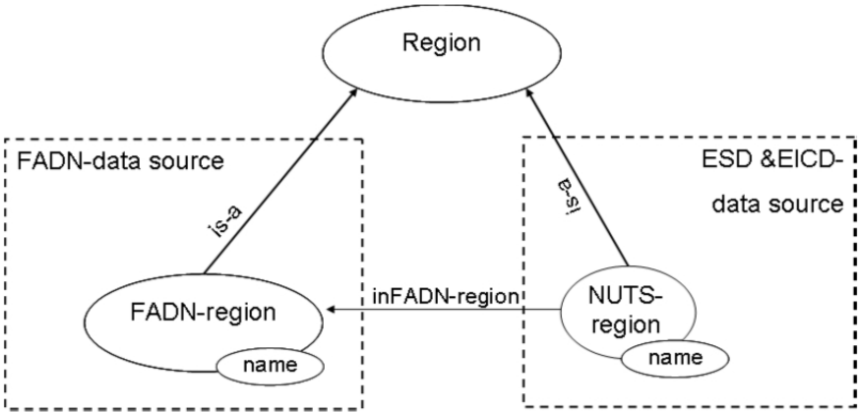


Figure 1. Different definitions of regions between data sources (Andersen et al 2010). ESD = European Soil Database; EICD = European Interpolated Climate Data.

FADN links the BioBio indicators to existing farm accountancy networks. However, we have to consider that there is a rather big variety in regions. As a country Austria, Czech Republic, Slovakia, Slovenia, the Netherlands, Ireland and the Baltic States are one region in FADN. Spain, Germany Belgium and Italy are divided according to Autonomous regions, Bundesländer and regions, while Switzerland and Norway are not included at all. For these countries a national regionalisation must be added. NUTS regions are available for all Europe including Switzerland and Norway and are scalable from local to national. Therefore it might be more logic to use NUTS regions as it will cover Europe better.

In general in landscapes with the same dominant land use type the landscape patterns will not change within a country, but might be different between countries such as between the Netherlands and Germany (Jongman 1996), where the landscapes between borders reflect clearly the land use practices and land use policy. This is caused by the history of land use: smallholders in the Netherlands compared to large land owners in Germany. The differences between southern Poland and Slovakia are caused by the collectivation process that took place in Slovakia in the 1950-1960s, but not in southern Poland. A test carried out in Estonia using Hyperspectral RS data (Lang et al, 2011) showed that habitat data collected in a central square in "homogeneous" landscapes represent about 50-70% of the habitats in the surrounding squares and that after adding 8-9 squares no increase in habitats occurred. Only in strong gradients (coastlines, foothills of mountains) this is different as there is no autocorrelation between squares. The risk of errors increases with the enlargement of the region.

The European datasets on farming such as Farm Accountancy Data Network (FADN) and Farm Structural Survey (FSS) cannot provide all the data on farm management that are needed for the use in indicators at the farm level (Anderson et al 2006). Examples of data that are not available in these European datasets are details of the farm typologies, fertiliser and livestock management practices (http://ec.europa.eu/agriculture/rica/methodology2_en.cfm#tuafooraamoc). In order to make the collected information operational and to link to the information in the EU-wide datasets a merging of data into regions or farm types should be used as a framework for presenting this additional data.

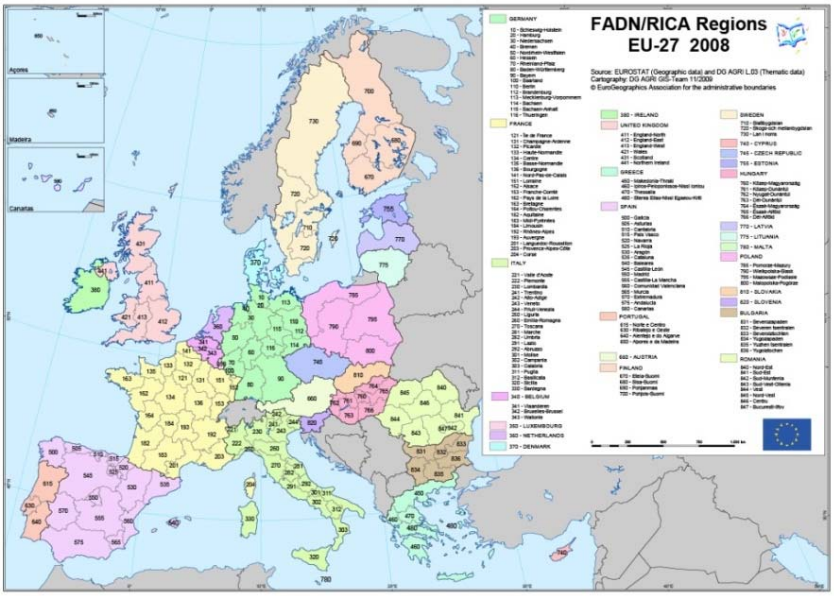


Figure 2. FADN regionalisation of the EU-27. There is a rather big variety between regions as Austria, Czech Republic, Slovakia, Slovenia, The Netherlands Ireland and the Baltic States are one region, Spain, Germany and Italy are divided according to Autonomous regions, Bundesländer and regions, while Switzerland and Norway are not included.

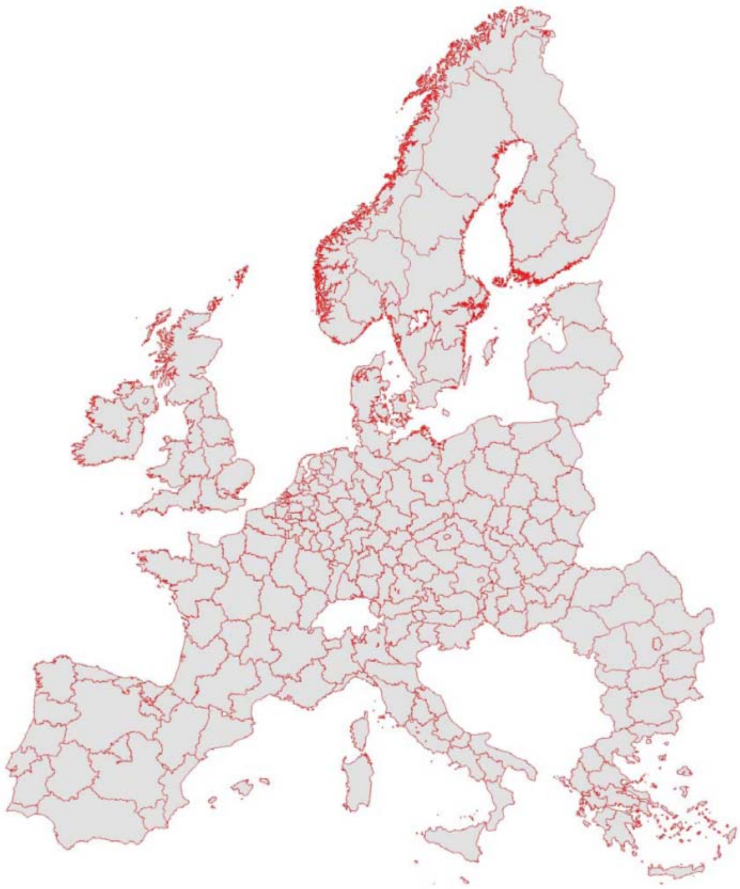


Figure 3. NUTS regions at level 3. Level 1 are the countries, level 2 are the regions. These are more or less in accordance with the FADN regions. According to this map Norway has also NUTS regions, but Switzerland does not (Anderson et al. 2010)

Figure 4. Environmental zones combined with NUTS regions. The Environmental zones are indicated by colours; the NUTS regions by the red lines (Andersen et al. 2010)

3. Design of a European sampling scheme for agrobiodiversity at farm level

3.1 Introduction

We propose to select farms by probability sampling within the NUTS regions and divided over the main farm types. This enables model-free, unbiased and valid estimation of target parameters and their standard errors (De Gruijter and Ter Braak, 1990; Brus and De Gruijter, 1997). This is impossible with non-probability sampling, like haphazard sampling, targeted sampling or convenience sampling. Valid quantification of the uncertainty of the monitoring result is important to avoid discussions on the statistical significance of estimated time trends in quality indicators and other target parameters (Brus et al 2011).

In the SEAMLESS project the farm typology has been built on (i) specialisation, (ii) land use, (iii) scale of production and (iv) intensity. This links best with the data from FADN as this is the only data set covering the entire territory of EU including information on all the dimensions.

Size, intensity and scale of farming are important dimensions in relation to economic and social aspects of farming. Small farms, with or without additional income from other sources than farming, often react differently to policy measures and/or market changes than larger farms and might, in many cases, contribute to the viability of rural areas in other ways than the larger farms. Small farms can be intensive horticulture farms or small farms with small incomes are subsistence farms or hobby farms. In FADN small farms and part-time farmers are not included. This means they are not counted in the statistics but do make part of the total farm number. In monitoring biodiversity, however, the type of land use and specialisation can be important. In the SEAMLESS database farms have been merged into 21 combined types of specialisation/land use types. This can be a basis for a European system for agrobiodiversity monitoring.

Upscaling requires then both information on the farms as well as on the regions. Essentially, it is the process of bringing information from the local level (in this case the farm) to the regional level. The adoption of a sampling strategy scheme involves the definition and delimitation of the target population that can be characterized in terms of farming type and their respective share of the farm population by the sample estimates. Populations are the farms in a region (e.g. district, NUTS region, group of NUTS regions) that is dominated by a certain farming type (olive farms, extensive cattle farms) or a combination of two or more farm types. The population is composed by N farms of each type, from which the sample will be drawn.

Upscaling has its limits as at the European scale climate differences influence the pattern of vegetation and the distribution of species. We have to determine the extent and the grain of observations. The extent of our observations is the upper limit where we can generalise and apply our knowledge and the grain is the minimum size of the information. In the BioBio case the grain is the farm and the data from the farm and the extent of its applicability is the region in which comparable farm types dominate such as the Bavarian case study region and the Spanish Olive grove case study region.

Table 1: The share of the farms, area, livestock units (LU) and output covered by the different size types, intensity types and specialisation/land use types in EU25 (Andersen et al 2010)

	Share of farms (%)	Share of area (%)	Share of LU (%)	Share of output (%)	Output/Area ratio
Arable/Cereal	12.4	18.6	2.2	9.4	0.5
Arable/Fallow	4.4	8.8	0.5	2.5	0.3
Arable/Others	6.3	6.1	1.1	4.8	0.8
Arable/Specialised crops	5.0	3.7	0.6	4.4	1.2
Total Arable	**28.1**	**37.2**	**4.4**	**21.1**	**0.6**
Beef and mixed cattle/Land independent	0.3	0.1	0.9	0.5	5.0
Beef and mixed cattle/Others	1.8	1.6	2.2	1.0	0.6
Beef and mixed cattle/Permanent grass	3.8	6.5	5.4	1.6	0.2
Beef and mixed cattle/Temporary grass	0.9	1.6	1.7	0.7	0.4
Total beef farming	**6.8**	**9.8**	**9.2**	**3.8**	**0.4**
Dairy cattle/Land independent	0.4	0.2	1.4	1.3	6.5
Dairy cattle/Others	6.9	7.6	10.8	10.2	1.3
Dairy cattle/Permanent grass	5.7	7.5	10.1	7.7	1.0
Dairy cattle/Temporary grass	2.2	2.8	3.4	3.3	1.2
Total Dairy farming	**85**	**112.1**	**53.9**	**72.3**	**1.2**
Horticulture	**27.2**	**7.7**	**0.4**	**14.1**	**1.8**
Mixed farms	6.6	11.0	11.8	8.5	0.8
Mixed livestock	2.3	2.7	8.9	4.2	1.6
Total Mixed farms	**8.9**	**13.7**	**20.7**	**12.7**	**0.9**
Permanent crops	**3.7**	**0.5**	**0.0**	**8.9**	**17.8**
Pigs/Land independent	0.9	0.6	10.8	4.4	7.3
Pigs/Others	1.2	1.3	10.7	4.7	3.6
Poultry and mixed pigs/poultry	1.0	0.5	9.0	3.7	7.4
Total pigs and poultry	**3.1**	**2.4**	**30.5**	**12.8**	**5.3**
Sheep and goats/Land independent	1.1	0.1	1.1	0.6	6.0
Sheep and goats/Others	6.0	10.4	7.2	3.5	0.3
Total sheep and goats	**7.1**	**10.5**	**8.3**	**4.1**	0.4

In the BIOBIO Dutch case study, for example, horticulture only represents 5% of the farms in the study area, divided between greenhouse farming, fruit production, perennial crops and tree nurseries with each between 1-2%. This means that horticulture was not a dominant farm type in that region and does not shape the population of farms. In the NUTS regions within the Netherlands some have no horticulture at all, while one region has 13%.

In general in the SEAMLESS database some farming types consist of mixed categories. Permanent crops can be olives as well as grapes and other fruit plantations and between them there will be great differences as can be seen in the two regions in Spain with a high percentage of permanent crops, Rioja and the eastern coast, where orange cultivation dominates.

Differences among organisms and biogeographic patterns of organisms affect the scale of observation. A honey bee and a vulture act on different spatial scales. Species can have differences in distribution. The earth worms of north-western Europe and southern Europe differ from each other in species and number. Plant species can differ in occurrence between biogeographic regions and the number of species within one group can be different. To address questions such as representativeness we must sharpen our thinking on extent, grain and scale. We have to analyse in which domain the presence of our species and habitats will fall. The species acting at European scale are different (Red Deer, Brown bear) from those acting at the landscape scale (mice, insects, bats) or the farm scale (e.g. earthworms). The reference species number also is different. In the Netherlands the number of occurring earthworms is 23 while in western Europe the total number of species is 35 (Grzimek 1971). In the Mediterranean region this can be much more; the eastern Mediterranean region (Turkey, Cyprus, Israel) Pavlicek et al. (2010) counted 81 species.

3.2 Sample selection and sample size

In this report we focus on the representativeness of the sampled area of a farm type for the region. To be able to upscale results the following parameters need to be known:

1. Size of total region (e.g. NUTS, District, Nation);
2. The dominant farm type in a region or the dominant combination of farm types
3. Number of farms in the region.

This will give a general indication of the representativeness of the sampled farms for the region. This can be fine-tuned by:

4. Number of the selected farming type sampled

In the BIOBIO case study areas we are only able to indicate the surface area we have sampled in relation to total regional size and the number of sampled farms in relation of the number of farms of a specific type in the region. Supposing that all farms have been randomly selected they are supposed to be representative for the biodiversity within this farming system.

In general, the sample set size (number of units that compose the sample) should be related to the heterogeneity of the region to be sampled, but this cannot be estimated in advance and is not susceptible to easy calculation during the sample survey (Bunce and Shaw, 1973). When deciding which is the best sample set it is the complex nature of the landscape, the spatial configuration of land use in each location and the heterogeneity of farm types that provide the basis of decision upon the optimal sample set size (Harrison and Dunn, 1993). It is necessary to have minimum number of sample farms in each region to produce acceptable estimates of their features. The optimum strategy for the allocation of samples to classes therefore depends upon the objective of the study (Bunce et al. 1996).

We are not carrying out an experiment in which conditions can be set, but working within life conditions that are complex, changing and unpredictable. Therefore it is not possible to state on beforehand how large the sample is needed to enable statistical judgments that are accurate and reliable and if we will detect effects. It is therefore important to prevent bias and improve sampling efficiency: develop a method for sample selection that are, at the lowest possible costs, precise enough for our purpose (Cochran 1977). If sample size is too low, it will be difficult to provide reliable answers, but if the sample size is too large, time and resources will be wasted and in a European set up this can be very costly. Therefore testing the sample size is an important step towards final sample proposal.

In the case of farm biodiversity measurement, we will not have access to all the farms in a region because the population is too large and too costly to measure and not all farmers are willing to cooperate. This means we only can sample a small proportion of the population. Therefore we make estimations on a region based on a relatively small amount of sample data. As we want to measure several variables to derive indicators we should aim for a variation that is not too big and that the variables within the region have the same distribution to let the sampling error to be as small as possible. In general, the larger the sample size *N,* the smaller sampling error *tends* to be. Once *N* is "large enough" to produce a reasonable level of accuracy, making it larger simply wastes time and money.

