Quantifying effects of changed farm practices on biodiversity in policy impact assessment – an application of CAPRI-Spat

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Executive Summary

Due to the large share of the European Union (EU) surface occupied by agriculture, the role of agricultural activities goes beyond provision of food, feed and fibre and involves externalities such as the creation and maintenance of cultural landscapes and the provision of specific habitats. Traditional agricultural practices, in particular, have created through the centuries specific environments that have supported large part of European biodiversity. Such environments have undergone deep transformations in the last 50 years due to the intensification of farming practices, which have contributed to biodiversity loss in Europe through a shift to high-input farming ststems, simplification of rotations, generation of larger plots, removal of landscape elements etc.

A common pan-European indicator to evaluate the likelihood for an agricultural system to support biodiversity must assess those fundamental characteristics which are common to all or at least the vast majority of farming systems considered as potentially supporting biodiversity. Furthermore, in order to allow for forward looking impact assessment, the indicator must be based on such data where changes can be projected into the future as well as simulated depending on variations in policies or market conditions. The latter adds a rather stringent restriction to its development compared to monitoring activities where e.g. ground surveys of species composition can be used directly. However, in policy impact assessment, it is necessary to assess how changes in the farming systems driven by policy changes impact on their contribution to biodiversity. The CAPRI (Common Agricultural Policy Regionalised Impact) modelling system offers a frame to perform this type of assessment, since it is structured in modules dealing with farming decisions at the level of individual EU regions, and links them to developments in EU and global markets for agricultural primary and secondary products based on a global agricultural trade model. The paper presents an operational methodology to calculate an indicator to assess the likelihood for farming systems at a EU-wide scale to support biodiversity, based on existing data and the results of CAPRI-Spat, a spatial downscaling component which delivers crop shares, stocking densities, yields and fertilizer application rates at a 1x1 km resolution for the EU derived consistently from regional CAPRI results. A scenario analysis is presented as well, focusing on the introduction of an ecological set-aside program as recently proposed by the advisory board to the German department for the environment.

The application highlights two important characteristics of the proposed indicator which are relevant in policy impact assessment. Firstly, it is provided on a continous scale and it is sensitive also to changes in intensive agricultural practices. Secondly, it is robust and transparent, easing communication of results to policy makers and the wider public. Current results are to a certain extent constrained by data availability at an appropriate spatial resolution and lack of data on common lands and linear landscape elements, nevertheless they show great potential for policy analysis.

Introduction

Agriculture appeared in Europe about 8000 years ago, spreading to great parts of the continent in the following 2000 years. In this slow process, people learned to adapt their agricultural practices to local pedo-climatic conditions while at the same time plant and animal resources co-evolved. They became in part dependent upon human land management, giving origin to characteristic agriecosystems. These are nowadays often embedded in traditional rural landscapes such as the Spanish dehesas, the steppic areas of Eastern Europe or the extensively grazed uplands in United Kingdom and Ireland. These agriecosystems are considered to be real biodiversity hotspots, hosting a high species and habitat diversity or species of European conservation concern. This is the so-called "*High Nature Value (HNV) farmland*".

Such agriecosystems depend crucially on a specific type and intensity of agricultural land management. Land abandonment would cause their reversion to the natural state and change their status and species composition as would increased intensity due to higher use of fertilisers and pesticides or higher grazing density, leading to a simplification of habitat composition in terms of species richness and species diversity.

The link between farming practices and biodiversity has been underlined since the early nineties in works by Baldock *et al*. (1993) and Beaufoy *et al*. (1994). Mapping efforts to identify HNV farmland have been carried out more recently (EEA, 2004; Pointereau *et al*., 2007; Paracchini *et al*., 2008; EENRD/EC, 2009). The HNV farmland concept has also been embedded in the Common Agricultural Policy (CAP): "To protect and enhance the EU's natural resources and landscapes in rural areas, the resources devoted to axis 2 should contribute to three EU-level priority areas: biodiversity and the preservation and development of high nature value farming and forestry systems and traditional agricultural landscapes; water; and climate change." (Community's Strategic Guidelines for rural development, 2007–2013, OJ L55/20, 2006). Furhtermore, the COM(2010) 4 final "Options for an EU vision and target for biodiversity beyond 2010" recognises the importance of the provision of ecosystem services outside protected areas while stating that the EU will not achieve its target of halting biodiversity loss by 2010.

Agriculture thus continues to play a crucial role both in the maintenance and the loss of biodiversity in rural areas. Ongoing intensification and mechanisation of agriculture shape modern agricultural practises which continue to replace HNV farming systems. These changes in agriculture are mainly linked to general macro-economic developments. A limited land base suitable for agriculture led early in Europe to intensity increases e.g. by mineral fertilizer and chemical use in order to offset increasing opportunity costs for farm labour due to higher wages in the non-farming sector. At the same time, these triggered labour-saving investments and structural change characterized by larger and more specialized farms. That in turn let plot sizes increase and promoted the removal of landscape elements. Intensification in partcular was supported for decades by the CAP (CEC, 1999) whose market support and border policies kept agricultural product prices in the EU above world market levels. The CAP of today is characterised also by elements such as Cross Compliance or Agri-Environmental Measures to offset negative and promote positive externalitities of farming such as those linked to bio-diversity.

