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Impact of CAP reform on the environment

- some regional results

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Summary

Introduction of the Single Payment Scheme (SPS) in 2005 constitutes perhaps the most radical reform of the Common Agricultural Policy (CAP) ever. This payment has replaced almost all previous forms of subsidies to farmers and is *decoupled*, i.e., paid regardless of whether the farmer produces commodities or not, as long as their land is kept in *Good Agricultural and Environmental Condition* (GAEC). Such a radical reform was expected to have a profound impact on European agriculture. In particular concern was raised about the impacts on historical landscapes and biodiversity if land were abandoned. This paper presents the findings of a large EU project, IDEMA, on the potential environmental impacts of the 2003 CAP reform for a selection of EU regions. Due to the complexity of the issues and the lack of historical data, the assessment was based on dynamic agent-based modelling with the AgriPoliS model extended for environmental analysis.

Our results indicate small impacts in relatively productive regions, since land use remains largely unchanged. In marginal agricultural regions, however, decoupling was shown to have a negative impact on biodiversity and landscape mosaic because of the homogenisation of land use that results from land being taken out of production. Existing agri-environmental schemes and national support acted however to buffer the full potential negative impacts of decoupling on landscape values in these regions.

The effects of the reform would have been more radical if there was *no* link between the decoupled payment and land, i.e. via the GAEC obligation. In this case the model results indicated that farmers would leave the sector at a faster rate and average farm size would increase (thereby improving competitiveness and incomes). On the other hand, significant areas of agricultural land, primarily grassland, were abandoned in the modelled marginal regions. Hence, it might be motivated to strengthen agri-environmental schemes if SPS support were to be reduced in such regions (i.e., with significant areas of grassland) to preserve landscape values.

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1 Introduction

Characteristic of Europe is its diversity of historical agricultural landscapes that echo a rich cultural heritage, provide semi-natural habitat for a wide range of species and generate value to society through, e.g., recreation, tourism and ecosystem services (Swinton et al. 2007; Benton et al. 2003; OECDb 2001). These landscapes have evolved over the eons and are dependent on continued management for their preservation (Scherr & McNeely 2008). Factors that influence farm profitability and hence production decisions can therefore have profound effects on the landscape and biodiversity.

Over the past 20 years the Common Agricultural Policy (CAP) has been gradually reformed towards increasing market orientation. Price-related support dominated agricultural policies in the EU in the 1970–80s, as in other OECD countries. Two reform packages in the 1990s replaced a large share of price support in the EU by direct payments per hectare of land and per head of livestock. These direct payments were only paid to certain types of crops and livestock. The 2003 reform constitutes a further and more radical change of European policies for supporting farmers (Andersson 2004). The central element of the reform is decoupling of direct payments from production via a Single Farm Payment (SPS). The SPS is paid per hectare of agricultural land, but is independent of the individual farmer's production decisions. It is paid regardless of whether the farmer produces commodities or not, as long as the land is kept in *Good Agricultural and Environmental Condition* (GAEC).

The reform intended to make European agriculture more competitive and market-oriented, and at the same time provide support to farmers with less distortion of production and trade. However, in the public debate preceding the 2003 reform it was argued that a decoupled SPS would lead to substantial abandonment of production in numerous regions and sectors, and an exodus from the most disadvantaged rural areas (COM 2003). Given the cultural and environmental values associated with European landscapes, the prospect of reduced agricultural activity was a cause for concern, as manifest in the concepts of the European model of Agriculture and Multifunctionality (e.g. Cahill, 2001). This follows from the argument that countryside services are produced jointly with commodities and hence a decline in production would lead to a concomitant loss in services (e.g. Hodge, 2000).

This paper presents some of the findings of a large EU project, IDEMA[2]: on the long-term effects (i.e. to 2013) of the 2003 reform on farm structure, landscape mosaic and biodiversity for a cross-section of EU regions. Due to the heterogeneity of agricultural and socio-economic conditions in the EU, adjustments to decoupled policies and potential landscape impacts are likely to vary widely between regions. To make the assessment feasible, a sub-set of five case-study regions—reflecting some of the diversity of the enlarged EU—were selected for analysis. These ranged from very extensive northern conditions in Sweden, to intensive regions in the Mediterranean. Due to the complexity of the issues at hand and the lack of historical data, impacts are quantified using a spatial agent-based modelling approach which is described below.

1.1 Theoretical insights on decoupling and environment

A fundamental insight from the literature is that a standard static or marginal economic analysis is not suitable for analysing the impacts of decoupling because it has the capacity to affect farmers' strategic decisions (e.g. to invest or exit farming). As a consequence the analysis is done in a dynamic setting where changes in the farmers' opportunity set can be considered (OECDa 2001; Romstad 1999). For example, if some farms close down as a result of decoupling the opportunity for remaining farms to expand will improve as more land enters

[2] The IDEMA project was supported by the European Community's Sixth Framework Programme (SSPE-CT-2003-502171). www.agrifood.se\IDEMA

the rental market, and as a consequence, result in a smaller reduction in agricultural activity than would be implied by a static analysis.