For selecting the samples we must decide on the total number of farms and on their distribution. In EBONE a proposal for sampling Europe was made to use a sample of 10,000 1 km squares in a rolling system of 2000 per year in subareas of the Environmental Stratification (Metzger et al 2005). The total area of Europe under consideration was in this case 4.027947 km^2 and the sample covers 0.25% of this area. In a case study for Portugal on representativeness of land cover for the (land cover) population of the region a sample of 10-40 sampling units have been used to represent the region of 3000 km^2, being 0.3-1,33 % of the area. Already 10 sample squares appeared sufficient for proper estimates, while mainly the SE (Standard Error) and the %CV (Coefficient of Variance) are being reduced by increasing the sample (Mateus 2004, Jongman et al. 2006). In the SEAMLESS study 15 sample farms per FADN region has been considered the minimum for characterising farm types for a region (Andersen et al. 2009). However, testing is required to conclude of the correctness of the proposed sample.

If BIOBIO is following the procedure that has been followed in SEAMLESS, then the number of farms in a region should be set at 15 per farm type. This is also the minimum aggregation level for FADN data.

Following the approach in the Portuguese study the number of farms is depending on the area of the region. This means that larger areas with more farms should contain proportionally more sample farms, but always with a minimum of 15. This means that all farms in a homogeneous region are numbered and if this population consists of e.g. 1000 farms then an agreed number, for instance 14 are randomly selected, being 1.4%. As the minimum is set on 15 it will be set higher to 15 to get the required minimum. When a region has 5000 farms the sample will be set at 70 sample farms if the sample size is set at 1.4%. If we need 1%, 1.4% or 2% is an issue that is to be determined by homogeneity of a region, the available budget for data collection, the standard error (SE) that is considered acceptable and the indicator applied.

3.3 Detecting change

From the BIOBIO CS we can estimate the variability of the data, hence we could make an estimate of the number of farms required to detect whether a certain difference between the indicator values monitored over time is statistically significant, e.g. the number of horticultural farms required to detect a decrease of the number of plant species per farm between 2015 and 2020 at $p<0.05$.

To this end we have to discuss with statisticians and stakeholders about the thresholds which are “significant” and “meaningful” for stakeholders. Is loss or gain of one species per farm a change or variability? This depends on the detection error of a variable as well as on the total population of a species. If the total number of earthworms occurring in the Netherlands is 15, what does a change in number of one or two species mean and how big should the sample at a farm be to get a high probability of change? When is a difference a detection error or real change? This requires testing. If the total pool of plant species in a region is 50, then what about the other indicators? We can work this out for the case study regions and for some key indicators. We have:

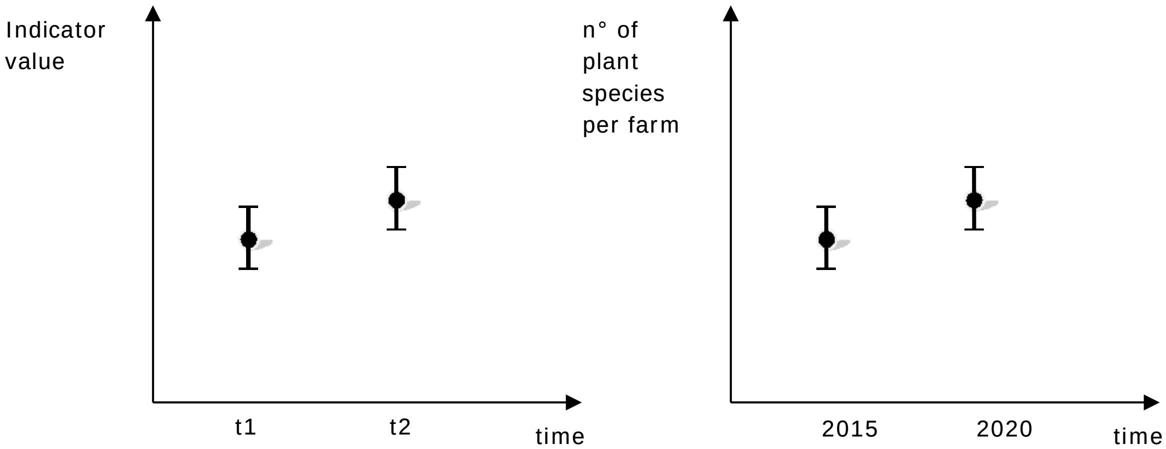
- Indicator values
- Their variability based on up to 20 farms
- The total farm population of the selected farm type in "the region"

We need to:

- Determine which change of the indicator value we consider as relevant
- Determine which level of significance we want to aim for ($p<0.05$? $p<0.1$?)
- What temporal scale we want to apply (e.g. 5 year intervals with rolling survey, such as Biodiversity monitoring in Switzerland or also as proposed by EBONE)

Then we can:

- Propose a sampling strategy
- Estimate the cost of its implementation



According to Fortin et al. (2002) "Ecological data is characterized by spatial structures due to spatial autocorrelation. Spatial correlation refers to the pattern in which nearby locations are likely to have similar magnitude than by chance alone". Ecological data exhibit some degree of spatial autocorrelation, depending also on the spatial scale on which the data is collected and then analysed. The inherent spatial autocorrelation of the ecological data has fundamental environmental implications: it violates assumptions of independence required by many parametric inferential tests. However, it perfectly reflects the real situation in the field. In biodiversity monitoring, the sampling strategy should take into account the possible and probable autocorrelation of the data collected depending on the organism under investigation. Spatial analysis of the data is then integral part of the analysis in a spatio-temporal design.

4. European farming regions for biodiversity monitoring

4.1 Methods

To design more or less homogeneous regions use has been made of the SEAMLESS database (Anderson et al 2006, 2010). This is the best database based on FADN and covering the EU 25, but with still gaps for Switzerland and Norway concerning the underlying agricultural data as well as incomplete coverage for Bulgaria and Romania. However, if this regionalisation works then the other countries could be added in a later phase. We have used the database and analysed this on farming types.

After testing the regionalisation in the database it appears that NUTS regions gave the best results on regions. The variables intensity and scale are not discriminating well at the European scale, but typology was a good entrance for division. The following steps have been set

1. At the level of NUTS2 all regions have been analysed on area covered by different farming scale, farming intensity and farming type;
2. Farming scale and intensity have not been used further as they were not enough discriminating;
3. Farming types (Table 1) have been aggregated into major types (see Table 2, bold);
4. Dominant farming types have been aggregated until 75% area cover of the UAA was reached; this varied from 1-4 farming types;
5. For all regions the location in an environmental zone has been identified.
6. Within a country comparable NUTS regions have been merged based on categories >75%, 50-75% and 15-50% coverage of farming types and it has been taken care that Mediterranean types did not fall in the same farm type region as Continental and Atlantic.

The NUTS-2 regions have been chosen as first level of analysis, because the highest level they can reach is the country level (e.g. Luxemburg, Denmark, Latvia). National policies can be of influence of farm structure and farm management, due to historical developments and national regulations for land management. European policies are being interpreted differently between countries.

It has also been taken care that contrasting biogeographic regions are not mixed by using a layer of the environmental zones that is included in the SEAMLESS database. There are of course regions with more environmental zones, but all this information is used to identify the final zonation.

4.2 Results

In the northern part of Europe the division of agrobiodiversity regions is rather consistent with the Environmental zones. Many of the regions are predominantly in one Environmental zone. Countries where this is not the case are Austria, France, Spain, Greece, Portugal and Italy. These Mediterranean countries share both the Mediterranean zones (North, South and Mountains), Lusitanian and Alpine South. This means that the variability in the species indicators can be higher than in other northern regions. This might be expected for the Mediterranean countries. If this is also the case for Austria cannot be confirmed at this stage.

Table 2. Biodiversity monitoring zones for the EU25 based on NUTS zones level 2 and Environmental Strata. Total farmland (ha), share of farm types and of environmental strata (% of area).

	Total UAA [ha]	Arable	Beef	Dairy	Horticulture	Mixed farms	Permanent crops	Pigs	sheep goats , Poultry	1 Alpine North	2 Boreal	3 Nemoral	4 Atlantic North	5 Alpine South	6 Continental	7 Atlantic Central	8 Pannonian	9 Lusitanian	10 Med Mountains	11Med North	12 Med South
BIOAT1	860382	48.60%	9.40%	11.50%	0.00%	15.20%	11.40%	3.00%	1.00%						58%		42%				
BIOAT2	658597	12.20%	19.20%	44.30%	0.90%	12.30%	1.00%	7.30%	2.70%					36%	63%						
BIOAT3	549438	2.60%	31.70%	56.50%	0.00%	4.30%	0.20%	1.00%	3.70%					86%	14%						
BIOBE1	374575	9.70%	42.90%	35.00%	0.90%	9.40%	0.20%	1.50%	0.50%						66%	34%					
BIOBE2	175167	19.70%	24.30%	16.80%	2.50%	23.90%	1.40%	10.90%	0.40%							100%					
BIOBE3	791906	33.40%	10.20%	7.40%	2.40%	23.40%	0.30%	1.90%	0.00%						19%	81%					
BIOCZ1	530915	76,6%	1,3%	1,2%	4,2%	16,6%	0,0%	0,0%	0,0%					3%	97%						
BIOCZ2	2447229	42,2%	12,8%	5,8%	0,0%	37,4%	0,6%	0,2%	0,9%					17%	83%						
BIODE1	701341	32,1%	4,9%	28,1%	0,5%	23,8%	2,0%	4,3%	4,4%					1%	61%	34%	4%				
BIODE2	2452806	20,7%	7,0%	45,9%	0,3%	21,2%	0,2%	2,8%	1,9%					3%	97%						
BIODE3	3712331	43,1%	6,0%	15,3%	0,1%	31,4%	0,2%	2,1%	1,8%				28%		71%		1%				
BIODE4	7435007	52,7%	5,5%	15,3%	0,4%	22,7%	0,4%	2,2%	0,8%				29%	4%	58%	8%	1%				
BIODE5	980303	13,0%	7,1%	39,6%	0,2%	23,8%	0,4%	10,3%	5,7%				81%		5%	14%					
BIODK1	2136770	51,4%	0.9%	15.0%	0.5%	23.3%	0.2%	7.1%	1.5%				64%		36%						
BIOEE1	827599	38,7%	9,1%	27,0%	0,4%	20,1%	0,2%	0,1%	4,3%		53%	47%									
BIOES1	979965	0,8%	65,6%	31,7%	0,2%	1,4%	0,0%	0,0%	0,2%					8%				90%	2%		
BIOES2	6888416	70,5%	8,5%	0,9%	0,8%	7,8%	3,8%	0,9%	6,8%					4%				4%	23%	51%	18%
BIOES3	5430805	27,6%	11,6%	0,7%	0,8%	27,0%	6,0%	2,0%	24,3%					1%				3%	9%	12%	75%
BIOES4	13534422	47,5%	13,7%	3,0%	1,0%	15,5%	4,6%	1,2%	13,3%										6%	25%	70%
BIOES5	99247	48,3%	0,3%	0,0%	8,9%	3,3%	31,6%	0,1%	7,5%					8%				9%	22%	38%	23%
BIOFI1	3621751	45,4%	7,8%	30,2%	0,3%	12,2%	0,0%	2,4%	1,6%	11%	89%										
BIOFR1	5785150	74,6%	4,5%	2,9%	0,1%	16,5%	0,6%	0,0%	0,8%						2%	97%		1%			
BIOFR2	4639189	17,3%	15,8%	35,8%	0,3%	26,7%	0,3%	1,8%	2,0%						5%	58%		37%			
BIOFR3	3625077	43,3%	20,3%	8,1%	0,0%	26,6%	0,5%	0,0%	1,2%						5%	94%	1%				
BIOFR4	2511337	50,1%	10,6%	3,9%	0,5%	18,7%	5,3%	0,5%	10,5%					1%		2%		93%	0%	4%	
BIOFR5	6796365	22,3%	33,7%	14,0%	0,3%	10,8%	1,7%	0,4%	16,9%					25%		21%		10%	20%	20%	2%

	Total UAA [ha]	Arable	Beef	Dairy	Horticulture	Mixed farms	Permanent crops	Pigs	sheep goats , Poultry	1 Alpine North	2 Boreal	3 Nemoral	4 Atlantic North	5 Alpine South	6 Continental	7 Atlantic Central	8 Pannonian	9 Lusitanian	10 Med Mountains	11Med North	12 Med South
BIOGR1	1848111	81,0%	2,7%	0,6%	0,8%	7,0%	4,4%	0,0%	3,5%					2%			1%		14%	55%	28%
BIOGR2	275478	57,6%	2,2%	0,5%	1,0%	18,8%	4,6%	0,0%	15,4%					1%					49%	31%	18%
BIOGR3	33211	15,3%	0,0%	0,0%	9,8%	17,2%	31,1%	0,0%	26,6%												100%
BIOHU1	3688487	73,9%	0,1%	4,8%	0,6%	15,2%	1,0%	0,5%	3,9%						7%		91%		2%		
BIOIE1	4514462	3,4%	50,7%	22,2%	0,0%	5,4%	0,0%	0,0%	18,2%				17%			83%					
BIOIT1	4792278	57,0%	11,8%	8,3%	0,6%	9,1%	4,3%	2,7%	6,1%					13%					37%	49%	1%
BIOIT2	313934	0,9%	14,3%	55,6%	0,1%	1,9%	7,2%	0,0%	20,0%					87%					13%		
BIOIT3	25141	49,7%	22,0%	6,3%	14,8%	4,6%	1,0%	0,0%	1,5%										75%	25%	
BIOIT4	1827183	54,9%	11,6%	0,7%	0,9%	7,6%	15,1%	0,0%	9,3%										3%	36%	62%
BIOIT5	2340654	30,6%	10,9%	2,8%	0,6%	11,0%	3,0%	0,1%	40,9%										16%	43%	41%
BIOLT1	1777701	49,9%	5,5%	16,8%	0,2%	25,7%	0,2%	0,5%	1,1%			98%			2%						
BIOLU1	98022	5,3%	32,4%	42,3%	0,0%	16,4%	0,7%	0,9%	2,1%						42%	58%					
BIOLV1	1119915	40,3%	2,3%	30,3%	0,1%	23,5%	0,1%	0,5%	2,9%		30%	67%			3%						
BIONL1	688859	41,8%	0,2%	33,1%	2,2%	7,6%	0,2%	0,5%	14,4%				17%		3%	81%					
BIONL2	181531	2,3%	3,3%	56,3%	13,1%	12,9%	3,5%	4,3%	4,3%				81%			19%					
BIONL3	650706	14,4%	1,7%	61,6%	4,2%	6,2%	2,0%	1,2%	8,8%				40%			60%					
BIOPL1	2801582	64,5%	1,9%	4,5%	0,3%	23,6%	0,1%	2,6%	2,5%					1%	99%						
BIOPL2	8102980	31,5%	4,4%	9,8%	0,9%	43,7%	0,8%	7,1%	1,8%			3%			97%						
BIOPL3	950902	10,3%	17,4%	30,8%	0,1%	36,9%	0,0%	3,0%	1,4%			49%			51%						
BIOPT1	2194944	19,5%	22,4%	1,5%	0,9%	25,7%	4,6%	0,5%	25,0%									22%	1%	41%	36%
BIOPT2	12908	1,3%	0,7%	0,0%	14,0%	0,7%	0,7%	0,0%	82,6%												100%
BIOSE1	1568425	52,7%	10,3%	19,0%	0,5%	15,3%	0,0%	1,1%	1,2%		7%	73%			21%						
BIOSE2	801555	20,7%	20,2%	46,2%	0,0%	11,6%	0,0%	1,2%	0,0%	5%	40%	43%			12%						
BIOSI1	369033	13,5%	16,6%	20,2%	0,5%	25,3%	2,2%	0,5%	21,3%					75%	6%		1%		17%	1%	
BIOSK1	669782	67,7%	0,0%	2,3%	0,0%	27,8%	0,3%	0,0%	1,8%						49%		51%				
BIOSK2	1043507	31,2%	8,7%	19,3%	0,0%	28,5%	0,1%	0,0%	12,1%	0%				11%	82%		6%				
BIOUK1	2692484	16,8%	14,0%	17,9%	0,3%	8,7%	0,0%	0,3%	42,0%				92%			8%					
BIOUK2	5838908	57,8%	5,2%	11,5%	0,6%	11,1%	0,3%	0,4%	13,0%				13%			87%					
BIOUK3	4695305	10,0%	12,7%	7,7%	0,0%	5,6%	0,0%	0,0%	64,1%				94%			6%					