Besides initiatives aimed at mapping the current state and distribution of HNV farmland, the process of shaping a CAP for the future requires tools which perform ex-ante impact assessment to inform the policy debate. This paper thus presents an operational methodology to calculate an indicator to assess the likelihood for farming systems to support biodiversity in general and HNV farmland in particular, operationalised at a EU-wide scale, based on existing data and on an economic simulation model for agriculture. The methodology is based on a tool for spatial downscaling from the regional NUTS2 (Nomenclature des Unités Territoriales Statistiques) level to 1x1 km grid cells (Leip *et al.*, 2008).

Methodology

Setting the frame for an indicator of biodiversity friendly practices

The concept of High Nature Value farmland links agricultural land use to species richness and abundance and habitat diversity or scarcity. It is challenging due to the fact that any agricultural production system is designed to host and promote agricultural species or breeds, but also provides habitats for non-agricultural species.The species composition on agricultural land is different from that found under natural succession so that agriculture may contribute to biodiversity. The contribution depends on different characteristics of the farming systems, such as crop rotations, intensity of cultivation, integration or not of livestock production and type of livestock production. All these elements are main drivers of species abundance and richness and the difficulty consists in measuring to what degree agriculture provides habitats to wild flora and fauna.

We aim at defining a common pan-European indicator to evaluate the likelihood for an agricultural system to support biodiversity. It must assess those fundamental characteristics which are common to all or at least the vast majority of farming systems considered as potential HNV candidates. Furthermore, in order to allow for forward looking impact assessment, the indicator must be based on such data where changes can be projected into the future as well as simulated depending on variations in policies or market conditions. The necessity to link the indicator to an economic simulation model adds hence a rather stringent restriction to its development compared to the characterisation of the current state of HNV farmland. The latter can be based on field surveys or biodiversity relevees without the necessity of a cause-effect analysis. However, in policy impact assessment, it is necessary to assess how changes in the farming systems driven by policy changes impact on their contribution to biodiversity. To name an example, grassland systems in a certain region, currently considered HNV, may lose that status in future if changes in markets and policies and other drivers lead to increased stocking densities or further changes in farming practices, such as as a move from grazing to cutting or from permanent grassland to regularly reseeded one.

The basic concept of the indicator

As underlined, for a certain landscape unit to be considered of High Nature Value, human intervention on nature must on one hand be strong enough to provide a land cover different from what is found under natural succession in order to prevent, for example, shrub encroachment in seminatural grasslands. Abandoned farmland will lose its HNV status in a relatively short period of time. On the other hand, the farming practices must prevent to a larger degree impacts which cause a simplification of floristic diversity, fragmentation of habitats, decrease in soil quality etc. It is clear then that the most important characteristic of HNV farmland are extensive agricultural practices. In fact, high fertilization doses, short crop rotations or monoculture combined with chemical plant protection measures cause depletion of species richness and species diversity (McLaughlin and Mineau, 1995), and thus are likely to make farmland lose the HNV status. These basic findings make clear that we deal here with a composite indicator, and that key sub-indicators can be identified with reference to the main farmland components: arable farming, grassland and permanent crops. This approach well responds to needs and constraints set by the modeling frame: firstly to directly measure the concept of intensity or provide at least robust proxies, and secondly to use existing data sets to calculate the indicator.

Unfortunately, concentrating on the intensity of agricultural practices as the major characteristic for HNV identification fails shorts to cover specific aspects of biodiversity also included in the HNV concept. One of these relates to species of particular conservation interest, which can be found on more intensively cultivated areas. A second characteristic of HNV relates to landscape elements, such as edges, hedgerows, ditches, terraces, all elements that contribute to the presence of biodiversity in farmed land. There is again a tendency under intensive cultivation practices to remove such elements which often hinder mechanization, but clearly, intensity of production does not allow to measure existence or absence of such landscape elements, nor it is possible, given current data availability, to introduce this element in the modelling system.

From policy to drivers: an economic model for agriculture

As mentioned above, the main purpose of the indicator discussed in this paper is to allow for forward looking impact assessment. This requires a tool which is able to simulate changes in those characteristics on which the indicator is based. For this purpose we have chosen the CAPRI (Britz and Witzke, 2008) model as the tool to provide the necessary input data. CAPRI, an acronym for Common Agricultural Policy Regional Impact, can be defined as a multi-purpose tool for forward looking policy impact assessment for European agriculture, based in its core on interlinked economic models. It covers modules dealing with farming decisions at the level of individual NUTS2 regions for the EU plus Norway, Western Balkans and Turkey, and links them to developments in EU and global markets for agricultural primary and secondary products based on global agricultural trade model. Simulation results cover prices, quantities of production, processing, feed, human consumption and trade of agricultural products as well as typical elements of an economic analysis as changes in agricultural profits, purchasing power of the consumer or the costs of running the policy. The model covers different environmental indicators such as nutrient balances or Green House Gas (GHG) inventories. It is an established tool to analyse reforms of the Common Agricultural Policy or agricultural trade policies, applied since the late nineties and consequently maintained and further developed since then. It has also been applied for different questions of agri-environmental policy, i.e. in the estimate of abatement costs of GHG in European agriculture, to analyse abatement options for Ammonia and impacts of Cross Compliance.