A basic feature of the 2003 reform is that farmers now have greater freedom to choose what and how to produce whilst total support to the sector is largely unchanged. This additional freedom or relaxing of institutional constraints on farmers' decision environment has two important implications. First, greater freedom implies that the cost of producing commodities and non-commodities alike should decline. Secondly, environmental provisioning (e.g., maintenance of landscape qualities) should become relatively more profitable, given unchanged agri-environmental schemes (OECDb 2001). Consequently the potential negative impacts of decoupling on the environment might be counteracted by reduced costs and the increased relative profitability of agri-environmental schemes. The strength of the effects are though likely to vary between regions, because the relative returns from commodity production and levels of agri-environmental schemes alike vary throughout the EU.

The obvious concern is that decoupling will lead to dramatic declines in agricultural activity in high-cost or marginal regions. However, since high-cost regions tend to be relatively more dependent on Pilar II agri-environmental schemes and national support schemes that remain coupled to production, it is likely that these payments will buffer some of the most serious potential consequences of decoupling for the environment (since farmers in these regions still won't be reliant on world market prices alone for their income). In the case of agri-environmental schemes this could be by encouraging a switch in farming focus from commodity production to "minimizing the costs" of landscape provisioning (e.g., instead of semi-natural grasslands being a bi-product of beef production, beef could well become a bi-product of environmental conservation), or in the case of national support, result simply in reduced returns to fixed factors rather than output (i.e., milk quota and land rents must fall to zero before output is affected by reductions in coupled support).

Significant impacts of the reform in relatively productive or low-cost regions are unlikely, since commodity production should prevail on most land despite decoupling. In these regions a degree of substitution from "eligible crops" to previously unsupported crops can be expected as the relative profitability of the latter increases. The environmental impacts of decoupling in low-cost regions will consequently be conditional upon the environmental characteristics of the substituted crops. From a landscape perspective greater crop diversity is generally positive for the landscape (Benton et al. 2003) whereas the pollution characteristics of any particular crop are an empirical issue (Shortle & Horan 2001).

Coupled Agenda 2000 type payments affect the relative price of alternative land uses such that the relative price of eligible crops increases (i.e., crops that are eligible for support such as grains and oilseeds). In this way farmers are provided with an artificial incentive to grow eligible crops, which distorts the market for agricultural products. In some high-cost regions the coupled payment has been sufficient to induce farmers to grow crops that otherwise would not have been profitable (i.e., the area payment was higher than the land rent). In this way coupled payments have made it profitable to maintain a greater diversity of commodity production and hence land uses, in high-cost regions. In contrast they have contributed to less diversification and hence greater homogenization of the landscape in low-cost regions. Decoupling can be expected to reverse these affects.

The focus of the environmental assessment in IDEMA was therefore on the value of environmental services provided by agricultural landscapes for the above argued reasons. The principle measures used for this purpose are indicators based on changes in land use; specifically landscape mosaic and biodiversity value, which are described more fully below. These indicators are also considered to be positively correlated with other values of landscapes such as; recreation, knowledge-pool, cultural heritage and amenity. A complementary assessment of the impact of decoupling on pollution risk is however also provided.

2 Agent-based approach to environmental assessment

In the assessment we use an empirical agent-based model (ABM) that is capable of simulating the long term consequences (i.e. to 2013) of CAP reform on land use and farming practices in a real agricultural region. This was done by extending an existing ABM of regional structural change in agriculture, the Agricultural Policy Simulator or *AgriPoliS* (Balmann 1997; Happe et al. 2006) for the purpose. The agent-based approach allows us to represent important aspects of the heterogeneity of farms, and their behaviour in space and time. We provide here only a short description of AgriPoliS and modelling assumptions. For more details see the paper by Brady et al. (2010) in these proceedings or for full documentation see Kellermann et al. (2008).

2.1 Overview of the AgriPoliS model

The observed population of farms in a region is modelled in AgriPoliS as a multi-agent system where individual farm-agent behaviour and their interactions—principally competition for land—are defined through an optimization framework with land use resulting as an emergent property of the system. Farm-agents 'optimizing' behaviour is modelled using mixed integer programming which is well suited to the task of combining economic, ecological and biophysical aspects of landscape evolution. Anonymous survey data on individual farms (i.e. FADN) and regional economic statistics to calibrate the model to a real agricultural landscape (Sahrbacher & Happe 2008).