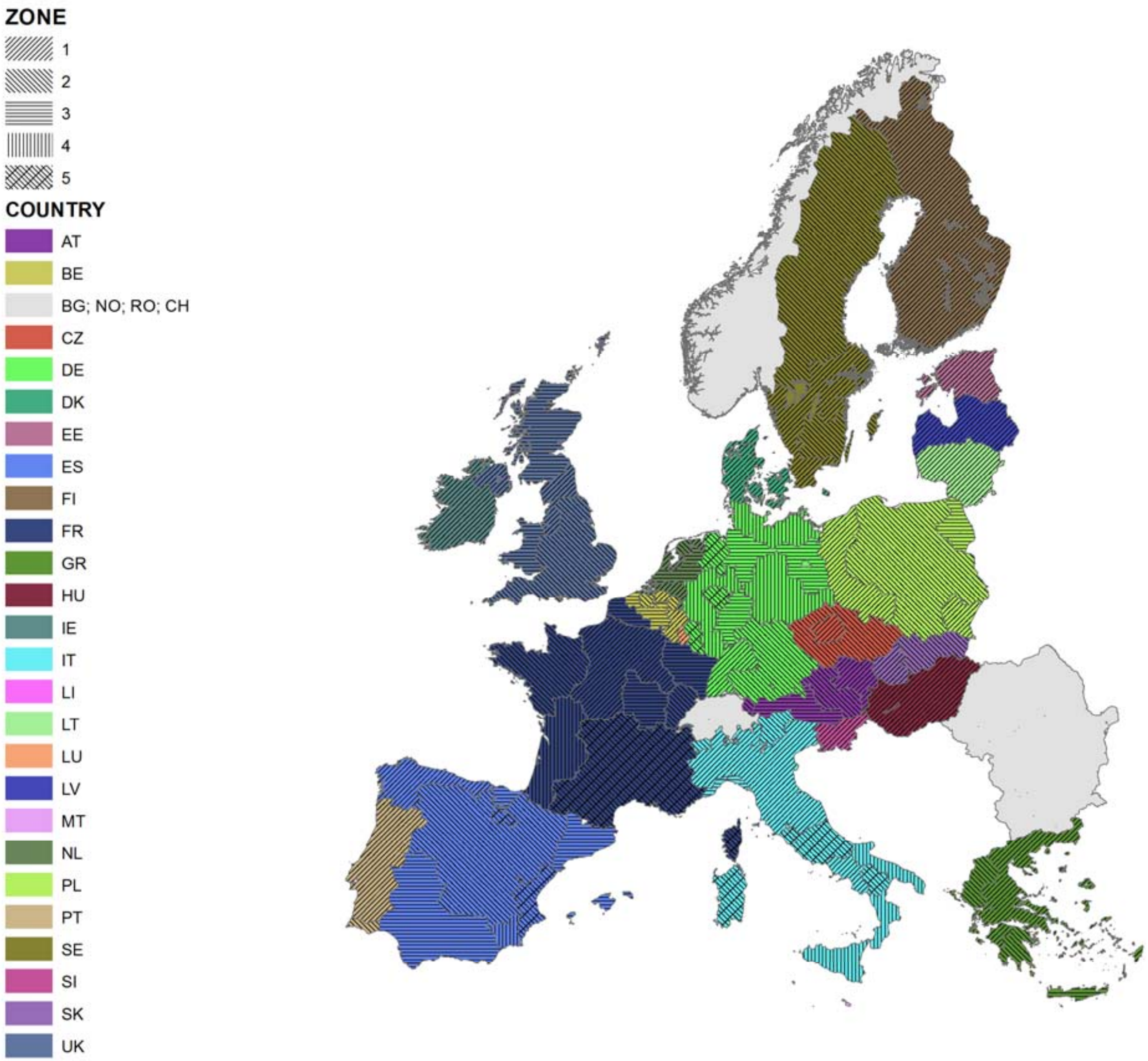


Figure 5. Agrobiodiversity monitoring regions in EU 25. The regions are made up by country+zone. Up to five zones can occur in one country. The dominant farm type is indicated in Table 2.

Table 3: Farms per farming type (number and %) in the different zones.

REGION	number	arable	%	beef	%	dairy	%	horticulture	%	mixed	%	permanent	%	pigs	%	sheep	%
BIOAT1	24446	8335	34%	2969	12%	4385	18%			3327	14%	4055	17%	1128	5%	247	1%
BIOAT2	24250	1814	7%	4175	17%	75	0%			3032	13%	1556	6%	2141	9%	522	2%
BIOAT3	10782	380	4%	2009	19%	6429	60%			641	6%	88	1%	383	4%	256	2%
BIOBE1	8731	707	8%	2718	31%	3131	36%	962	11%	590	7%	79	1%	503	6%	41	0%
BIOBE2	7178	963	13%	1129	16%	1224	17%	1258	18%	1201	17%	274	4%	1008	14%		
BIOBE3	12725	3333	26%	2395	19%	1678	13%	569	4%	3908	31%	143	1%	623	5%	62	0%
BIOCZ1	24446	8335	34%	2969	12%	4385	18%		0%	3327	14%	4055	17%	1128	5%	247	1%
BIOCZ2	10256	4331	42%	1666	16%	849	8%			2567	25%						
BIODE1	15187	3535	23%			4312	28%			2934	19%	1727	11%	651	4%		
BIODE2	59080	8541	14%			33014	56%			9474	16%						
BIODE3	23857	7771	33%			5433	23%			5944	25%						
BIODE4	47723	15978	33%			9304	19%			9750	20%						
BIODE5	18952	1552	8%	1828	10%	6674	35%			3889	21%			3100	16%		
BIODK1	30715	17908	58%			4085	13%			5410	18%			1451	5%		
BIOEE1	7103	3138	44%	405	6%	1287	18%			1275	18%					521	7%
BIOES1	61671			40115	65%	18463	30%										
BIOES2	167205	94893	57%	8228	5%					14128	8%	35492	21%			8299	5%
BIOES3	126440	43912	35%	4982	4%			20770	16%	16754	13%	16401	13%	4352		16323	13%
BIOES4	7188	511	7%					3593	50%	2081	29%	407	6%			274	4%
BIOES5	30599	10537	34%					3111	10%			8864	29%				
BIOFI1	37270	16858	45%	1972	5%	5673	15%			3537	9%			795	2%	424	1%
BIOFR1	48264	32644	68%	2421	5%	2569	5%			8020	17%						
BIOFR2	72175	11276	16%	10207	14%	27443	38%			16215	22%						
BIOFR3	34715	15287	44%	5693	16%	3767	11%			8274	24%						
BIOFR4	40588	16992	42%	3705	9%	2085	5%			6379	16%					4010	10%
BIOFR5	96023	23070	24%	24240	25%	13765	14%			9952	10%					11209	12%
BIOGR1	237577	151512	64%							16315	7%	44251	19%			12156	5%
BIOGR2	53599	22540	42%							7395	14%	12803	24%			5355	10%
BIOGR3	31368	6262	20%					4707	15%	2687	9%	15471	49%			1919	6%
BIOHU1	69367	42299	61%	3304	5%					11588	17%					1926	3%
BIOIE1	98786			51069	52%	18826	19%									18796	19%
BIOIT1	254490	132867	52%	15200	6%	12556	5%			20104	8%	42876	17%	4105	2%	10087	4%
BIOIT2	11456		0%	1073	9%	5542	48%					2928	26%			775	7%
BIOIT3	9409	2842	30%	113	1%	138	1%	4704	50%			1253	13%				
BIOIT4	132844	61086	46%	3952	3%					5330	4%	51549	39%			3799	3%
BIOIT5	97300	38717	40%	5643	6%					8783	9%	20464	21%			15677	16%
BIOLT1	38650	13137	34%	3421	9%	8785	23%			12028	31%						
BIOLU1	1284	61	5%	388	30%	552	43%			221	17%						

REGION	number	arable	%	beef	%	dairy	%	horticulture	%	mixed	%	permanent	%	pigs	%	sheep	%
BIOLV1	21875	6131	28%			8193	37%			5970	27%						
BIONL1	15552	5159	33%			4023	26%			1406	9%					2764	18%
BIONL2	11547		0%			4211	36%	1506	13%	1568	14%						
BIONL3	26484	2855	11%			10213	39%	5716	22%	1383	5%					2641	10%
BIOPL1	106727	47916	45%			5478	5%			41106	39%						
BIOPL2	572954	149130	26%	24246	4%	48028	8%			258789	45%			39192	7%		
BIOPL3	55974	5683	10%	8483	15%	15222	27%			23620	42%			1673	3%		
BIOPT1	65767	20661	31%	3960	6%					12205	19%					6236	9%
BIOPT2	1131							167	15%							760	67%
BIOSE1	18897	9974	53%	1863	10%	3051	16%			2640	14%						
BIOSE2	6470	1234	19%	1413	22%	2961	46%			649	10%						
BIOSI1	38564	6255	16%	5622	15%	6448	17%			10173	26%					6312	16%
BIOSK1	1822	1338	73%							202	11%						
BIOSK2	1878	795	42%	156	8%	243	13%			373	20%					307	16%
BIOUK1	21700	3159	15%	4406	20%	5841	27%									5564	26%
BIOUK2	42608	20402	48%	6041	14%					3902	9%					4810	11%
BIOUK3	18409	3211	17%	3716	20%	3895	21%			1367	7%					6799	37%

The following regions have been identified and can be characterised by Farming combinations in area and number of farms and Environmental Zone:

Austria:

BIOAT1: ENV Zone: Continental and Pannonian, 50% arable, the remaining is equally divided between dairy farming, mixed farming and permanent crops (vineyards). The number of farms is dominated by arable with farms with permanent crops.

BIOAT2: ENV Zone Continental (63%) with an aspect of Alpine South; there is 44% dairy farming and 19% beef raising and 12% for both mixed farms and arable farming, with a comparable division in farm number

BIOAT3: Dominated by Alpine south (86%) and some continental climate. Farming is mainly dairy farming (56%) and Beef farming (32%)

Belgium:

BIOBE1: 66% in Continental (Ardennes) and 34% in Atlantic Central, mainly beef raising(42%) and dairy farming (35%) in area; however the farm numbers are 35% and 31% respectively with also 16% horticulture farms covering only 1.4% of the area.

BIOBE2, ENV Zone: 100% Atlantic Central; in area there is a mix of farming systems without dominance. Arable, beef, dairy and mixed farms are equally important in area (between 20 and 25%. 42% are arable farms and 30% mixed farms; the arable farms are larger as they form only 30% of the number of farms.

BIOBE3 Env Zone: This zone is mainly Atlantic and covered for 36% in arable and mainly continental; 30% mixed farms and 20% beef farming; the farm distribution reflects this well.

Czech Republic

BIOCZ1: Env Zone Continental, 76% arable; this is well reflected in the farm distribution except for horticulture (4.2% of the area) that counts for 17% of the farms.

BIOCZ2: ENv Zone Continental, 42% arable, 37% mixed farming; this is well reflected in the farm distribution with smaller numbers in beef and dairy farming.

Germany

BIODE1 Env Zone: 61%Continental, 34%Atlantic Central; mix of arable (32%), dairy (28%) and mixed farming (24%), which is well reflected in the distribution of farms except for permanent crops (area 2.0%) counts for 11% of the farms.

BIODE2 Env Zone: Continental; In area this is covered for 45% by dairy farming, 21% mixed farming and 21% arable farming; this is well reflected in the number of farms per type.

BIODE3 Env Zone: 71% Continental, 28% Atlantic North; it is covered by 43% arable, 31% mixed farming and 15% dairy farming; it is clear that arable farms are larger than mixed farms and these again are larger than the dairy farms.

BIODE4: Env Zone: 58% Continental, 29%Atlantic North; 53% arable, 22% mixed farming and 15% dairy farming; also here the arable farms are much larger than mixed and dairy farms that have a more or less comparable amount (19-20%).

BIODE5: Env Zone: Atlantic North, 40% dairy, 24% mixed farming in area; they make up respectively 35% and 21% of the number of farms while the area of 10% pig farms count for 16% of the farms.

Denmark

BIODK1 Env Zone: Atlantic North 64%, Continental 36%; there is about 51% arable, 23% mixed farming, while dairy is counting for 15% and pig farming for 7%. This is more or less reflected in the number of farms.

Estonia

BIOEE1 Env Zone: Boreal 53%, Nemoral 47%; the UAA covered for 39% by arable, 27% by dairy farming and 20% by mixed farming. This is reflected in the number of farms.

Spain

BIOES1 Env Zone: Lusitanian; 66% of the area is beef raising, 32% dairy farming; this is also reflected in the number of farms.

BIOES2 Env Zone: 51% Mediterranean North, 23% Mediterranean mountains; the UAA is for 71% arable, 8 % beef and mixed farming and less than 4% permanent crops. However permanent crops count for 21% of the farms.

BIOES3 Env Zone: 75% Mediterranean South, 28% arable, 27% mixed farming and 24% sheep and goats. The arable are relatively small as the take 35% of the farms. Sheep farming is relatively large scale as they count only for 13% of the farms. Although horticulture covers only 0.8% of the UAA, they count for 16% of the farms.

BIOES4 Env Zone: 70% Mediterranean South; this is a small area with 47% arable, 15% mixed farming, 13% sheep and goats; although horticulture covers 1% of the area it counts for 50% of the farms.

BIOES5 Env Zone: 38% Mediterranean North, 23% Mediterranean South, 22% Mediterranean Mountains; 48% arable, 32%permanent crops (vineyards, citrus); arable farms count for 34%, permanent crops for 29% and horticulture for 10%.

Finland

BIOFI1 Env Zone: 89% Boreal; 45% arable, 30% dairy farming; the number of farms is more or less comparable over the different types.

France

BIOFR1 ENV Zone: 97% Atlantic central; 74% of the UAA is arable, 16% mixed farms. The number of farms s compatible with the area.

BIOFR2 Env Zone: 58% Atlantic Central, 37% Lusitanean; the UAA is for 36% in dairy farming, 27% mixed farming, 17% arable and 15% beef raising; the number of farms has a more or less comparable division.

BIOFR3 Env Zone: 94% Atlantic Central; the main farming types are arable (43%), beef raising (20%) and mixed farming (26%); the division over farms is comparable.

BIOFR4 Env Zone: 93% Lusitanian; the main land uses are arable (50%), mixed farms (19%), beef and sheep (both 11%); the distribution over farms is more or less comparable.

BIOFR5 Env Zone: 25% Alpine south, 21% Atlantic, 20% Mediterranean mountains, 20% Mediterranean North; Beef raising covers the largest area (33%), arable covers 22%, sheep and goats 17% and dairy 14%; this is also expressed in the division of farms.

Greece

BIOGR1 Env Zone: 55% Mediterranean North, 28% Mediterranean South and 14% Mediterranean Mountains; The UAA is 81% arable and 7% mixed farms, 4.4% permanent crops and 3% sheep and goats; the division over farm types is comparable, with a relatively lower number of arable farms (64%) and a relatively higher number of farms with permanent crops (19%).

BIOGR2 Env Zone: 49% Mediterranean mountains, 31% Mediterranean North and 18% Mediterranean South; The UAA is 58% arable, 19% mixed farms, 15% sheep and goats and 5% permanent crops. The division over farms is comparable except for permanent crops that count 24% of the farms.

BIOGR3 Env Zone: 100% Mediterranean South; Here 31% are covered by permanent crops, 27% are used for sheep and goats, 17% are in mixed farms and 15% are arable. In numbers 49% of the farms are growing permanent crops, while only 6% are having sheep and goats, the region has 15% horticulture farms.

Hungary

BIOHU1 Env Zone: 91% Pannonian; The UAA is for 74% arable, 15% mixed farming and 5% dairy farming. The division over farms is comparable.

Ireland

BIOIE1 Env Zone: 83% Atlantic central, 17% Atlantic North; the UAA is for 51% covered by beef raising, 22% dairy farming and 18% by sheep and goats. The division over farms is comparable.

Italy

BIOIT1 Env Zone: 49% Mediterranean North, 37% Mediterranean Mountains and 13% Alpine South; the UAA is for 57% arable, 12 % are beef raising, 9% mixed farming and 8% dairy farming, 6% sheep and goats and 4% permanent crops. The division over farms is comparable except for permanent crops which count for 17% of the farms.