All major regional results of CAPRI – crop areas and yields, animal herds, organic and mineral fertilizer application rates and further input coefficients – can be downscaled from regional NUTS2-NUTS3 level to clusters of 1x1 km grid cells for the EU. The downscaling process disaggregates consistently the above listed parameters of the regional

CAPRI dataset to sub-regional processing units covering the agricultural area of the EU. These units are chosen to be approximately homogenous with respect to soil, slope and land cover by combining grid cells of the same soil type, slope class, land cover class and administrative unit. The resulting clusters of 1 km x 1 km pixels are the so-called Homogenous Spatial Mapping Units (HSMUs). The details of the downscaling procedures are discussed in Leip *et al.* (2008) and are summarised as follows.

Crop shares for each HSMU are derived by downscaling the regional data on crop shares – either from statistical data (ex-post) or CAPRI projection or simulation results (ex-ante) – based on binary Maximum Likelihood regression models of growing each crop as a function of local factors. The models are estimated from actual land use recorded in the LUCAS dataset (European Commission, 2003). This delivers a priori distributions for crop shares in each HSMU which are readjusted to give the total area per crop in each NUTS2 region, in a way which maximizes the total likelihood of the distribution.

The crop yield estimation determines the most probable combination of crop yields and irrigation shares per crop in each HSMU. In an analogous procedure to the crop-area assignments, the initial yield estimates are based on existing crop models (Genovese *et al.*, 2007), and the irrigation map of the Food and Agriculture Organization of the United Nations (Siebert *et al.*, 2005), and then adjusted so that the results aggregated to NUTS2 conform to the NUTS2 production volumes.

Regression models for animal stocking densities for 13 different animal activities as well as aggregates for ruminant and non-ruminants are estimated from the Farm Structure Survey (European Commission, 2008) with about 500 observations for administrative units of the EU, using the following explanatory variables: crop and land cover shares, certain crop yields, economic performance indicators for plant production, altitude, slope and climate data.

Fodder produced on farm and organic fertiliser may be easily transported between the (often rather small) HSMUs. The regression models are therefore applied to a distance and area weighted average of the explanatory variables around each HSMU and provide the expected mean and associated forecast error for each animal category as a priori distribution per HSMU. A Highest Posterior Density estimator (Heckelei *et al.*, 2005) selects then the most probable combinations of stocking densities per HSMU which aggregate to the regional herd sizes.

Manure and mineral fertilizer nitrogen application rates at regional level are determined based on results of expert surveys on mineral application rates for crops or group of crops at country level, taking into account regional yields, manure availability, average regional soil parameters and emission factors from animal housing and manure storage systems lined up with the MITERRA-EUROPE (Oenema *et al.*, 2007) and Regional Air Pollution Information and Simulation (RAINS) (Klimont and Brink, 2004) models. At sub-regional level, organic N, P and K application rates per crop and HSMU are first estimated by modulating the organic application rate for the crop at regional level depending on crop yields and the estimated manure availability derived from stocking densities and excretion coefficients. Here again, as in the case of the estimation of the stocking densities, distance- and size-weighted averages of the organic nutrient availability around the HSMU are used rather than spot observations. The resulting estimated manure application rates per crop are then scaled in order to recover the given regional rate per crop. In a similar manner, inputs from crop residues, biological fixation and atmospheric deposition are calculated. Finally, the estimated application rates of synthetic fertilizer nitrogen are based on the difference between the crop nutrient need and all non-mineral sources, corrected by typical loss rates, and a factor based on soil properties. Those estimates per crop are then again scaled to deliver in average the regional mineral nitrogen application rates.

Definition of an indicator of biodiversity friendly practices

The proposed indicator evaluates separately arable crops, grasslands and permanent crops as shown in figure 1. Olive groves have been treated separately from the rest of permanent crops since a targeted method was found to evaluate their type of management. For each of these categories a score is calculated, corresponding to the likelihood that the type of management is beneficial to biodiversity. Furthermore the indicator is built in a way that it remains sensitive to changes in the lower part of the scale as well, indicating beneficial changes in intensively managed areas. The different elements are discussed and motivated in more detail in the following paragraphs.

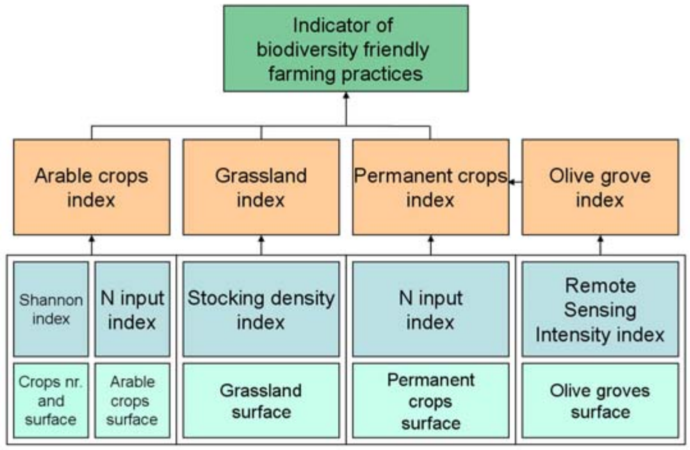

Figure 1. Scheme of the indicator of biodiversity friendly farming practices

Index score for arable cropping

Arable land is not generally considered as the main source of biodiversity in agricultural land, especially when compared to seminatural grasslands or traditional orchards. Nevertheless there are conditions under which arable land provides relevant habitats for biodiversity and can be classified of high nature value. Such conditions are linked to a few characteristics identified by several authors (Beaufoy *et al.*, 2004; EEA, 2004; EENRD/EC, 2009): intensity of management, presence of seminatural vegetation and crop diversity. Each of these characteristics was analysed in order to find a suitable way to include it in the modelling methodology. The basic assumption of the indicator is that arable cropping is only beneficial to bio-diversity when it combines a low intensity of management with rich crop rotations.