Spatial representation in AgriPoliS is by a 2-dimensional grid of equally sized cells or plots (Happe 2004). Five different landscape layers are used to represent the structure of agriculture and the landscape in each region (Kellermann et al. 2008);

1) The ownership layer denotes the ownership or rental of a specific plot.
2) The soil layer reflects the distribution of any number of different land or soil quality types, which determines what types of (endogenous) agricultural land use are feasible on a particular plot.
3) The block layer replicates the distribution of contiguous areas of a particular land type that are separated from land of the same type, by either another land type or physical borders that are protected through say legislation (e.g. hedge rows, ditches, roads, etc.), and hence, for all intensive purposes, can be assumed to be permanent boundaries that are not affected by agricultural policy.
4) The allocation layer represents the allocation of plots to farms and reflects farmers' land rental decisions (referred to as farm-blocks).
5) The fifth layer reflects a farm's cropping decisions, i.e. a field comprising a number of contiguous plots used for a particular activity (e.g. wheat).

Consequently the modelling framework can simulate from policy to individual farms and changes in cropping patterns at the plot level based on farm-agent behaviour. In this idealized representation all land uses other than agricultural, such as forest, lakes, urban, etc. are subsumed into a single plot type: non-agricultural land. This abstraction is based on the assumption that only agricultural land use is affected by changes in agricultural policy, and hence all other features of the landscape remain unchanged. A further simplification is that AgriPoliS models the landscape synthetically, rather than as the actual location of farms and land as seen on a map. Using a landscape calibration algorithm, AgriPoliS generates a statistically similar landscape based on the size distribution of agricultural blocks and non-agricultural land in the region. This approach captures some important characteristics of the actual landscape (field size distribution and fragmentation) while other characteristics are ignored (field shape).

2.2 Model assumptions and drivers of land use change

The following assumptions are made about the farm-agents' decision environment. First, it is assumed that individual farmers aim to maximize net family income given the family's land, wealth and labour endowments. The area of agricultural land in the region is limited and the opportunities for employment in other sectors determine the opportunity cost of on-farm labour. The family's wealth endowment determines their cost of capital. The landscape is represented by a set of agricultural land blocks of varying size and distance from farmsteads in the region. Labour and capital are substitutes in the model whereas field-size and capital are complements. These relationships imply that families (and regions) with a low opportunity cost of labour will utilize relatively more labour in the farm enterprise and that cost savings can be achieved by farm and field expansion. Finally, farmers influence the landscape through their land use decisions (i.e., which blocks to farm and how) that, in turn, are influenced by the nature and level of agricultural support. Given the existence of a competitive land market (as assumed in the model), rental land will over time gravitate to the most efficient or profitable producers (i.e., those that can extract the highest rent/profit from each block).

The shadow price of land (i.e. implicit land rent) is a crucial policy variable because the higher the potential land rent the less sensitive land use will be to changes in market and policy conditions (identical reasoning applies to quota constrained outputs such as milk). Factors that reduce implicit land rents over time will therefore influence structural change and hence need to be distinguished from the impacts of decoupling support. For example rising off-farm wage rates as a result of growth in other sectors is a particularly critical factor, as this implies that the returns from farming need to increase over time if farmers are to maintain income parity and remain in the sector. Further, off-farm employment opportunities vary considerably between regions and have the potential to buffer the impacts of decoupled support where the opportunity cost of labour is low, which is important to be aware of when considering the regional comparisons in the empirical results. On the other hand the joint distribution of block size and distance of blocks from farmsteads are important physical constraints on farm expansion (since transport is costly).

2.3 Environmental indicators

The ability to model land use change as an emergent property of the interaction between individual farm-agents—through space and time—provides a basis for simulating and evaluating the impacts of changes in agricultural policy on landscape quality via changes in farm-agent behaviour. This is done by incorporating mathematical functions into the model that relate changes in land use to environmental variables. The functions used to measure changes in mosaic and biodiversity are described below.

2.3.1 Landscape mosaic

The more diverse and heterogeneous a landscape, the more complex its mosaic, and hence the more it can potentially contribute to amenity, recreational, cultural and knowledge values. Hence, mosaic complexity was taken as a general indicator of landscape value. Changes in the landscape mosaic are measured using Shannon's Diversity Index (SDI):

$$H = -\sum_{i=1}^{I} p_i \ln\left(p_i\right) \qquad (0.0)$$

where H denotes mosaic diversity, *I* is the set of different land uses, i $\in$ I, and p_i is the share of the total land area covered by the ith land use (i.e., $p_i = a_i \big/ \sum_i a_i$ where a_i is the area of land use *i*). It can be shown that for any given number of land uses, there is a maximum possible diversity, $H_{\max} = \ln I$, which occurs when all land uses are present in equal area, i.e.,

$p_i = 1/I$ for all *i*. According to this indicator mosaic value increases if the area of a relatively scarce land-use (i.e., $p_i < 1/I$) increases or a relatively common land-use (i.e., $p_i > 1/I$) decreases (and vice versa); which is consistent with our understanding that humans prefer a mosaic landscape (as observed in some reference year) compared to a more homogenous landscape.