BIOIT2 Env Zone: 87% Alpine South, 13% Mediterranean Mountains; dairy farming covers 56% of the UAA, sheep and goats 20%, beef raising 12%, mixed farms 9% and permanent crops 4%. The division over farms is comparable except for permanent crop farming that counts 26% of the farms.

BIOIT3 Env Zone: 75% Mediterranean Mountains, 36% Mediterranean North; it is a small coastal area of which the UAA is covered for 50% by arable farming, 22% beef and 15% horticulture. The large area of horticulture is expressed in the number of horticulture farms (50%); the beef farms are low in number (1%).

BIOIT4 Env Zone: Env Zone 62% Mediterranean South, 36% Mediterranean North; 55% of the UAA is covered by arable farming, 15% in permanent crops, 12% by beef raising and 9% sheep and goats. The distribution over farm type is comparable, except for permanent crop farms that make up 39% of the farms.

BIOIT5 Env Zone: 43% Mediterranean North, 41% Mediterranean South; 41% of the UAA are covered by sheep and goat farms, 31% by arable, 11% by mixed farms and 11% by beef raising farms, permanent crops cover only 3%. The arable farms make up 40%, the permanent crop farms 21% and the sheep farms only 16%.

Lithuania

BIOLT1 Env Zone: 98% Nemoral; the UAA is 50% arable, 26% mixed farming and 17% dairy farming. The division over farm types is more or less comparable.

Luxemburg

BIOLU1 58% Env Zone: Atlantic Central, 42% Continental; UAA is for 42% dairy farming, 32% Beef raising and 16% mixed farming. The division of farms is comparable.

Latvia

BIOLV1 Env Zone: 67% Nemoral, 30% Boreal; the UAA is 40% arable, 30% dairy farming and 24% mixed farms. Arable farms are less than dairy farms (28% versus 37%), which indicates considerable size differences.

Netherlands

BIONL1 81% Env Zone: Atlantic Central, 17% Atlantic North; UAA is arable for 41%, dairy farming for 33% and sheep and goat farming for 14%. This is also reflected in the number of farms per category.

BIONL2 Env Zone: 81% Atlantic North, 19% Atlantic Central; in this small region UAA is 56% dairy farming and 13% horticulture and mixed farming. This is reflected in the number of farms per category; it also means that horticulture farms are large in this region.

BIONL3 Env Zone: 40% Atlantic north, 60% Atlantic Central; in this region there is 62% dairy farming, 14% arable farming, 9% sheep and 6% mixed farming. Although horticulture is only 4% of the UAA if counts for 22% of the farms; the other farms are divided comparable to the area.

Poland

BIOPL1 Env Zone: 99% Continental; here UAA is composed of 65% arable and 24% mixed farms; this is reflected in the number of farms per category.

BIOPL2 Env Zone: 97% Continental; UAA consists of 44% mixed farms, 32% arable and 10% dairy farming. This is reflected in the distribution of farms over these categories.

BIOPL3 Env Zone: 51% Continental, 49% Nemoral; UAA is made for 37% of mixed farming, 31% of dairy farming and 17% of beef raising. This is also reflected in the farms over the different categories.

Portugal

BIOPT1 Env Zone: 41% Mediterranean North, 36% Mediterranean South, 22% Lusitanian; the UAA is 26% mixed farming, 25% sheep and goats, 22% beef raising and 20% arable. This is not reflected in the division of farms, as 31% of the farms are arable, only 89% are sheep farms and only 6% are beef farms.

BIOPT2 Env Zone: 100% Mediterranean South; this is a small region (Algarve) in which UAA is made for 83% by sheep farming an 14% by horticulture. This is reflected in the division of farms.

Sweden

BIOSE1 Env Zone: 73% Nemoral, 21% Continental; the UAA is 53% arable, 19% dairy farming and 15% mixed farming. This is reflected in the farm distribution.
BIOSE2 Env Zone: 43% Nemoral, 40% Boreal; the UAA consists of 46% of dairy farming, 21% arable, 20% beef raising and 12% mixed farming. This is well reflected in the distribution of farms over the types.

Slovenia

BIOSI1 Env Zone: 75% Alpine South, 17% Mediterranean Mountains; the UAA consists for 25% of mixed farms, 21% of sheep farming, 20% of dairy farming, 16% of beef farming and 13% arable. This is also reflected in the number of farms per category.

Slovakia

BIOSK1 Env Zone: 51% Pannonian, 49% Continental; 68% of the UAA is in arable farming, 28% in mixed farming. The division of farms is 71% arable and 11% mixed farming.
BIOSK2 Env Zone: 82% Continental, 11% Alpine South; there is a high variety in land use; 31% of the UAA are in arable farming, 29% mixed farming, 19% dairy farming and 12% sheep farming. Of the farms 42% are arable, 20% are mixed farms, 16% are sheep farms and 13% are dairy farms.

United Kingdom

BIOUK1 Env Zone: 92% Atlantic North, 8% Atlantic Central; the UAA is for 42% in sheep farming, 18% in dairy farming, 17% arable and 14% beef raising. The farms are 27% dairy farms, 26% sheep farms, 20% beef raising and 15% arable farms.
BIOUK2 Env Zone: 87% Atlantic Central, 13% Atlantic North; the UAA is for 58% arable, 13% sheep farming, 12% dairy farming and 11% mixed farming. The farms are divided in 48% arable farms, 14% beef farms, 11% sheep farms.
BIOUK3 Env Zone: 94% Atlantic North, 6% Atlantic Central; In this region the UAA is for 64% in sheep farming, 12% in beef farming and 10% arable farming. The sheep farms make up 37% of the total number of farms, dairy farms 21%, beef raising farms 20% and arable farms 17%.

4.3 Defining the sample size

For selecting the samples we must estimate the total number of farms and their distribution across and within the regions. As the farms in the regions vary considerably in size and intensity, it will be impossible to carry out a thorough statistical analysis of the minimum number of farms given a requirement on the quality of the monitoring result. In illustrating the types of spatial sampling design we used a tentative percentage of the farms to be sampled. This has to be based on a balance between statistical rigor and available budget.

The guidelines from the BioBio project have focused on the scientific soundness of the building blocks of this process and cannot deliver an answer on which monitoring scheme is most ideal. When considering actually implementing a monitoring scheme, iteration is likely to take place to find the best compromise between available financial resources, what knowledge is required to reach the monitoring objective and which sampling design is still considered to be scientifically sound. This iteration is a negotiation between political will and priorities and scientific evidence. This means that it makes sense to take the budget spent for agri-environmental policies priority as a starting point. Rieder, (2011) recommended to invest in evaluating the effectiveness of programs or projects a range between 0.5 and 10 % of their total budget. Recommendations of the European Commission are at the lower end of this range, at 0.5%, (EC 2004). Given the importance of the Common Agricultural Policy (CAP) for social, environmental and economic development of rural Europe, we argue that a significant share (*e.g.* 3%) of the CAP budget could reasonably be allocated to the evaluation of its effects, and that 0.5% could be a reasonable budget percentage to be allocated on monitoring the effectiveness of the CAP in enhancing and preserving landscape and biodiversity. Let us further assume that 0.25% could be allocated towards a farm based monitoring scheme such as proposed by BioBio (farm scale biodiversity) and 0.25% of the budget could be allocated to a landscape oriented approach. This would mean that 125 € million per year would be available (625 € million in five years, given the permanence of the current average CAP budget) for the farm based monitoring scheme. To estimate the number of farms that could be monitored with 0.25% of CAP budget we need (see Geijzendorffer, *et al.,* 2012; and Targetti *et al.,* 2011 for further details):

A. the budget items to be included in a monitoring scheme;
B. the average cost of sampling biodiversity at farm scale;

to take into account the cost variability across European countries.

A: budget items

Budgetary costs of monitoring programs were synthesised by Caughlan and Oakley (2001):

1. Development phase;
    1.1. Objective setting;
    1.2. Design planning;
    1.3. Administrative support development;
    1.4. Pilot study.
2. Regular monitoring phase;
    2.1. Scientific oversight;
    2.2. Data collection;
    2.3. Data management, analysis and reporting;
    2.4. Quality assurance;
    2.5. Administration and other expenses (*e.g.* staff training).

After consultation with the BioBio case study leaders, the cost of the BioBio activities have been translated in “Data collection costs” (point 2.2) applying the following reduction rates (as compared to Targetti *et al.* 2011) and synergies between indicator groups (reduction rates in brackets, Geijzendorffer *et al.,* 2012).

- Habitat mapping (50%)
- Vegetation (20%)
- Bees. No cost reductions are envisaged
- Spiders (30%)
- Earthworms. No cost reductions are envisaged
- Questionnaires (30%).
- Taxonomy1 (15%).
- Consumables and equipment (20%).

B: cost of sampling of the “average BioBio farm”:

The 12 BioBio case studies covered a wide range of farm types and regions. Thus, the range of differences in efforts and cost per farm in the different case studies are significant. For this reason, we referred the efforts and costs of the BioBio parameters to the most appropriate unit of measurement: hours of work per hectare for the habitat mapping, per farm for the questionnaire and per plot for the others (Figures 6).

[1] Species identification costs were separated from the other costs for the bees, spiders and earthworms. Identification of plant species was performed by internal resources.

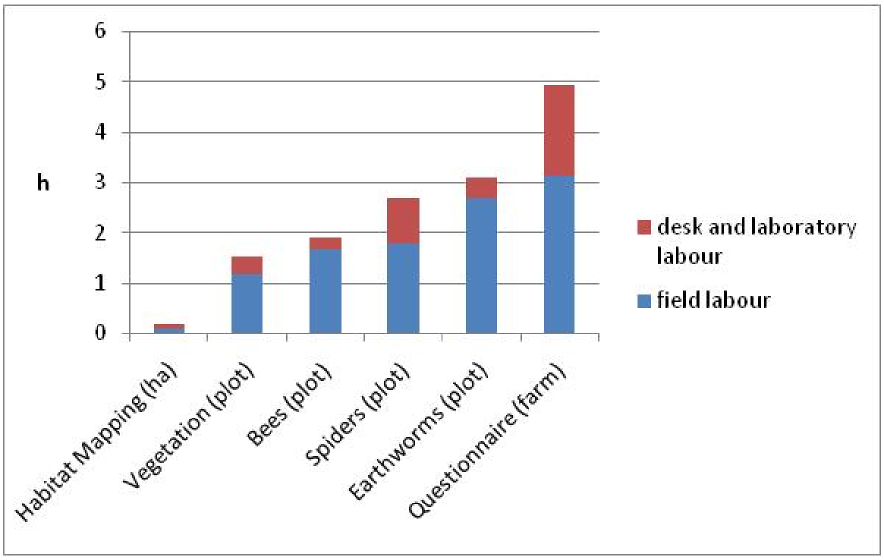


Figure 6: Overview of estimated labour efforts (after travel) required for the measurement of the BioBio indicator groups, based on data recorded in the 12 case study regions and applying assumptions for reductions of effort in a monitoring context (point A). Between brackets on the horizontal axis the measurement unit of each single parameter.

It is important to note that a reliable estimation of the monitoring costs should consider the specificities of the agricultural systems to be surveyed (*e.g.* hectares of farmland, distance and accessibility of plots, expected number of plots, *etc.).* Nevertheless, in a first approach, we base our estimation on the efforts and costs assessed for the "average BioBio farm" (Table 4 and figure 7).

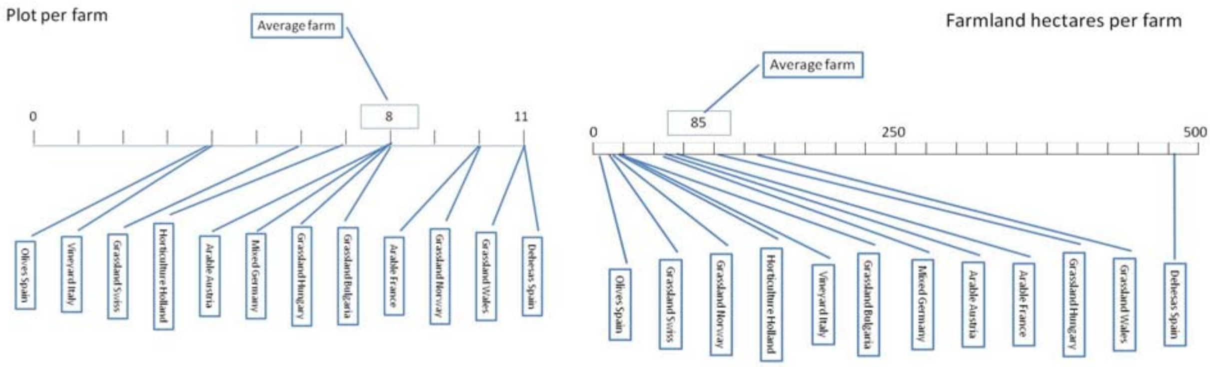


Figure 7: Average number of plots per farm (A) and average hectares per farm (B) in the 12 BioBio case studies.

Based on the experience of the BioBio field activities, the field staff composition has been standardised in order to optimise the costs (salary bands) with the skills required (high skilled, low skilled). Field staff calculation will consider the following standardised field staff composition:

- Habitat mapping + Vegetation: 2 persons
- Bees: 1 person
- Spiders: 2 persons

- Earthworms: 2 persons
- Questionnaire: 1 person

Table 4. Labour efforts and costs for consumables, equipment, taxonomy and others for the average BioBio farm. Person days are assessed assuming 7 hours of work per day.

	Skilled labour (person days)	Not skilled labour (person days)	Total labour (person days)	Consumables, equipment, taxonomy, others (€)
Habitat mapping	1,7	0,6	2,3	111
Vegetation	1,1	0,7	1,8	60
Bees	2,6	0,0	2,6	204
Spiders	1,0	2,5	3,5	303
Earthworms	0,5	3,7	4,2	360
Questionnaire	0,8	0,0	0,8	11
Total	**7,6**	**7,5**	**15,1**	**1048**

C: Accounting for cost variability in EU:

Because of clear differences of labour costs across the European countries, the assessment of costs of the monitoring program strictly depends on the country to be surveyed (according to Council Regulation –EC- No 1239/2010). Given the fact that the cost for the other resources (consumables *etc.)* were assessed as an average from 12 European countries and that these represent a relative minor cost, the costs outlined in the Table 4 for consumables, equipment taxonomy and others can be employed as a reference (Table 5).

Table 5. general assumptions for the cost estimation (Geijzendorffer *et al.,* 2012)

Item	**Cost allocation**
Scientific oversight	1% of data collection costs
Data collection	BioBio task 3.3 (Empirical cost data collection and reduction rates)
Data management, analysis and reporting;	4 person days (skilled labour) per farm
Quality assurance	4 person days (skilled labour) per farm in the first year + 5% reduction rate in the following years
Administration and other expenses	1% of data collection costs

We consider a scenario where the labour cost of quality assessment and data analysis (points 2.3 and 2.4) is not adjusted to the different cost levels (taking Belgium costs as reference). This should allow for a homogenisation of data quality assessment across EU and help to counterbalance the effect of the higher competition in the call for tenders in the high cost countries. Labour costs (in person days) for skilled and not-skilled workers are presented in Table 6 for France, Italy (actual data) and Belgium (estimation based on correction coefficients)

Approximately just over 50.000 farms over 55 European regions and eight farming categories, 1.7 % of the total number of farms in Europe could be sampled for the budget or 625 EUR million corresponding to 0.25% of the CAP for a farm based monitoring (section 4.3, Table 7). If carried out in a rolling programme of five years, every year 10,000 farms approximately should be sampled.

A statistical test on the minimum size of samples cannot be carried out without insight in the data to be sampled. Such a test on farm sample size and its variance will be calculated for the 12 case study areas in a separate report.

Table 6 Labour cost for skilled and not skilled workers for biodiversity monitoring in EU countries (*Council Regulation –EC- No 1239/2010*).