Concerning the intensity of management, the assumption is that the potentially positive effect on biodiversity of a rich crop composition is dampened if management practices prevent growth of competing natural species. Clearly, the aim of any farming practice is to favor the growth of the selected agricultural crop(s) by reducing water and nutrient stress and suppressing competitors, e.g. by mechanical and chemical weed control. By doing so, biodiversity in the field is reduced. It is therefore not astonishing that approaches to assess the impact of farming practices on biodiversity typically include some measurement of management intensity. Several indices had been proposed to measure management intensity (i.e. input costs per ha, yield differences to national averages, N-application rates). We opted to use the sum of manure and mineral nitrogen applied per ha. In order to assess the impact of increasing nitrogen doses, a step-wise linear function is implemented to allow for a differentiated impact of an additional kg of nitrogen in relation to the total amount applied. Depending on the analyzed taxon, literature gives different estimates of the steepness of the relation between increased N doses and biodiversity loss (Billeter *et al.* 2008; Batary *et al.*, 2008, Clough *et al.*, 2007; Kleijn *et al.*, 2009), this information was used as reference to build the step-wise linear function, that tries to capture an average overall estimate of species loss in the broad sense. The function drops from a value of 10 to a value of 8 in the range of 0-30 kg per ha, then from 8 to 1 on the range of 30-200 kg per ha, and then to zero at 800 kg per ha. In this way the index is not only sensitive to changes in the upper part of the scale, but reacts to changes in the lower part as well.

Crop diversity per se cannot be directly associated with management intensity (Herzog *et al.* 2006) but associated with low inputs and a network of natural/seminatural features constitutes one of the categories of HNV farmland (Andersen *et al.*, 2003; Paracchini *et al.*, 2008). Crop diversity contributes to the indicator with the assumption that the richer the crop composition and the more equal the shares, the better for biodiversity. A modified Shannon index is applied, which has the properties to give numbers between 0-1, and to measure simultaneously changes in crops diversity and evenness in crop distribution. The crops available from the CAPRI land use map were grouped into 22 categories for the calculation of the index.

Presence of seminatural vegetation is acknowledged (Duelli and Obrist, 2003; Billeter *et al.*, 2008) as probably the most important factor explaining species richness across different taxonomic groups. The presence of a network of natural and seminatural vegetation (i.e. field margins, hedges, edges, woodlots, ditches etc.) leads in fact to the creation of multiple habitats hosting different species. As already stated the CAPRI modeling framework does not allow for the modeling of natural/seminatural features, therefore the indicator of biodiversity friendly farming practices is calculated on the basis of crop diversity and nitrogen input as an indicator of management intensity. This is indeed a limitation of the final sub-indicator but constitutes a minimum requirement for an agricultural area to reach some nature potential. The presence of natural/seminatural vegetation can only increase such potential.

The final index score for the arable part of the crop shares is the geometric mean of the index value for the richness and distribution of the crops (multiplied by a factor of 10) and the intensity index.

Index score for grasslands

Seminatural grasslands are well known biodiversity hotspots, they are among the most species-rich habitats (Pykälä, 2007) and for this reason they have been identified as a primary component of High Nature Value farmland (Beaufoy *et al.*, 1994; Andersen *et al.*, 2003). Their ecological value is dependent on grazing and mowing, but the impact of management is strictly dependent on environmental characteristics of the sites (Bakker, 1998) and to availability of biomass. When this is scarce (i.e. in semi-arid environments), grazing impacts negatively on plant species richness, which, on the contrary, is favoured by grazing in more temperate climates characterised by a higher vegetation productivity (Olff and Ritchie, 1998). There is, though, an optimum interval of intensity of management that corresponds to a peak in plant species richness, in fact the latter declines on one hand when the level of nutrient input increases due to higher fertilization rates (Klimek et al, 2008; Kleijn *et al.*, 2009), on the other following abandonment (Pavlu *et al.* 2005; Wahlman and Milberg, 2002).

In this study stocking density was selected as a proxy for management intensity. The density was calculated by converting the different types of cattle and sheep found in the CAPRI data to livestock units, and then relating the resulting livestock unit sum to the areas of fodder (all types of grassland, fodder maize, fodder root crops).