2.3.2 Biodiversity value

To measure biodiversity we draw on the *species-area* relationship—one of community ecology's few genuine laws—which defines the relationship between the expected number of species and habitat area. This approach to modelling biodiversity is also used by e.g. Nelson *et al.* (2009). If one graphs the number of species s_i supported by a particular habitat (i.e. an agricultural land use) *i,* against its area, a_i , then the data are well approximated by a power function (Rosenzweig 1995):

$$s_i = c_i a_i^{\,z} , \qquad (0.0)$$

where we interpret the parameter c_i as the species *productivity* of land use *i*. The higher *c* the more species a habitat is likely to support. In contrast *z* is a scale parameter that determines how species productivity changes in response to habitat area. We then calculate biodiversity or species value as the expected number of unique species in the landscape, $\sum_i s_i$, the upper value of which is constrained by the total area of agricultural land, $\bar{A}$, such that $\sum_i a_i < \bar{A}$. Since c_i and z are positive constants, the marginal diversity value of habitat is positive $\left(ds_i / da_i > 0 \right)$ but decreasing in area $\left(d^2 s_i / da_i^2 < 0 \right)$ since $z < 1$. Hence *any* reduction in habitat area will be negative for its contribution to biodiversity—which follows common perception—but the strength of the impact will depend on the relative *scarcity* of the habitat and its species productivity. A relatively large reduction in a common habitat would, in other words, imply a relatively small reduction in biodiversity value, whereas a marginal decrease in relatively scarce, productive habitat would imply a relatively large loss in value. The impact of a land use change at the landscape level on biodiversity could therefore be either positive or negative depending on the marginal biodiversity value of competing habitat (e.g., grassland or arable crops).

This indicator has a number of characteristics that are both appealing and useful for policy analysis. First given observations of species and habitat area the species productivity factor can be calibrated by rearranging Equ. (0.0) and plugging in the relevant data, i.e.,

$$c_i = \frac{s_i}{a_i^{\,z}} . \qquad (0.0)$$

Secondly, Equ. (0.0) is a homothetic function because it is homogeneous of degree *z*. Since *z* typically falls within a narrow range (0.18-0.25) for a diverse suite of ecosystems we set it to 0.19 (Rosenzweig 1995). This implies that only relative values of *c* are needed to rank different land allocations in terms of their contribution to biodiversity. Hence given some information about the relative values of *c* for different habitat the species-area relationship can be used to *rank* the impacts of changes in agricultural habitat on biodiversity. This is important because few surveys tally all species (Magurran 2004).

In the model we use the number of threatened or red-listed species as a proxy for uniqueness and hence value (IUCN 2001)—fundamental to the nature of biodiversity value is the number of different or unique species present in the landscape (Weitzman 1992). Red-listing considers a range of characteristics that are relevant to value (in particular regional and global scarcity) and is the central indicator in international conventions on biodiversity (e.g., Countdown 2010). Red-listed species represent as well a subset of total species, and given that the most species rich habitat in our case-study regions are also those supporting most red-listed species (i.e., pasture and grasslands compared to intensive arable crops), our biodiversity measure can be considered a weighted index of biodiversity value, which is what we require.

3 Results of environmental impact assessment

Environmental assessment in IDEMA has mainly focused on the implications of decoupling for preservation of landscape values (Brady *et al.* 2009). An important reason is that the principal environmental risk associated with decoupling is the loss of landscape values that are produced jointly or in conjunction with agricultural commodities (because decoupling reduces the level of returns to commodity production). Land abandonment, in particular, may result in the loss of landscape values. We provide nevertheless an abridged assessment of the impact on pollution risk at the end of this section (for detailed results see Brady et al. (2007)).

3.1 Case-study regions

The case-study regions were selected to capture some of the diversity of the EU-25. Selection focused on the following characteristics: agricultural (North/South); socio-economic (high /low income); mode of operation (intensive/extensive); scale of operations (small/large farm); and legal form (private/corporate). Further, because decoupling is more likely to have significant landscape effects in marginal regions—due to commodity production becoming unprofitable on the margin—we biased selection away from the most competitive agricultural regions. Table 3 provides an overview of farm and landscape structure in each region.

Table 1. Farm and landscape structure of selected regions

		Sweden		**Italy**		**Czech Rep.**
Indicator		*Jönköping*	*Västerbotten*	*Marche*	*Calabria*	*Vysočina*
Total UAA[§]	*ha*	134,216	74,414	49,082	29,176	393,726
Lower limit on farm size [#]	*ha*	2 ha	2 ha	All farms	All farms	1 ha
Number of farms	*nr*	3,824	2,506	5,785	10,626	3,433
Average farm size	*ha*	35	30	8.5	2.7	114
Grassland area	*UAA*	82 %	80 %	2 %	5 %	21 %
Livestock density	*LU/ha*	1.1	0.8	1.6	0.9	0.8
Normal yield (Barley)	*t/ha*	3.5	2.3	4,1	-	5.2
Milk yield per cow	*kg/year*	9,000	9,000	n/a	7,260	6,175
Landscape structure						
Share of agricultural land		14 %	n/a [+]	85 %	85 %	77 %
Median block size	*ha*	1.41	1.48	0.32[*]	0.85[*]	10.63
Mean block size	*ha*	1.76	2.23	0.71	2.05	19.26
CV block size[¤]		1.27	1.36	1.61	1.87	1.26

§ Utilisable Agricultural Area. # Minimum area of land to be defined as a farm in statistics.
+ Concentrated along river valleys. * Arable land only. ¤ CV or Coefficient of Variation as indicator of variability in block size.