Country	Correction coefficient	€ person day (skilled)	€ person day (not skilled)
Austria	106,2	686	457
Belgium[c]	100	646	431
Bulgaria	62,7	405	270
Cyprus	83,7	541	360
Czech Republic	84,2	544	363
Denmark	134,1	866	578
Estonia	75,6	488	326
Finland	119,4	771	514
France[a]	116,1	750	500
Germany	94,8	612	408
Greece	94,8	612	408
Hungary	79,2	512	341
Ireland	109,1	705	470
Italy[b]	106,6	689	459
Latvia	74,3	480	320
Lithuania	72,5	468	312
Luxembourg	100	646	431
Malta	82,2	531	354
Netherlands	104,1	672	448
Poland	77,1	498	332
Portugal	85	549	366
Romania	69,5	443	295
Slovak Rep.	80	517	345
Slovenia	89,6	579	386
Spain	97,7	631	421
Sweden	118,6	766	511
UK	134,4	868	579

[a] average salary band of one public organization, one naturalist NGO and one private firm based on 2010 labour cost (source: Levrel et al., 2010)

[b] average salary band of three private agencies based on 2012 labour cost (source: Targetti and Viaggi survey in 2012)

[c] average salary band of data for France and Italy adjusted for Belgium by means of the Council Regulation (EC) No 1239/2010 correction factor.

Table 7 Samples of farming type per region with a size of 1.7% of the farms of a certain type in that region. Some samples are too small to be realise a statistical reliable sample set. These can be excluded from the sample or be expanded to a size big enough to be statistically reliable.

REGION	total nr farms	sample size arable farms	sample size beef farms	sample size dairy farms	sample size horticulture farms	sample size mixed farms	sample size permanent crop farms	sample size pig farms	sample size sheep farms	sample size sheep farms	N° farms	scientifica oversight	data collection	Data management, analysis and reporting	Quality assurance	Administration and other expenses	total cost
BIOAT1	26684	139	53	80	0	53	86	0	0	0	412	€ 32.467	€ 3.246.665	€ 849.050	€ 768.004	€ 32.467	€ 4.928.652
BIOAT2	40895	44	137	323	0	60	0	0	0	0	564	€ 44.428	€ 4.442.805	€ 1.161.857	€ 1.050.953	€ 44.428	€ 6.744.472
BIOBE1	6394	0	38	33	16	5	0	0	0	0	92	€ 6.895	€ 689.470	€ 189.919	€ 171.790	€ 6.895	€ 1.064.969
BIOBE2	10722	54	22	22	0	54	0	0	0	0	152	€ 11.356	€ 1.135.598	€ 312.808	€ 282.949	€ 11.356	€ 1.754.066
BIOBE3	4700	11	27	22	0	11	0	0	0	0	70	€ 5.272	€ 527.242	€ 145.232	€ 131.369	€ 5.272	€ 814.388
BIOBE4	7393	16	21	21	21	21	0	16	0	0	114	€ 8.517	€ 851.698	€ 234.606	€ 212.212	€ 8.517	€ 1.315.550
BIOCZ1	3279	34	0	0	10	5	0	0	0	0	49	€ 3.154	€ 315.422	€ 100.545	€ 90.948	€ 3.154	€ 513.223
BIOCZ2	10256	68	26	16	0	42	0	0	0	0	152	€ 9.813	€ 981.312	€ 312.808	€ 282.949	€ 9.813	€ 1.596.695
BIODE1	15187	58	0	69	0	48	26	11	0	0	211	€ 15.110	€ 1.510.999	€ 435.696	€ 394.107	€ 15.110	€ 2.371.023
BIODE2	59080	141	0	537	0	152	0	0	0	0	829	€ 59.278	€ 5.927.767	€ 1.709.271	€ 1.546.114	€ 59.278	€ 9.301.707
BIODE3	23857	125	0	87	0	98	0	0	0	0	309	€ 22.084	€ 2.208.384	€ 636.787	€ 576.003	€ 22.084	€ 3.465.342
BIODE4	47723	260	0	152	0	157	0	0	0	0	569	€ 40.681	€ 4.068.075	€ 1.173.029	€ 1.061.058	€ 40.681	€ 6.383.524
BIODE5	18952	27	27	108	0	65	0	49	0	0	276	€ 19.759	€ 1.975.922	€ 569.757	€ 515.371	€ 19.759	€ 3.100.569
BIODK1	30715	296	0	66	0	88	0	22	0	0	472	€ 45.631	€ 4.563.089	€ 971.938	€ 879.163	€ 45.631	€ 6.505.452
BIOEE1	7103	40	4	18	0	18	0	0	31	31	141	€ 8.332	€ 833.239	€ 290.464	€ 262.738	€ 8.332	€ 1.403.106
BIOES1	61671	0	654	300	0	0	0	0	0	0	954	€ 69.969	€ 6.996.869	€ 1.966.220	€ 1.778.536	€ 69.969	€ 10.881.562

BIOES2	167205	1285	113	0	0	189	478	0	523	523	3111	€ 228.193	€ 22.819.334	€ 6.412.558	€ 5.800.453	€ 228.193	€ 35.488.732
BIOES3	126440	505	57	0	237	191	188	50	876	876	2981	€ 218.652	€ 21.865.216	€ 6.144.437	€ 5.557.925	€ 218.652	€ 34.004.883
BIOES4	7188	9	0	0	51	28	5	0	19	19	130	€ 9.541	€ 954.119	€ 268.121	€ 242.528	€ 9.541	€ 1.483.849
BIOES5	30599	173	0	0	49	0	146	0	0	0	369	€ 27.033	€ 2.703.336	€ 759.676	€ 687.162	€ 27.033	€ 4.204.240
BIOFI1	37270	257	30	86	0	55	0	10	30	30	499	€ 43.537	€ 4.353.691	€ 1.027.797	€ 929.689	€ 43.537	€ 6.398.251
BIOFR1	48264	531	38	43	0	130	0	0	0	0	743	€ 63.255	€ 6.325.546	€ 1.530.523	€ 1.384.429	€ 63.255	€ 9.367.009
BIOFR2	72175	183	167	442	0	264	0	0	0	0	1057	€ 90.035	€ 9.003.514	€ 2.178.482	€ 1.970.537	€ 90.035	€ 13.332.604
BIOFR3	34715	249	92	60	0	136	0	0	0	0	537	€ 45.710	€ 4.571.015	€ 1.105.999	€ 1.000.427	€ 45.710	€ 6.768.860
BIOFR4	40588	200	43	24	0	75	0	0	220	220	780	€ 66.487	€ 6.648.749	€ 1.608.725	€ 1.455.166	€ 66.487	€ 9.845.615
BIOFR5	96023	263	278	156	0	114	0	0	597	597	2005	€ 170.836	€ 17.083.590	€ 4.133.530	€ 3.738.968	€ 170.836	€ 25.297.761
BIOGR1	237577	2034	0	0	0	219	595	0	760	760	4369	€ 312.273	€ 31.227.321	€ 9.004.393	€ 8.144.887	€ 312.273	€ 49.001.148
BIOGR2	53599	269	0	0	0	87	150	0	297	297	1100	€ 78.649	€ 7.864.946	€ 2.267.856	€ 2.051.380	€ 78.649	€ 12.341.480
BIOGR3	31368	83	0	0	61	35	202	0	118	118	618	€ 44.168	€ 4.416.767	€ 1.273.574	€ 1.152.006	€ 44.168	€ 6.930.683
BIOHU1	69367	606	48	0	0	167	0	0	129	129	1079	€ 66.273	€ 6.627.324	€ 2.223.169	€ 2.010.958	€ 66.273	€ 10.993.998
BIOIE1	98786	0	534	195	0	0	0	0	917	917	2564	€ 206.846	€ 20.684.594	€ 5.284.216	€ 4.779.816	€ 206.846	€ 31.162.318
BIOIT1	254490	1845	213	176	0	277	596	55	652	652	4466	€ 353.156	€ 35.315.633	€ 9.205.484	€ 8.326.783	€ 353.156	€ 53.554.213
BIOIT2	11456	0	12	70	0	0	37	0	46	46	211	€ 16.715	€ 1.671.492	€ 435.696	€ 394.107	€ 16.715	€ 2.534.726
BIOIT3	9409	49	0	0	76	0	22	0	0	0	146	€ 11.572	€ 1.157.187	€ 301.636	€ 272.844	€ 11.572	€ 1.754.810
BIOIT4	132844	880	58	0	0	77	746	0	255	255	2271	€ 179.578	€ 17.957.828	€ 4.680.944	€ 4.234.129	€ 179.578	€ 27.232.057
BIOIT5	97300	420	62	0	0	94	221	0	794	794	2385	€ 188.579	€ 18.857.862	€ 4.915.550	€ 4.446.340	€ 188.579	€ 28.596.910
BIOLT1	38650	213	55	142	0	197	0	0	0	0	607	€ 34.683	€ 3.468.252	€ 1.251.231	€ 1.131.796	€ 34.683	€ 5.920.644
BIOLU1	1284	0	5	11	0	5	0	0	0	0	22	€ 1.622	€ 162.228	€ 44.687	€ 40.421	€ 1.622	€ 250.581
BIOLV1	21875	98	0	136	0	98	0	0	0	0	331	€ 19.273	€ 1.927.251	€ 681.474	€ 616.424	€ 19.273	€ 3.263.694
BIONL1	15552	52	0	42	0	14	0	0	136	136	379	€ 29.391	€ 2.939.084	€ 782.019	€ 707.372	€ 29.391	€ 4.487.257
BIONL2	11547	0	0	67	26	26	0	0	0	0	119	€ 9.237	€ 923.712	€ 245.777	€ 222.317	€ 9.237	€ 1.410.281
BIONL3	26484	35	0	121	66	16	0	0	144	144	526	€ 40.727	€ 4.072.731	€ 1.083.655	€ 980.216	€ 40.727	€ 6.218.056
BIOPL1	106727	783	0	87	0	669	0	0	0	0	1539	€ 92.501	€ 9.250.098	€ 3.172.764	€ 2.869.911	€ 92.501	€ 15.477.775
BIOPL2	572954	2423	396	780	0	4206	0	640	0	0	8444	€ 507.453	€ 50.745.257	€ 17.405.515	€ 15.744.087	€ 507.453	€ 84.909.764
BIOPL3	55974	92	136	249	0	385	0	27	0	0	889	€ 53.416	€ 5.341.606	€ 1.832.159	€ 1.657.272	€ 53.416	€ 8.937.870

BIOPT1	65767	233	45	0	0	139	0	0	328	328	1073	€ 69.945	€ 6.994.521	€ 2.211.997	€ 2.000.853	€ 69.945	€ 11.347.262
BIOPT2	1131	0	0	0	3	0	0	0	29	29	60	€ 3.886	€ 388.584	€ 122.889	€ 111.159	€ 3.886	€ 630.403
BIOSE1	18897	163	33	49	0	43	0	0	0	0	287	€ 24.933	€ 2.493.318	€ 592.100	€ 535.582	€ 24.933	€ 3.670.866
BIOSE2	6470	22	22	49	0	11	0	0	0	0	103	€ 8.938	€ 893.831	€ 212.262	€ 192.001	€ 8.938	€ 1.315.971
BIOSI1	38564	68	61	68	0	112	0	0	317	317	943	€ 64.258	€ 6.425.836	€ 1.943.876	€ 1.758.326	€ 64.258	€ 10.256.555
BIOSK1	1822	22	0	0	0	5	0	0	0	0	27	€ 1.679	€ 167.911	€ 55.859	€ 50.527	€ 1.679	€ 277.654
BIOSK2	1878	8	0	4	0	4	0	0	16	16	49	€ 3.022	€ 302.239	€ 100.545	€ 90.948	€ 3.022	€ 499.777
BIOUK1	21700	29	42	59	0	0	0	0	255	255	640	€ 62.014	€ 6.201.363	€ 1.318.261	€ 1.192.428	€ 62.014	€ 8.836.078
BIOUK2	42608	232	69	0	0	46	0	0	255	255	856	€ 83.035	€ 8.303.519	€ 1.765.129	€ 1.596.640	€ 83.035	€ 11.831.359
BIOUK3	18409	32	35	38	0	13	0	0	299	299	715	€ 69.371	€ 6.937.117	€ 1.474.665	€ 1.333.902	€ 69.371	€ 9.884.427
Total	**3099567**	**15661**	**3651**	**5004**	**616**	**9003**	**3497**	**879**	**8042**	**8042**	**54395**	**€ 4.003.221**	**€ 400.322.078**	**€ 112.119.221**	**€ 101.416.981**	**€ 4.003.221**	**€ 621.864.722**

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ANNEX 1, Computing the required sample size for testing the change of mean biodiversity indicators of farms

Computing the required sample size for testing the change of mean biodiversity indicators of farms

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Theory

The sampling variance of the estimated change equals

$$V_{2,1} = V_2 + V_1 - 2C_{1,2} \; . \tag{1}$$

The variances V_1 and V_2 and covariance $C_{1,2}$ are *sampling* (co)variances of the estimated means. The accuracy of the estimated change of the mean can be maximized by maximizing this sampling covariance. This sampling covariance will be maximum when all sampling locations are revisited, leading to a so-called static-synchronous pattern. In independent synchronous the sampling sampling covariance is 0 by construction because the means are selected from independently selected samples. In space-time sampling with partial overlap between the spatial samples at the two times, as in supplemented and rotational panel designs, the two estimated means will be correlated, but the correlation will not be as strong as in static-synchronous sampling. Therefore, in estimating the change of the mean, space-time designs with partial overlap will perform not as poor as independent-synchronous, but not as good as static-synchronous designs.

For simple random sampling (with replacement) we have

$$V_1 = \frac{S_1^2}{n_1} \; , \tag{2}$$

with S_1^2 the population variance (variance between farms in the population) at time 1 and n_1 the number of farms in the sample at time 1. In practice farms will not be selected with replacement, but without replacement. This would imply that the sampling variance must be multiplied by a finite population correction factor equal to $1 - \frac{n}{N}$. However, N is very large compared to n, so that we can ignore this correction factor. When all farms observed at time 1 are revisited at time 2, i.e. with a static-synchronous space–time design (pure panel) the sampling covariance can be written as

$$C_{1,2} = \frac{S^2_{1,2}}{n} = \frac{r_{1,2}\ S_1\ S_2}{n} = r_{1,2}\ \sqrt{V_1}\ \sqrt{V_2}\ , \tag{3}$$

with $S^2_{1,2}$ the population covariance of the indicator at time 1 and 2, and $r_{1,2}$ the correlation of the indicator observed at time 1 and 2 (at the same farm). If we assume that the population variances at time 1 and 2 are equal, than for a static-synchronous design the sampling variance of the estimated change equals

$$V_{2,1} = (2 - 2\ r_{1,2})\ V_1\ . \tag{4}$$

When only a part of the farms at time 1 are revisited at time 2, the sampling covariance $C_{1,2}$ term becomes smaller:

$$C_{1,2} = \frac{S^2_{1,2}\ p}{n} = r_{1,2}\ p\ \sqrt{V_1}\ \sqrt{V_2}\ , \tag{5}$$

with p the fraction of farms in the sample that is revisited at time 2, so that with equal population variances at time 1 and 2 the sampling variance of the estimated chnage becomes

$$V_{2,1} = (2 - 2\ r_{1,2}\ p)\ V_1\ . \tag{6}$$

Analysis of required sample size

The analysis of the required sample size started with the following assumptions:

- A change in average number of species per farm of at least 10% is relevant to be detected.

- The probability of wrongly concluding that the average number of species changed (probability of type I error, α) should not be larger than 0.1.

- The probability of wrongly concluding that the average number of species did not change (probability of type II error, β) should not be larger than 0.1 for changes in the mean number of species of 10% (i.e. the power, $(1-\beta)$, $\geq 90\%$).

Of course these assumptions can be discussed and replaced by more realistic ones.

Prior data on numbers of species per farm are available for four groups of species, observed at farms in 12 European case study regions (CS). Thus the total number of combinations of CS and species groups is 48. The four species groups are plants, earthworms, spiders and bees. The file with prior data is BioBio_Data_at_farm_scale.xls.

In this first analysis no distinction has been made between organic and conventional farming systems.

The required sample size depends on the coefficient of variation (population standard deviation relative to the population mean). The required sample size for a specific CS is determined by the species group having the highest coefficient of variation. Table 1 gives the coefficients of variation for all 48 combinations of CS and species groups, estimated from the prior data.

The analysis is focused on the species groups with the highest coefficient of variation in each CS (bold in Table 1), because these determine the required sample size. The following situations are considered:

Table 1: Coefficients of variation of numbers of species per farm, for 12 European case study regions (CS) and for four species groups, estimated from the prior data. An asterisk indicates that there were missing data. The highest coefficient of variation for each CS has been printed bold. n_{p} is the number of prior data.