A step-wise linear function is used to characterize the effect of the stocking density on the nature value of grassland. In order to define appropriate thresholds for grazing densities reflecting the variety of European environments a survey has been carried out involving European HNV experts. Firstly, each one was asked to give values for the minimum and maximum grazing density that generate a HNV farmland context in his/her country and per environmental zone. The reference for the environmental zones is the Environmental Stratification of Europe version 6.0 (Metzger *et al.*, 2005). Secondly, the information collected was used to derive two continuous functions that relate grazing pressure to potentially available biomass and define locally the optimal grazing regime with regards to biodiversity. The reference data for potential biomass is a layer of land suitability for grassland calculated in the frame of the LUMOCAP project (Dynamic land use change modelling for CAP impact assessment on the rural landscape, http://agrienv.jrc.ec.europa.eu/indexlm.htm), with the assumption that land suitability directly correlates to potential biomass.

The information was used as follows. Firstly, the estimated herd sizes for ruminants were converted into livestock units and aggregated. The livestock units were then converted into a ruminant stocking density per ha by dividing the total livestock units in a HSMU by the area of permanent grassland, fodder maize, fodder root crop, other fodder on arable land, set-aside areas not used for non-food production and fallow land. The resulting stocking density was then put in relation to the thresholds for grazing density in order to define the indicator score as shown in figure 2. The first part of the curve increases from 1 to 8 point linearly for stocking densities below the minimum threshold. The second part increases from 8 to 10 point until the average of the thresholds is reached, and then drops to 8 points to the maximum threshold. The third part drops to 1 point when a value corresponding to three times the maximum threshold is reached, and finally to 0 at ten times the maximum threshold. The shape of the curve keeps into account the fact that the majority of species is lost immediately after the increase in management pressure after the optimal range (Kleijn *et al.*, 2009). The highest nature value is therefore a-priori associated to scores above 8 points.

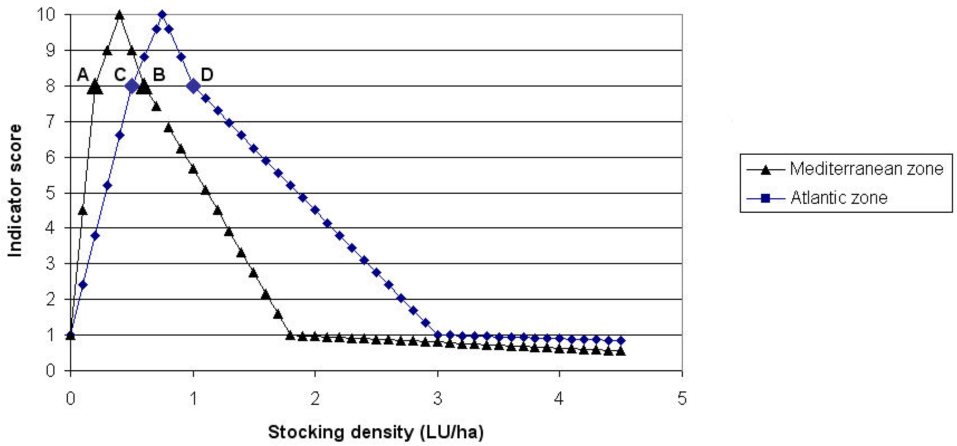

Figure 2 – Example of ruminant stocking density index functions, relative to different environmental contexts. Points A-B-C-D represent respective critical stocking densities for High Nature Value farmland

Index score for permanent crops

Permanent crops are associated to a high nature value when they are traditionally managed. This is normally linked to the presence of old trees, permanent vegetation cover of the floor, and a very low (or inexistent) input of pesticides and fertilizers. Vineyards and olive groves can be associated to arable crops or grasslands; the floor of traditional orchards is likely to be constituted by grassland (mown or grazed, or both). In the case of permanent crops nitrogen input was selected as the variable describing the intensity of land management. There are no studies available in literature about biodiversity loss associated with increasing nitrogen input in permanent crops, therefore the function identified for arable crops was applied in this case as well.

A specific index for olive groves

In the specific case of olive groves a pilot study has been carried out on the possibility of using remote sensing to assess land use intensity associated to olive groves (Weissteiner *et al.*, 2006). In fact, remote sensing monitoring using continuous long-term satellite data time series collected and compiled from daily observations over numerous years provide sufficient information to detect differences in cultivation schemes or agricultural practices that may have a significant influence on the phenological behaviour of the observed land surface unit. Olive groves are known to differ more or less characteristically in their relative composition of proportional olive tree cover and associated annual herbaceous vegetation (whether arable crop, managed or natural grassland) in function of management intensity, ranging from traditional, extensive multifunctional land use (e.g. olive crops and extensive grazing) to highly intense management systems including irrigation and suppression of annual herbaceous vegetation by ploughing or herbicide treatment; remote sensing can then be used to detect the presence of annual herbaceous vegetation in olive groves and the degree of mixing with other land cover types, allowing the distinction of classes of different intensity.

The methodology was applied in the areas mapped as olive groves in CORINE2000 land cover map, and lead to the classification of five classes of different intensity, that could be roughly divided in two groups corresponding to more intensive or more extensive olive groves.

Aggregated indicator of biodiversity friendly practices

The final aggregated indicator is obtained by adding the three components corresponding to arable crops, grasslands and permanent crops, each composed by the single scores weighted with the respective shares in the Utilised Agricultural Area (UAA), more precisely the share of arable crops, grasslands and the rest of the UAA. The index equals ten under a combination of a rich crop composition and very extensive management and/or extensively managed grasslands. It drops to low values under intensive management, or under not well balanced crop composition. CAPRI provides the necessary input data at the resolution of 1 sqkm; the organisation of land uses within such areal reference unit is not known and for this reason the shares are used as weights, though such organisation certainly influences the overall index score.