The criterion South implies Mediterranean, which is represented by the two Italian regions, Marche and Calabria. These and Vysočina in the Czech Republic, are low income regions with poor employment opportunities outside of agriculture. Intensive regions are defined by high input levels per ha land (e.g. labour, nutrients and chemicals). The Mediterranean regions are the most intensive followed by Vysočina. The two Swedish regions, Jönköping and Västerbotten, are considered extensive because the area of grassland is high and livestock density low (Table 2). Milk yield per cow is though relatively high. These regions also provide contrast with respect to the various Pillar II instruments of the CAP and how they might interact with the SPS. Jönköping has a large area of semi-natural grassland that is important for conservation of biodiversity and its mosaic of arable land adds value to a landscape otherwise dominated by spruce forest. Agri-environmental schemes are as a result relatively common in this region. Farmers' in Västerbotten on the other hand are entitled to complementary national support coupled primarily to milk production (at 0.10 €/kg).

Vysočina is typical of historical landscape degradation in NMS and the urgency of environmental problems (Jelinek et al., 2007). Extreme expansion and amalgamation of fields under the Communist era has resulted in gigantic fields (frequently > 100 ha) that are both erosion prone and increase the risk of flooding. Much of the historical mosaic and species rich habitat such as pasture was also destroyed. Mediterranean landscapes on the other hand are characterized by perennial crops and small fields (0.5-2 ha) which contribute to a mosaic considered integral to tourism. Farms are also small on northern European standards but produce higher value products such as grapes, olives, fruits and vegetables. Calabria has conditions and an output mix (fruits and olives) that are similar to those found in Spain and Greece. Marche has features closer to continental agriculture having a mix of arable crops and wine-grapes.

3.2 Evaluated policy scenarios

The AgriPoliS simulations were run over a 13 year period from 2001 to 2013 (the end of the current programme period). We considered three policy scenarios in EU-15, these being:

- A benchmark scenario which represents continuation of the previous Agenda 2000 policy framework with coupled payments beyond 2004 (referred to as **AGENDA)**.
- The actual 2003 CAP reform, including partially decoupled payments, as it was implemented in each MS (**REFORM**).
- A Bond scheme where the obligation to keep land in good agricultural and environmental condition (GAEC), as in the REFORM scenario, is removed (**BOND**). In this case the SPS for each farm is not distributed as a payment per hectare of managed land, but goes directly to the farmer. Hence, the farmer can produce or choose to leave the sector and still receive support.

Note, for New Member States (NMS), i.e. Vysočina in Czech Republic, AGENDA mirrors the pre-accession policy framework continued beyond 2004 and the REFORM phasing in of CAP decoupled payments on accession to the EU. Consequently the impact of the REFORM for Vysočina is more likely to reflect the implications of a substantial increase in payments under CAP, rather than decoupling of historical support.[3] The BOND has identical interpretation across all regions. Details of the policy framework for Vysočina can be found in Jelinek *et al.* (2007), for the Swedish regions in Sahrbacher *et al.* (2007) and for the Mediterranean in Lobianco and Esposti (2006).

[3] Prior to accession payments for agricultural land were 10 €/ha, rising first to 57 €/ha on accession and progressively to 244 €/ha after 2008. An environmental payment of 110 €/ha for grassland was also introduced.

3.3 Impacts of decoupling on farm structure

As a basis for understanding the consequences of decoupling for landscape we first present the modelled impacts on farm structure. Compared with continuation of production support (AGENDA), decoupling (REFORM) slows the rate of farm exits, as shown in Figure 1, and hence growth in farm size, Figure 2, in all regions. This is because farmers have the alternative of not producing and simply maintaining land in GAEC, a relatively low cost measure. For these farms, maintaining their least productive land in GAEC is, according to the model, more profitable than commodity production or off-farm work opportunities. This effect was least noticeable in the Mediterranean because only a minor area of land was taken out of production and most significant in the Swedish regions because of the large areas of grassland.

The BOND results demonstrate that the GAEC requirement slowed structural change considerably in EU-15 regions (and avoided 'abandonment' of land in the most extensive regions, see **Fel! Hittar inte referenskälla.** below. The GAEC condition had little impact on farm structure in Vysočina because of poor off-farm work opportunities. Thus the type of decoupling scheme—with or without a land mangement obligation—has potentially important implications for structural change and hence the landscape.