CS	n_{p}	Species group			
		plants	earthworms	spiders	bees
Austria	16	0.3147	0.3185	0.3742	**0.7620**
Bulgaria	16	0.3045	0.3882	0.2735	**0.4803**
Switzerland	19	0.3163	0.1442	0.3557	**0.4020**
Germany	16	0.2251	0.1494	0.2309	**0.7703**
Spain (Dehesa)	10	0.1975	**0.3841**	0.2462	0.2834
Spain (olives)	20	0.5367	0.5322	0.4799	**0.5887**
France	16	0.2698	0.1441	0.1622	**0.4361**
Hungary	18	0.2688	**0.6869**	0.5800	0.5418
Italy	18	0.2312	0.4799	0.4097	**0.5035**
The Netherlands	14(8)	0.2291	0.4181*	**0.5174***	0.3993*
Norway	12	0.1947	0.1911	**0.2344**	0.2224
Wales	20(16)	0.2022	0.1517*	**0.2264***	0.2161

- The second sample overlaps the first sample for 0, 50 or 100%;
- The temporal correlation between number of species at a farm is 0.1, 0.5 or 0.9.

An overlap of 50% means that 50% of the farms sampled at a given time is resampled at the subsequent time. Combining the three overlaps with the three correlations leads to nine situations.

Results

Graphs showing the relation between sample size and power for the nine combinations of overlap and correlation are given in Figures 1 to 12. Note that without overlap

(overlap 0%) the three curves coincide. Without overlap the power is independent of the temporal correlation. These figures indicate that a power of 90% can only be achieved against realistic sample sizes (say $n < 100$) if a temporal correlation of 0.9 can be assumed and the second sample completely overlaps the first sample.

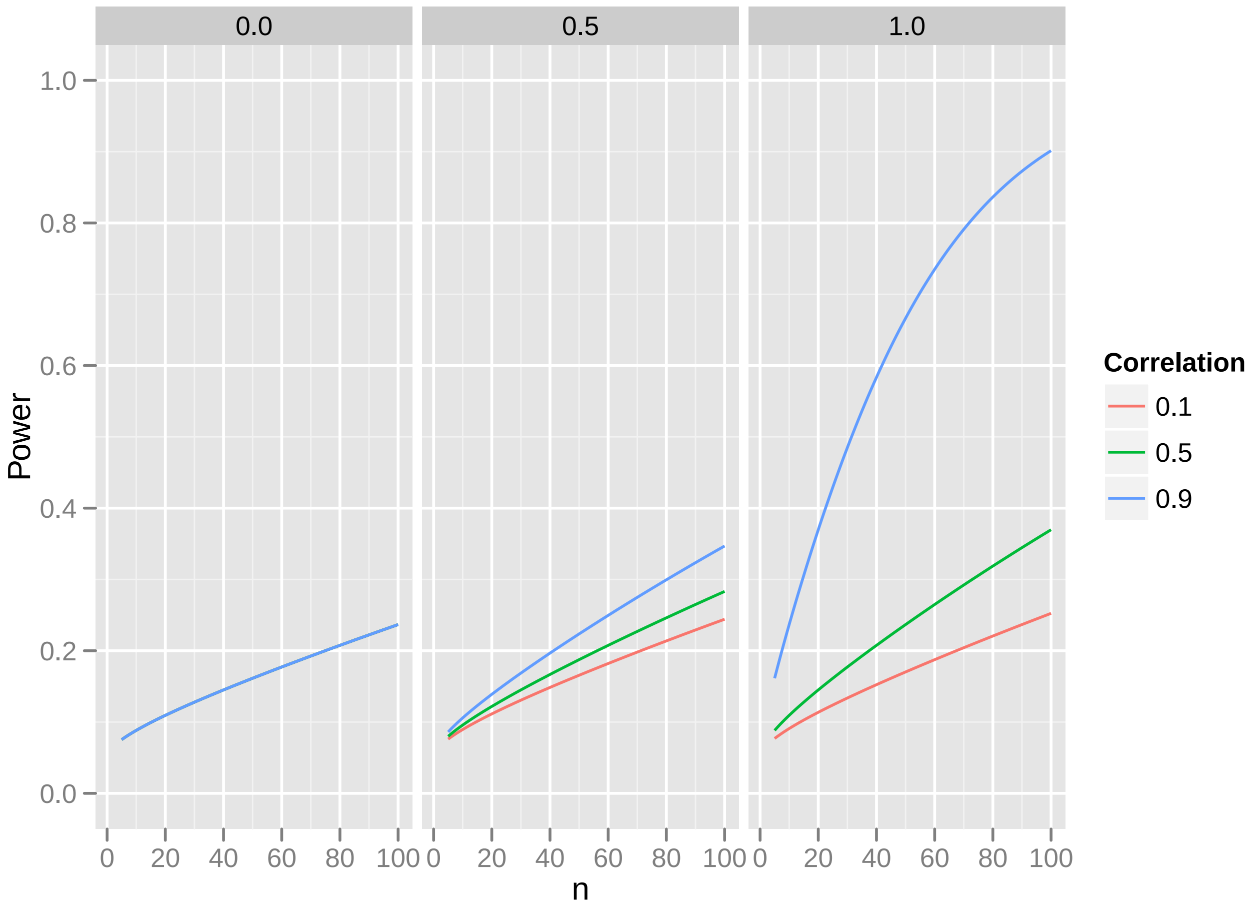

Figure 1: Relation between power and sample size for three possible fractions of overlap between the first and second sample (0, 0.5 and 1) and for three possible temporal correlations in number of species at a farm (0.1, 0.5 and 0.9). Case study region: Austria, species group: bees. $\alpha = 0.1$, least relevant temporal change is 10% of the mean number of species per farm.

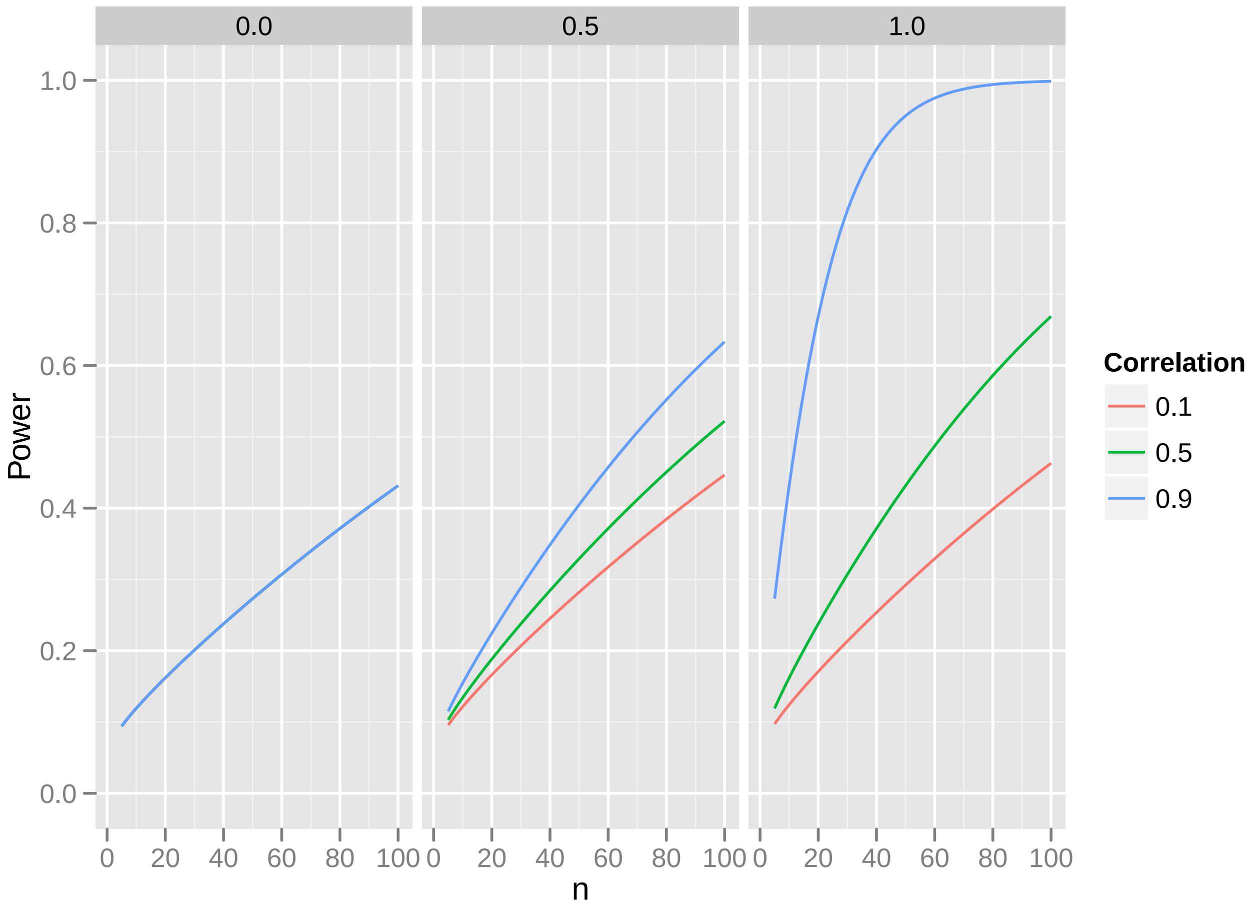

Figure 2: Relation between power and sample size for three possible fractions of overlap between the first and second sample (0, 0.5 and 1) and for three possible temporal correlations in number of species at a farm (0.1, 0.5 and 0.9). Case study region: Bulgaria, species group: bees. $\alpha = 0.1$, least relevant temporal change is 10% of the mean number of species per farm.

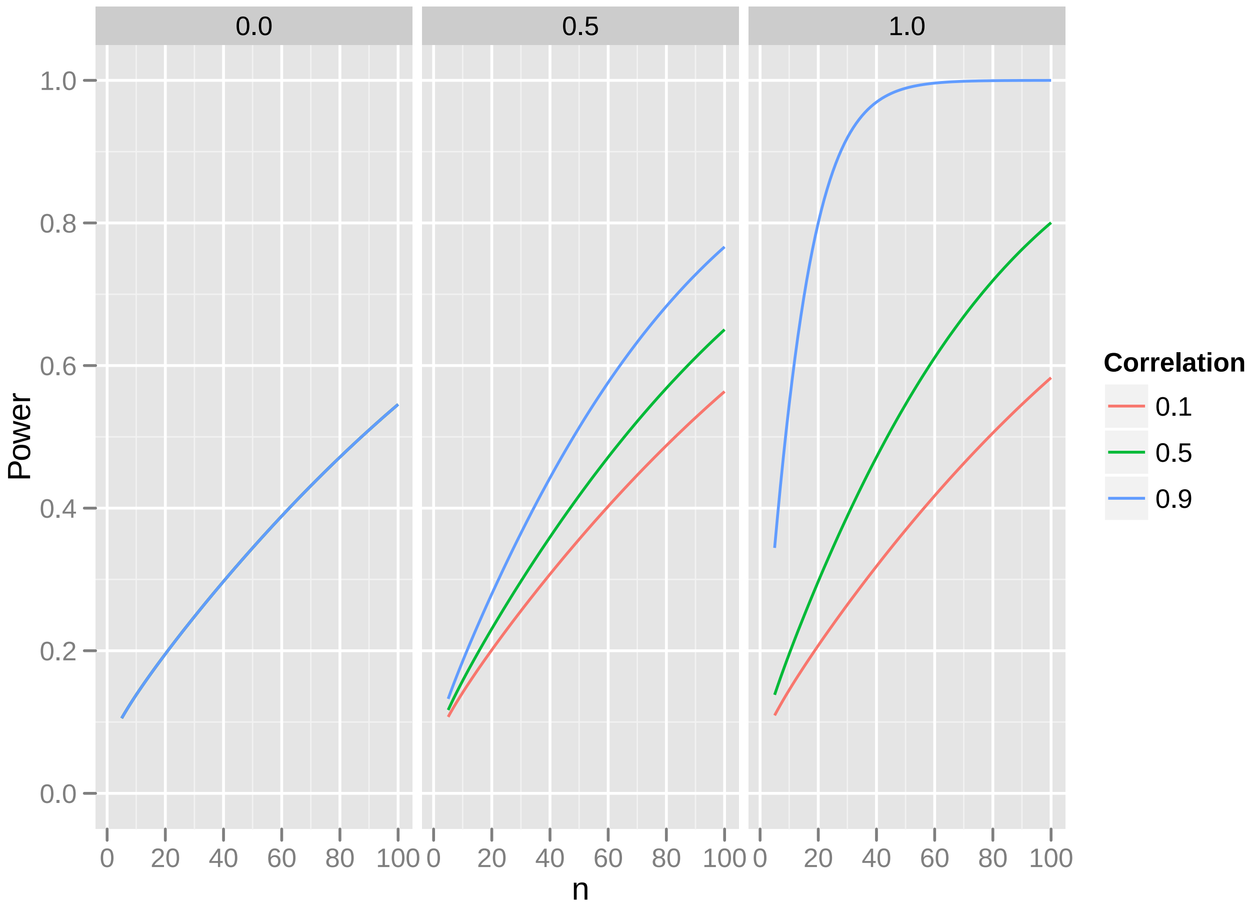

Figure 3: Relation between power and sample size for three possible fractions of overlap between the first and second sample (0, 0.5 and 1) and for three possible temporal correlations in number of species at a farm (0.1, 0.5 and 0.9). Case study region: Switzerland, species group: bees. $\alpha = 0.1$, least relevant temporal change is 10% of the mean number of species per farm.

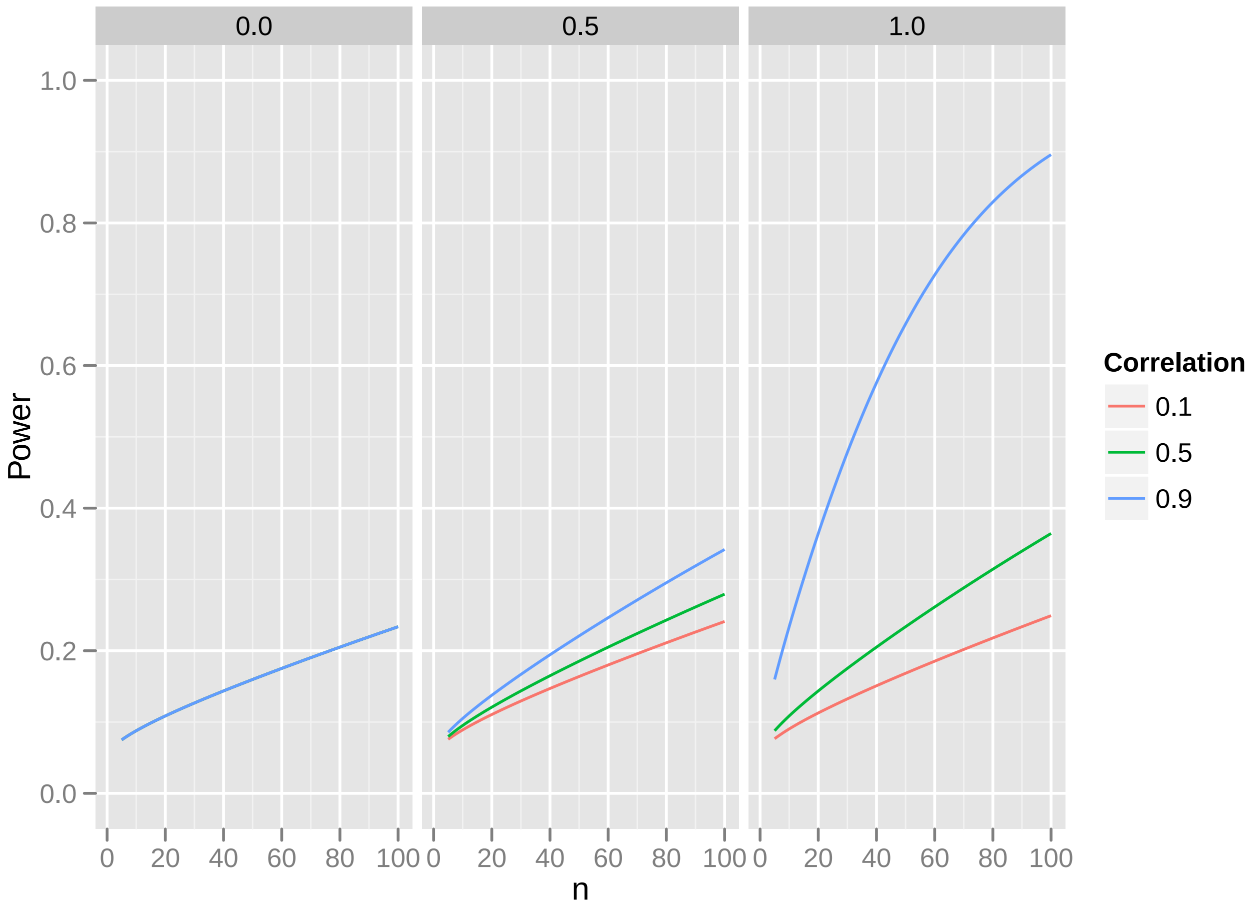

Figure 4: Relation between power and sample size for three possible fractions of overlap between the first and second sample (0, 0.5 and 1) and for three possible temporal correlations in number of species at a farm (0.1, 0.5 and 0.9). Case study region: Germany, species group: bees. $\alpha = 0.1$, least relevant temporal change is 10% of the mean number of species per farm.