In figure 3 (left) results for France are shown. Two considerations must be kept in mind when analysing the results: the first is that the index is constructed applying a continuous scale rather than a classification. In the results, areas under biodiversity friendly management can be identified according to a whole range of values; this allows measuring even small changes in the indicator and gives an indication not only of where the areas that may correspond to HNV farmland are located, but different degrees of biodiversity-friendliness can be identified in more intensive areas. This applies to changes as well: in the scenario analysis improvements in management in more intensive areas can be highlighted. Secondly, the results represent the driving force, therefore they represent (High) Nature Value farming systems and not the HNV farmland current status. There might be the case, in fact, of areas that still hold a high nature value but where a change in the intensity of management is ongoing. In this sense coupling a map of HNV status with the results of this study may point out areas where land management is not appropriate.

Figure 3 shows on the right HNV farmland mapped following a procedures based on statistical information and farm practice surveys (Pointereau *et al.*, 2007) available in France at regional/municipal level. Similarities between the two maps are evident.

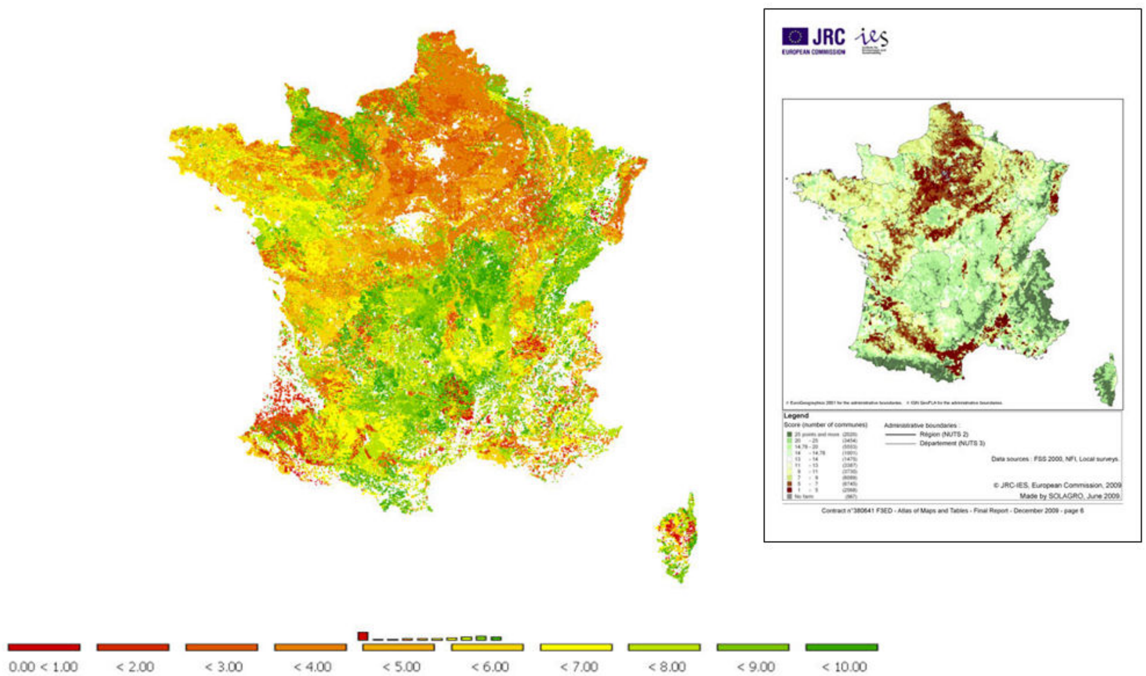

Figure 3 – Comparison of CAPRI-Spat indicator value for France and 2010 revision of the results from Pointereau *et al.*, 2007. Non agricultural areas are represented in white.

Scenario analysis

As underlined in the introduction, the indicator presented in this paper was built for applications in a context of policy analysis by drawing on results of the CAPRI modelling system. The reference dates for the analysis are 2004 and 2020. A necessary step in this process is the definition of a baseline scenario, that describes the situation in 2020 under the assumption that the current policy lawbook including future changes is implemented. The CAPRI version available in spring 2010 (rev. 4396) includes a baseline scenario which comprises the major elements of the CAP under the so-called Health Check: sugar reform, abolishment of dairy quotas, coupled supports only allowed for suckler cows, sheep & goat and fruits & vegs and full implementation of the Single Farm Premium (SFP) in the new Member States. Yields for major crops in Europe are continuing to grow, albeit at a somewhat lower rate compared to past trends. Beef production is stable or even slightly declining, as a response to removed coupled support.