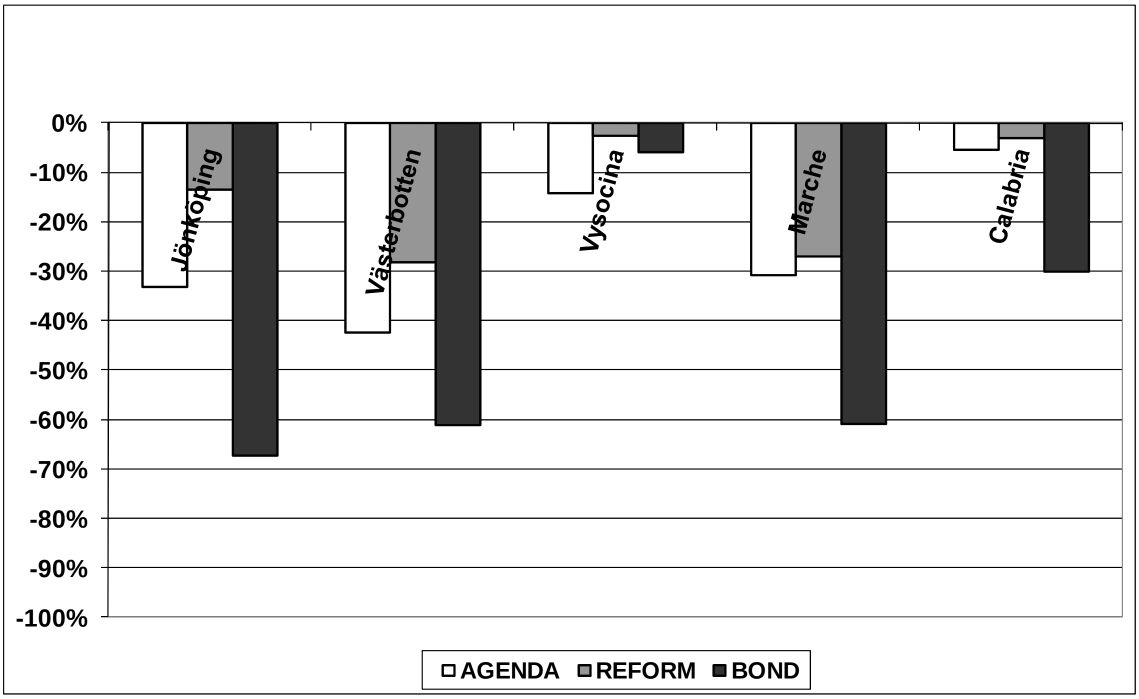

Figure 1. Change in number of farms from 2004 to 2013 with the Agenda 2000 scenario, actual implementation of the 2003 reform and Bond scenario.
Source: Brady et al. (2009)

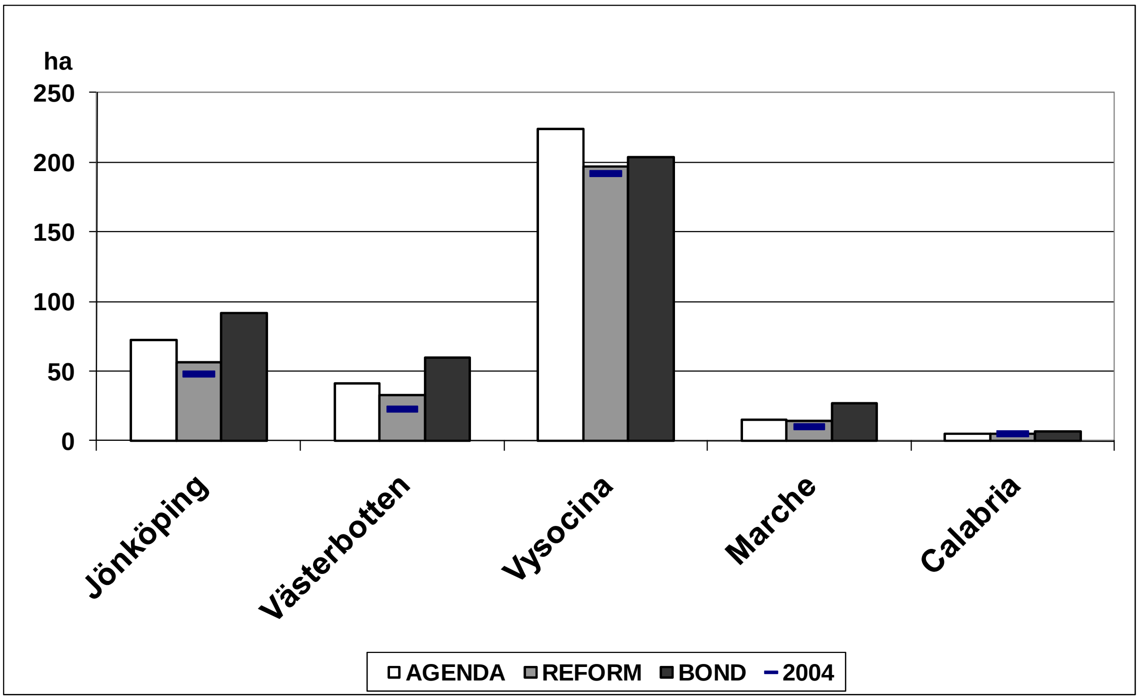

Figure 2. Average farm size in 2013 with the Agenda 2000 scenario, actual implementation of the 2003 reform and Bond scenario.
Source: Brady et al. (2009)