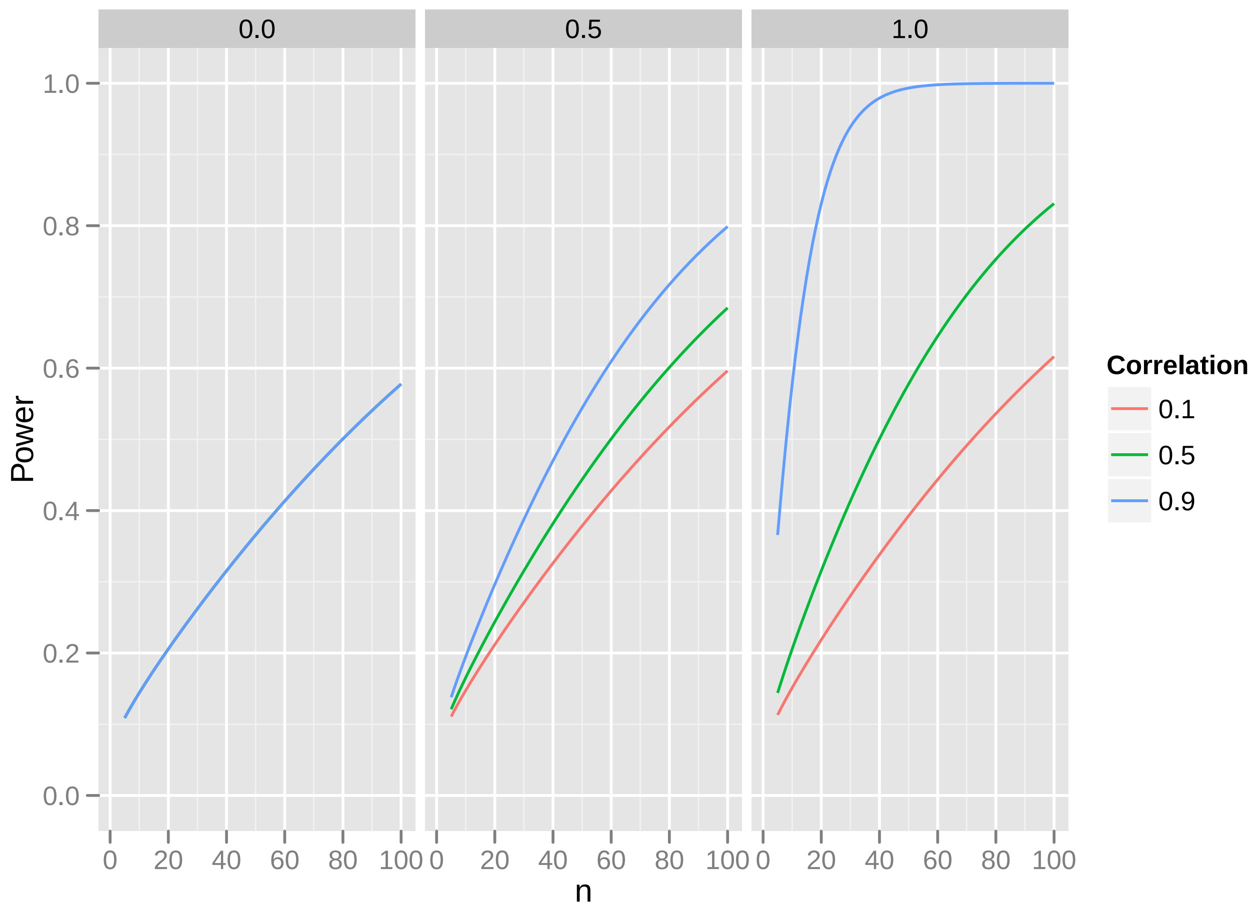

Figure 5: Relation between power and sample size for three possible fractions of overlap between the first and second sample (0, 0.5 and 1) and for three possible temporal correlations in number of species at a farm (0.1, 0.5 and 0.9). Case study region: Spain (Dehesa), species group: earthworms. $\alpha = 0.1$, least relevant temporal change is 10% of the mean number of species per farm.

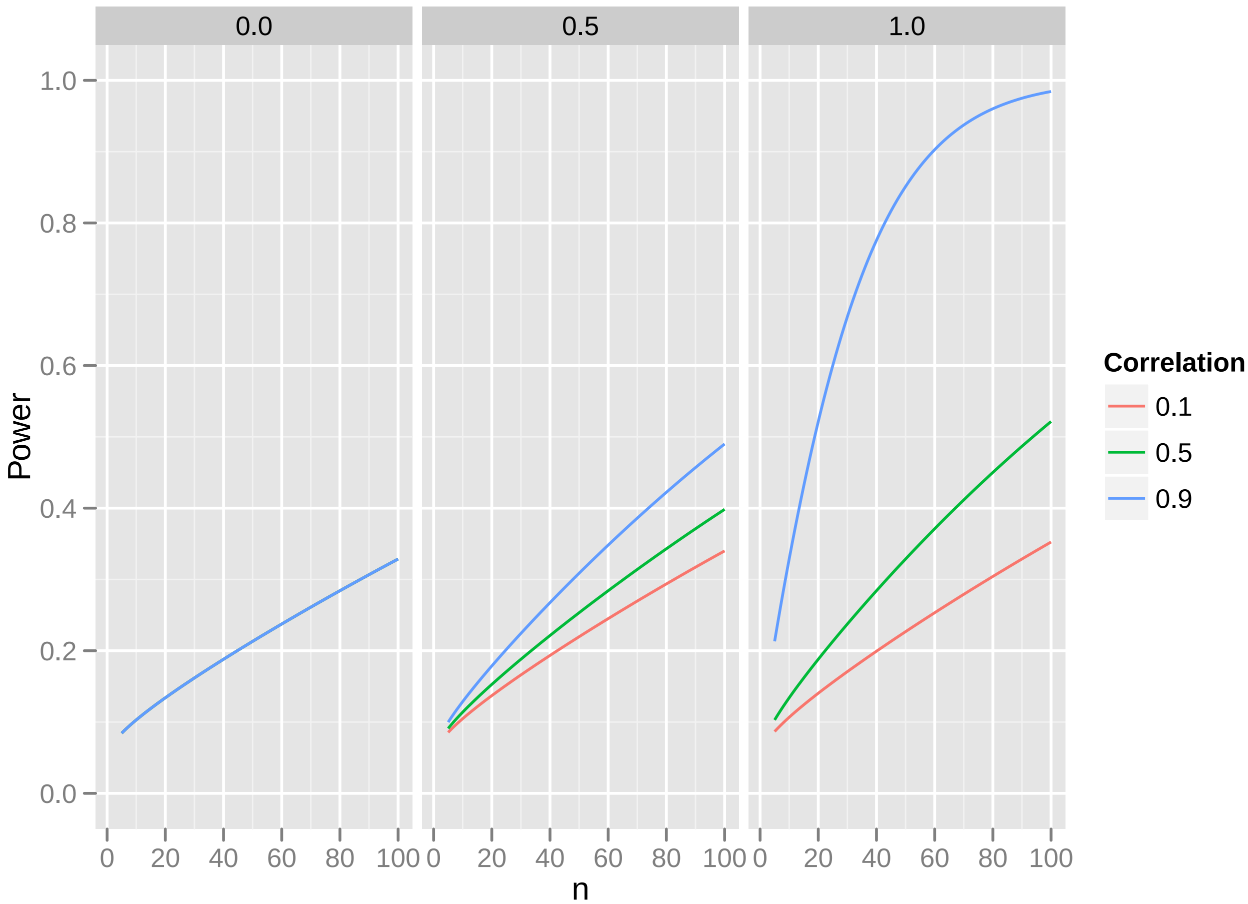

Figure 6: Relation between power and sample size for three possible fractions of overlap between the first and second sample (0, 0.5 and 1) and for three possible temporal correlations in number of species at a farm (0.1, 0.5 and 0.9). Case study region: Spain (olives), species group: bees. $\alpha = 0.1$, least relevant temporal change is 10% of the mean number of species per farm.

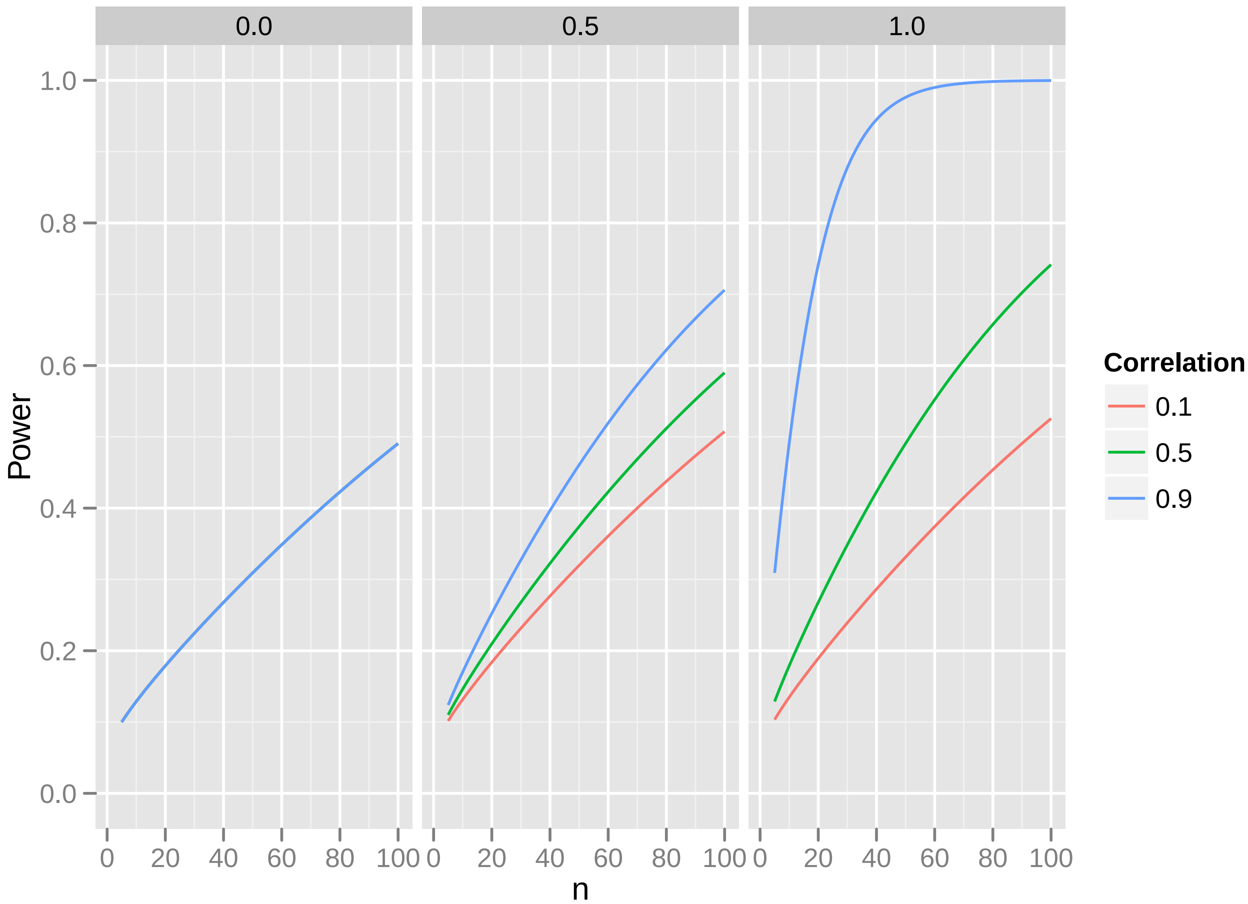

Figure 7: Relation between power and sample size for three possible fractions of overlap between the first and second sample (0, 0.5 and 1) and for three possible temporal correlations in number of species at a farm (0.1, 0.5 and 0.9). Case study region: France, species group: bees. $\alpha = 0.1$, least relevant temporal change is 10% of the mean number of species per farm.

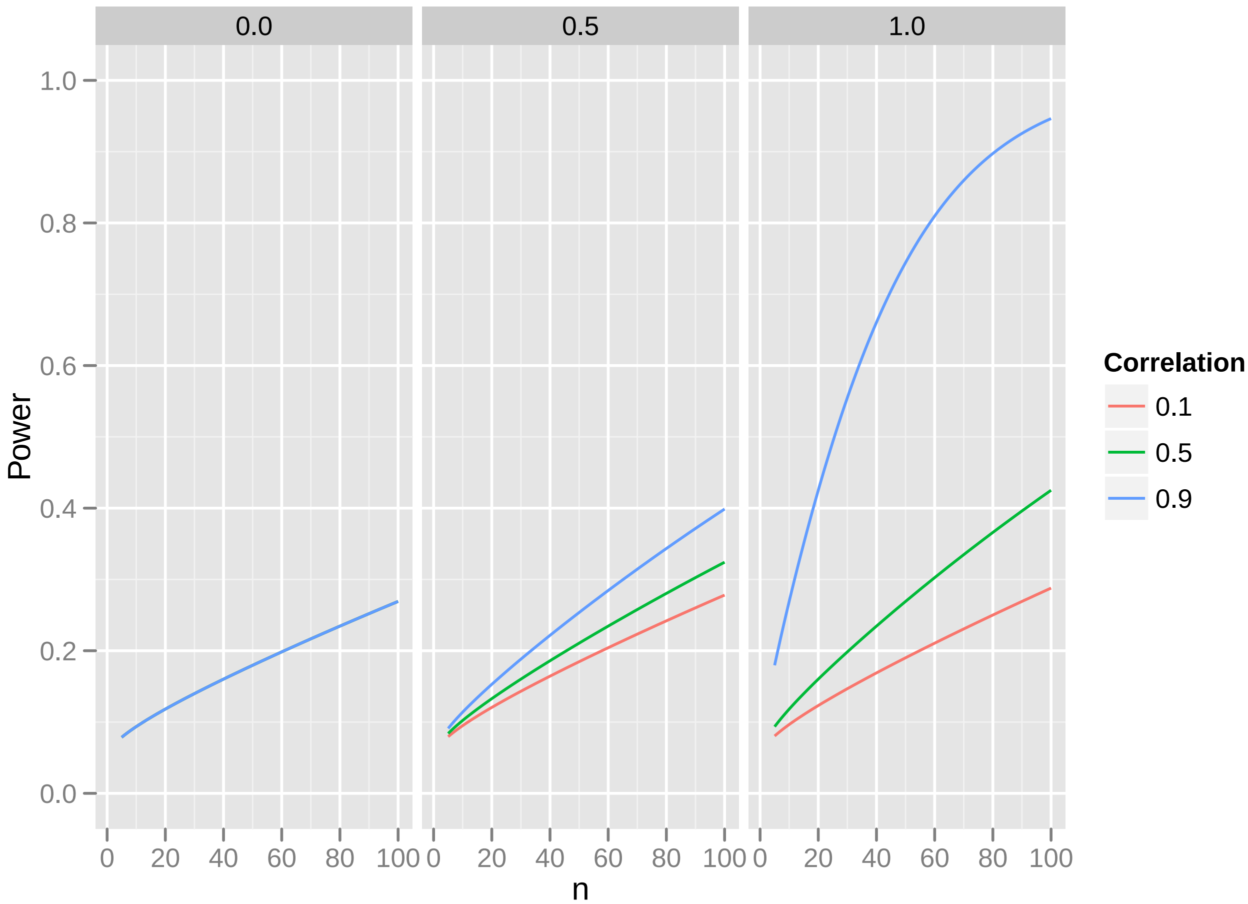

Figure 8: Relation between power and sample size for three possible fractions of overlap between the first and second sample (0, 0.5 and 1) and for three possible temporal correlations in number of species at a farm (0.1, 0.5 and 0.9). Case study region: Hungary, species group: earthworms. $\alpha = 0.1$, least relevant temporal change is 10% of the mean number of species per farm.