There is a vivid discussion in Europe about the future of the Common Agricultural Policy which is estimated to spend about 50 billion € annually to the benefit of farmers (Farmer *et al.*, 2008). A group of European agricultural economists (Hofreither *et al.*, 2009) recently proposed to abandon completely the so-called "Pillar 1" which comprises (de-)coupled income support to farmers and market interventions linked to a so-called price safety net, while targeting the CAP towards public goods. The declaration states that "*the protection of biodiversity also warrants EU support because animals, ecosystems and biodiversity-threatening pollution cross borders*" (Hofreither *et al.*, 2009). Biodiversity is as well listed among the public goods provided by the CAP in the report "*Provision of Public Goods through Agriculture in the European Union*" (Cooper *et al.*, 2009). Indeed, since 2003 the CAP comprises in its so-called Pillar 2 a strategic focus that requires EU member states to use funds to contribute to biodiversity conservation and the maintenance of High Nature Value farming systems. These opt-in measures are implemented in order to support the so-called 2010 objective of halting biodiversity loss (EC, 2006). This objective will obviously not be met (EC, 2010), triggering more stringent proposals. Therefore the advisory board to the German Department for the Environment (Sachverständigenrat für Umweltfargen - SFU) has recently suggested to set-aside 10% of all farmed lands for biodiversity protection (SFU, 2009). The proposal states that the requirement for such 10% ecological priority farming area might encompass elements such as hedges, non-cropped field margins and specific types of fallow, but also extensively managed grazings and meadows. Equally, areas under so-called Agri-Environmental Measures might be included (SFU 2009). In order to translate this somewhat open definition into a quantitative scenario, we opt for a stringent and clear assumption, which defines a kind of maximal impact of such a proposal: only areas currently in strongly protected state (Natura 2000 network) and areas under extensive management (High Nature Value farmland) are counted as already falling under the definition. Starting with 10% of all agricultural areas, we deduct areas in Natura 2000 reserves and classified as High Nature Value farmland, drawing on the EU HNV farmland map (Paracchini *et al.*, 2008) to find the amount of agricultural land which should be taken out of production. This approach gives a kind of upper limit of environmental benefits which can be achieved in Europe from a scheme operating on arable land, but also of supply reactions in Europe and the rest of the world. Any real-world implementation would most probably allow the EU Member States to also include areas in existing Agri-Environmental Measures into the scheme, softening the overall impact.

The effective set-aside rate calculated is shown in figure 4. It is important to note that Natura 2000 areas and High Nature Value farmlands are typically marginal areas, managed in an extensive way. The set-aside rate is hence high in areas where little of such land is found, so that we have a kind of "adverse" slippage effect at regional scale: the required reduction is higher in more productive regions. This is also intended by the SFU: the so-far existing measures are all of an opt-in nature where incentives were too low in high yielding regions. The map shown in figure 4 also underlines that in the Mediterrean member states, most of the new EU member states, large parts of France and Germany, according to our data and scenario definition, no immediate impact of the program could be expected.

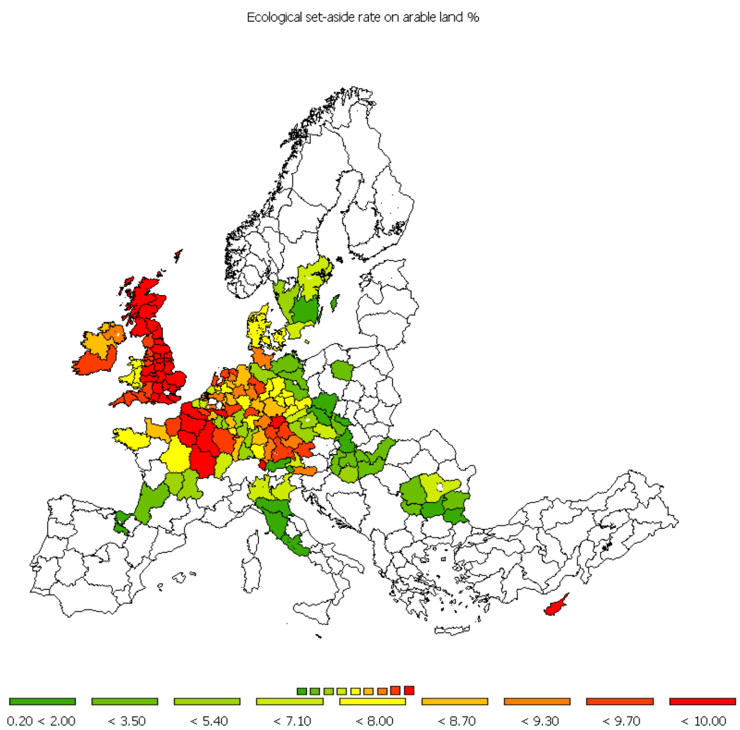

Figure 4. Effective additional set-aside required on arable land

We implement the above described scenario into CAPRI, solving simultaneously at NUTS2 level for all of EU and the global market model, and downscaling the NUTS2 results for France to the 1x1 km grid to analyse consequences on biodiversity based on the indicator. Generally, the scenario shows at a first glance some (perhaps) unexpected effects. By reducing farmed areas, especially in the high yielding regions, EU agricultural output drops and lets prices increase, for major arable crops between +1% and +2%, and for meat in the range of +0.5%. This leads to a slight intensification of crop reduction across the EU so that yields increase, e.g for cereals in average by around +0.5% in the regions. However, due to the area loss in the high yielding regions, cereals yields in EU average are almost unchanged.