3.4 Impacts on land use

Fel! Hittar inte referenskälla. shows the impacts on land use in terms of the resulting areas of Set-aside, GAEC and Abandoned land for the applicable scenario, relative to the total agricultural area in 2004. In focus here is the area of land abandoned under the BOND (Theoretically no land should be abandoned due to the REFORM because of the GAEC obligation). To begin with note that under the BOND only a very small area is abandoned in Vysočina and nothing in Marche, despite relatively large areas of minimum GAEC appearing in response to the REFORM. This is because the areas of GAEC shown in **Fel! Hittar inte referenskälla.** mirror, approximately, the historical area of obligatory set-aside that still needed to be maintained at the time of the 2003 reform, rather than representing voluntary idling of land by farm-agents (NB this requirement was recently waivered by the EU in response to, at the time, rising global food prices). Consequently, the areas of Set-aside/GAEC in these regions are used in commodity production when farm-agents are given full freedom to choose land use under the BOND.

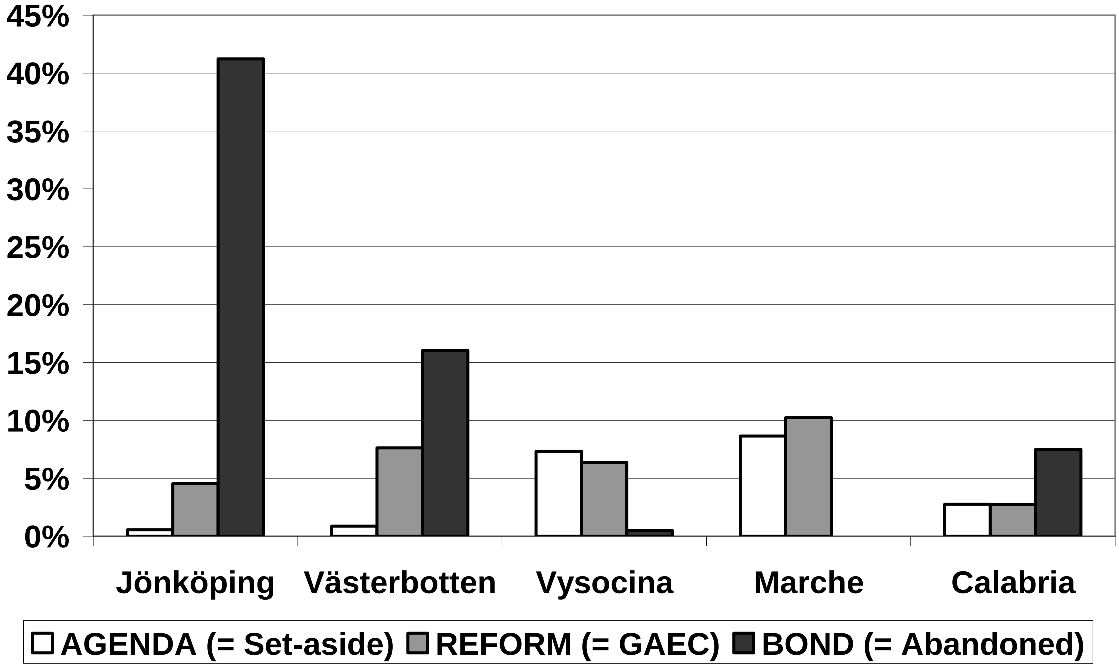

Figure 3. Area of Set-aside, GAEC or Abandoned land in 2013, relative to total agricultural area in 2004.
Source: Brady et al. (2009)

Land abandonment of sharply varying degree is shown to occur in the other regions. In Calabria a relatively small area related to olives is abandoned under the BOND. The most substantial effects, as expected, occur in the extensive regions of Jönköping and Västerbotten. Somewhat surprising might be that the area abandoned is much larger than the area of GAEC, especially in Jönköping, which should reflect the area of land not profitable to farm at market prices. This occurs in the model because semi-natural grassland is required to be grazed by ruminants according to the Swedish GAEC obligation (a relatively costly obligation that mimics agri-environmental schemes), but which is eliminated in the BOND scenario. Thus this result reflects the stringency of the Swedish GAEC obligation rather than the profitability of commodity production after the 2003 reform. For impacts of the BOND on land use in some of the other regions modelled in IDEMA (i.e. Brittany, Hohenlohe, Saxony, South-east UK) see the paper by Brady (2010) in these proceedings.