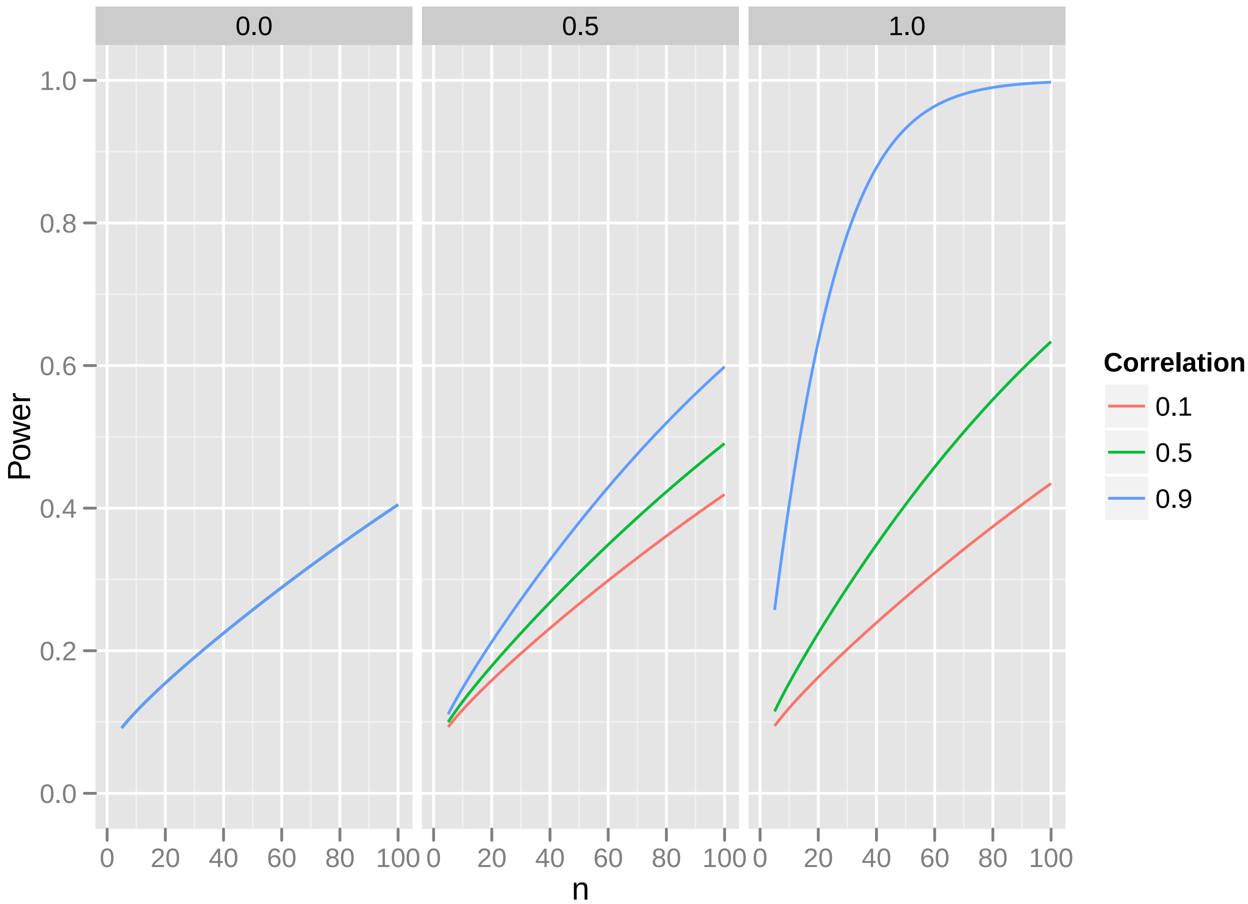

Figure 9: Relation between power and sample size for three possible fractions of overlap between the first and second sample (0, 0.5 and 1) and for three possible temporal correlations in number of species at a farm (0.1, 0.5 and 0.9). Case study region: Italy, species group: bees. $\alpha = 0.1$, least relevant temporal change is 10% of the mean number of species per farm.

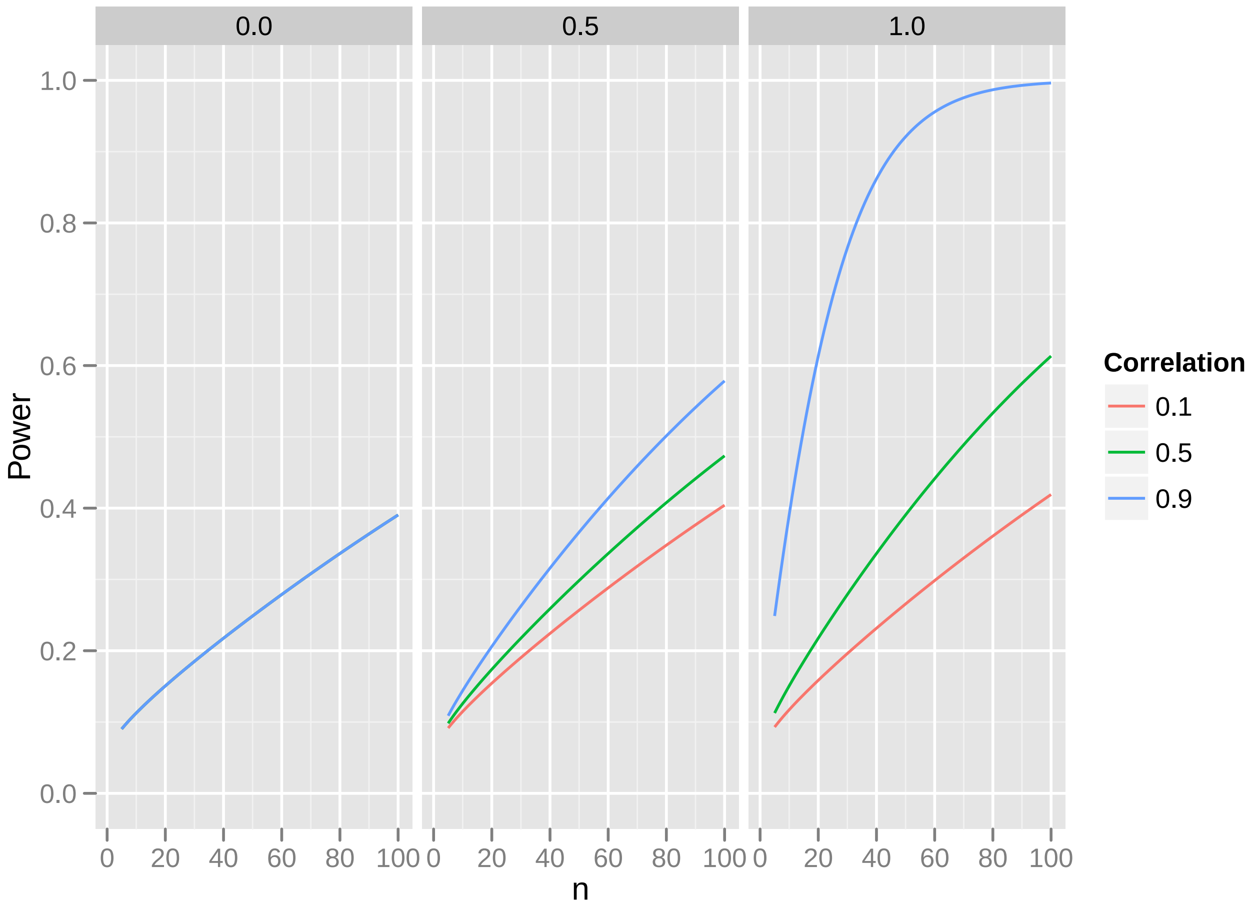

Figure 10: Relation between power and sample size for three possible fractions of overlap between the first and second sample (0, 0.5 and 1) and for three possible temporal correlations in number of species at a farm (0.1, 0.5 and 0.9). Case study region: the Netherlands, species group: spiders. $\alpha = 0.1$, least relevant temporal change is 10% of the mean number of species per farm.

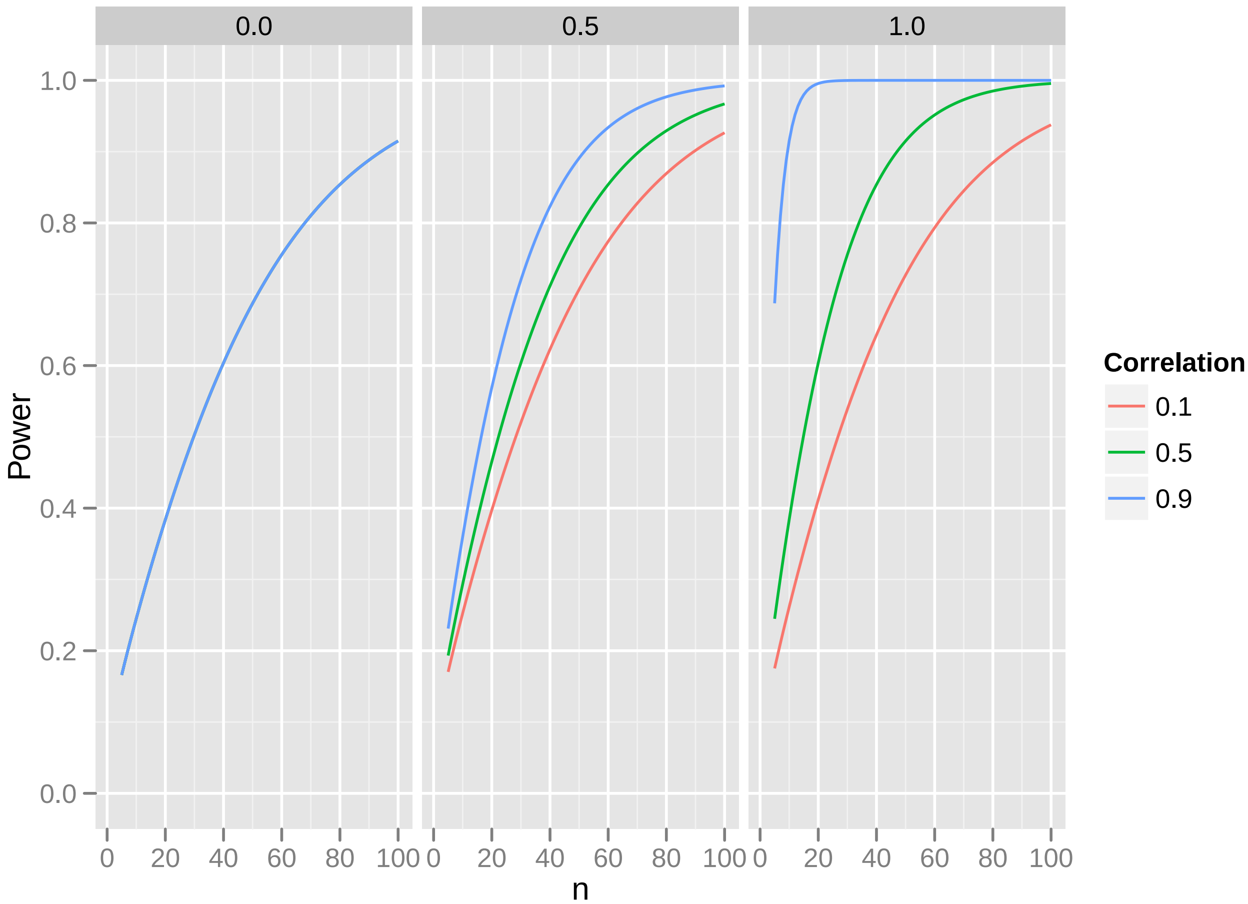

Figure 11: Relation between power and sample size for three possible fractions of overlap between the first and second sample (0, 0.5 and 1) and for three possible temporal correlations in number of species at a farm (0.1, 0.5 and 0.9). Case study region: Norway, species group: spiders. $\alpha = 0.1$, least relevant temporal change is 10% of the mean number of species per farm.

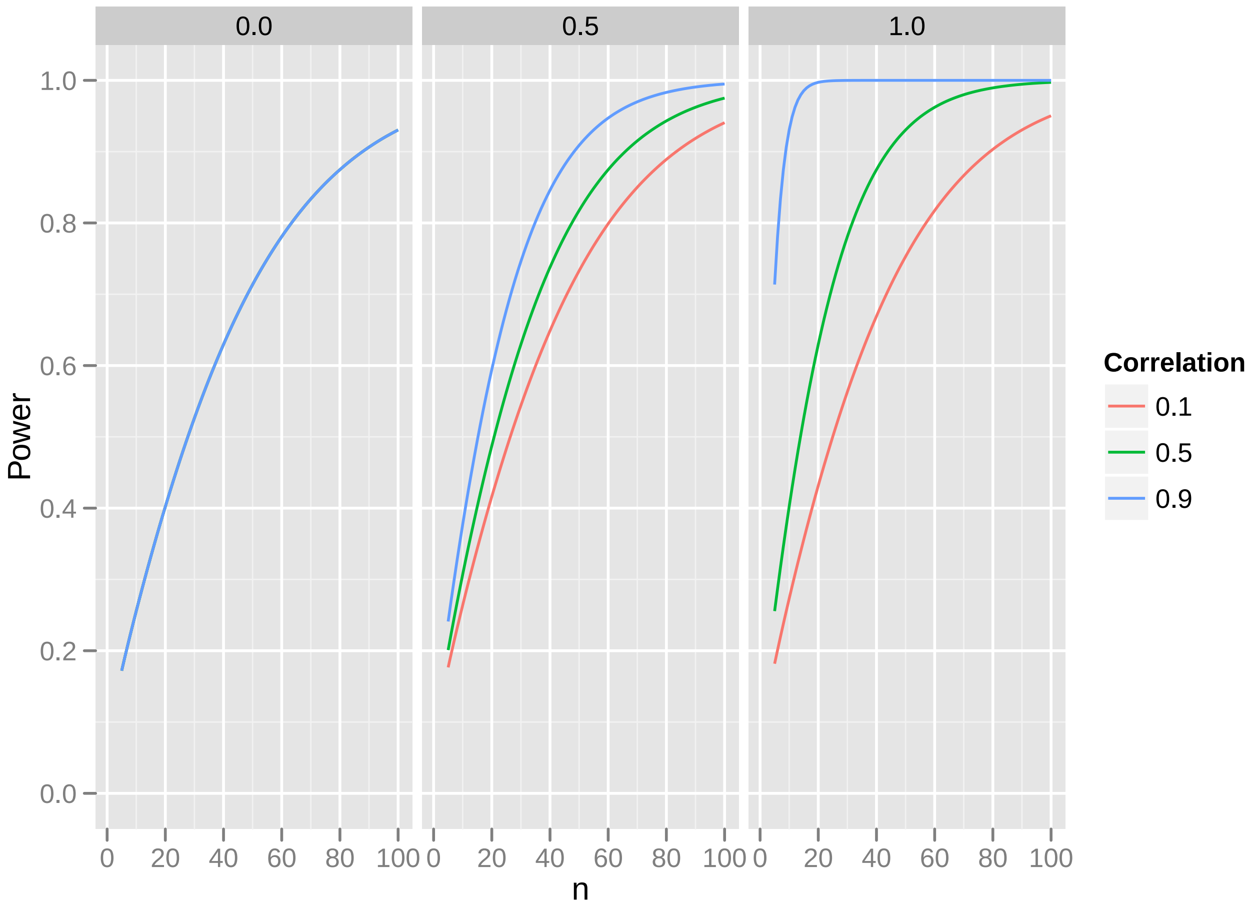

Figure 12: Relation between power and sample size for three possible fractions of overlap between the first and second sample (0, 0.5 and 1) and for three possible temporal correlations in number of species at a farm (0.1, 0.5 and 0.9). Case study region: Wales, species group: spiders. $\alpha = 0.1$, least relevant temporal change is 10% of the mean number of species per farm.