We will refrain here from analysing the results further at the regional scale, but turn now to the 1x1 km resolution results related to biodiversity. Figure 5 shows the difference in indicator scores between the baseline scenario and the set-aside scenario. The map for France reveals that the program has in average a slight positive effect on biodiversity when measured on the basis of the proposed indicator. The intensive regions with a high share of arable cropping gain about half an indicator point, as the areas that are now forced to be idling contribute to biodiversity maintenance. The crop rotations become more diversified, as proved by higher values of the Shannon indicator, while nitrogen loads decreases, in average, in arable areas, now including the new idling land.

The map also reveals that in those regions where the 10% requirement for ecological buffers was already reached, the indicator value decreases. The changes are small, they result from increased yields in response to higher prices for arable crops. The intensification effect is a combination of a higher share of arable crops, which also means that stocking density on grasslands increases with corresponding unchanged herd sizes, and of higher nitrogen loads. Generally, this application underlines the major properties of the indicator, which make it useful in impact assessment: it is sensitive also to relatively small changes, and driven by impacts simulated with an economic model.

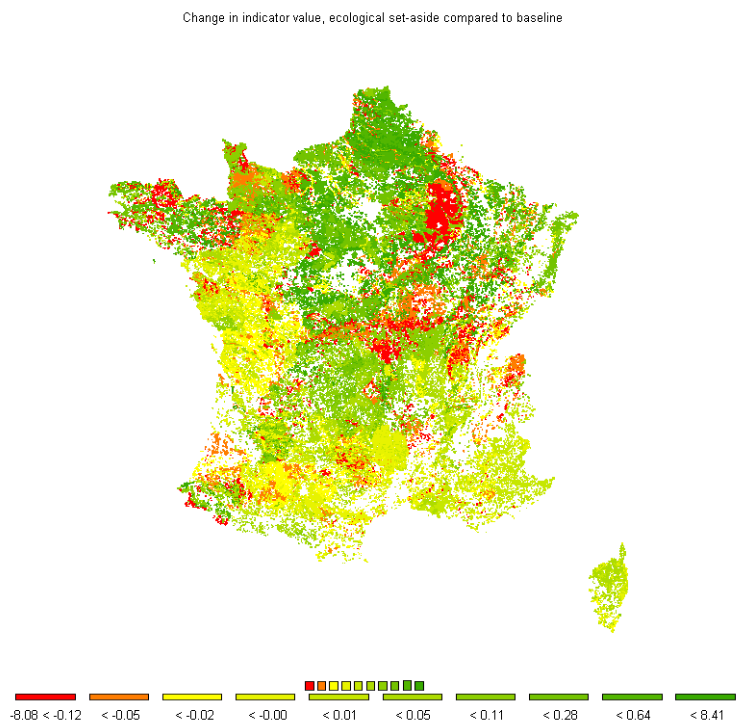

Figure 5. Change in indicator value

Summary and Conclusions

Assessing impacts on biodiversity from changes in farming practices in policy impact assessment faces two major challenges. Firstly, the interaction between agricultural land management and biodiversity requires a spatial resolution typically not offered in economic models. We respond to that challenge by basing our analysis on crop shares, stocking densitiy and nitrogen application rates derived from CAPRI-Spat (Leip *et al.*, 2008). This statistical downscaling tool linked to CAPRI delivers the necessary input data from scenarios EU wide at a 1x1 km resolution. Secondly, a complex bundle of agricultural land management characteristics impacts on biodiversity, such as management intensitiy, crop rotation, grazing pressure, but also maintenance of linear landscape elements and semi-natural vegetation or the presence of rare breeds. Our analysis concentrates on the interaction of the most important drivers: crop shares, stocking densities and fertilizer application rates, all shown in different studies to be crucial for habitats composition, species abundance and richness. These elements are integrated in an indicator that has three major advantages: (1) it is calculated on a continuous scale and reacts also to smaller changes in the sub-components, (2) it is linked to results of an established tools for impact assessment, the CAPRI model, and (3) is relatively simple and robust, easing communication in impact assessment exercises. As underlined, the indicator is not comprehensive of all elements that in rural areas enhance or contribute to the maintaince of biodiversity; what is modelled here are farming practices in the strict sense, and how they can contribute –as a basic but fundamental factor- to create a biodiversity friendly environment. For example, the presence of linear elements per se is not sufficient to classify an area as HNV (Paracchini *et al.*, 2008) but it certainly increases the nature value of farmland, in this sense the results we obtain here represent a minimum nature value, that can be higher under certain conditions (i.e. presence of linear features), but not lower.

The major drawbacks of the presented approach are linked to data availability issues. The maps for the base year are not derived from high resolution ground observations, but are the outcome of downscaling statistical data for larger adminstrative regions. Access to existing datasets such as the Farm Structure Survey (FSS) at sub-regional level could improve the reliability of results. Secondly, major determinants of farm practices such as fertilizer applications rates or feeding practices are not available from existing EU-wide datasets. They are inferred from sectoral datasets and engineering information. Inclusion of key data characterising farming management in datasets such as the FSS or FADN (Farm Accountancy Data Network) is a key element in improving the realiability of impact assessment.

Our analysis for an ecological set-aside program shows the advantages of the presented indicator in a policy relevant application: it measures the immediate benefit from increasing idling land, but also captures the intensification effect provoked by the higher prices in EU markets which result from reduced supply.

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