3.5 Impacts on landscape mosaic

The impacts of decoupling on landscape mosaic are summarized in Figure 4 using Shannon's Diversity Index (SDI). Each column shows the change in mosaic compared to the observed situation in 2004. A negative value indicates that mosaic has deteriorated (i.e. become more homogenous) which is most pronounced for all scenarios in Jönköping and Västerbotten. In these extensive regions the REFORM leads to a significant reduction in the area of grain and grass-fodder, yet the GAEC condition ensures that land is not abandoned (**Fel! Hittar inte referenskälla.** above), and hence avoids the larger deteriorations in mosaic occurring under the BOND. Nevertheless mosaic deteriorates compared to AGENDA because managing land according to minimum GAEC results in an increase in the area of the dominating land use, grass. In this sense the SPS provides an incentive to homogenize the landscape in extensive regions. Mosaic declines less in Västerbotten compared to Jönköping because national milk support is sufficient to maintain land in production.

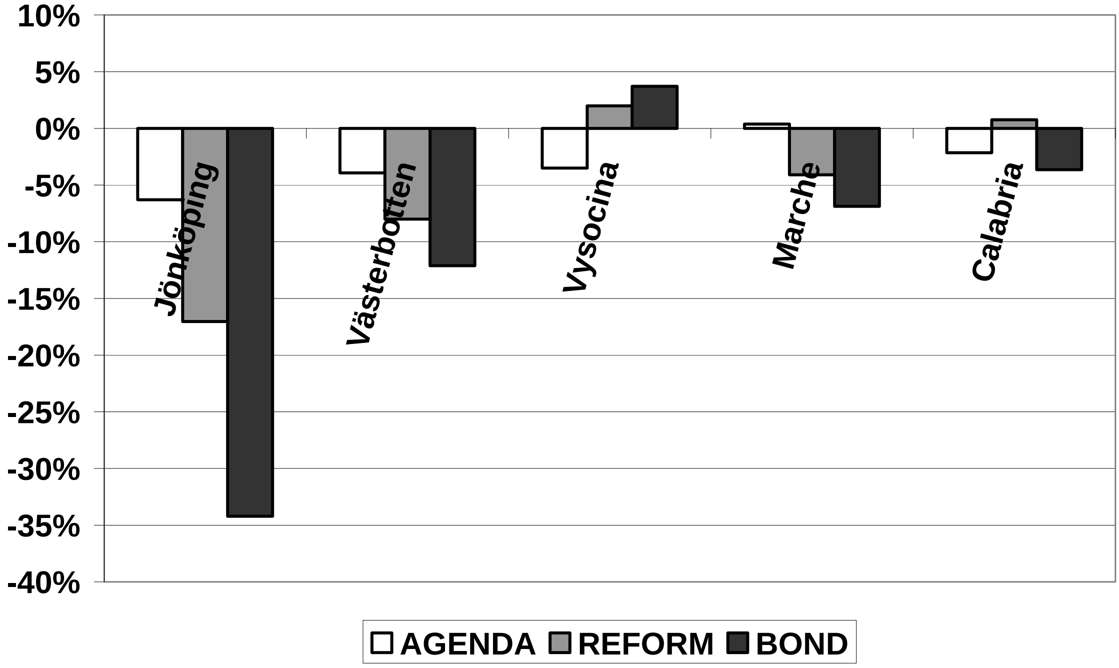

Figure 4. Change in landscape mosaic in 2013 compared to 2004 (Shannon's Index).
Source: Brady et al. (2009)

In regions where cultivation of crops remains largely profitable after decoupling (Czech and Italian regions) it causes a small negative to positive impact on mosaic depending on the regional crop mix, and consequent substitution effects between common and less-common crops. Mosaic improves in Vysočina as a result of REFORM (i.e. accession) because the area of grain declines—the dominating crop type in 2004—and the area of less common fodder crops increases, due to an increase in the relative profitability of intensive beef production. Mosaic improves further under the BOND scenario due to increased crop diversification. AGENDA (i.e., pre-accession) on the other hand results in a slightly larger area of grain and hence reduced mosaic.

In the Mediterranean the REFORM results in fairly small but contradictory effects on mosaic due to region specific changes in the crop mix. The BOND scenario shows a somewhat larger reduction in mosaic in Marche due to reductions in the areas of durum wheat, sugar beet, sunflower and silage crops, and in Calabria due to reductions in soft wheat and olives. This implies that continued production of these crops was the most cost-effective way to fulfil regional GAEC requirements according to the model. Overall the effect of the GAEC obligation on mosaic in Vysočina and the Mediterranean is fairly small since market prices are sufficient to maintain most land in commodity production: hence the GAEC obligation is redundant in these regions for maintaining landscape. Instead some substitution between crops occurs, the effects of which are crop and region specific.

3.6 Impacts on biodiversity

Impacts on biodiversity are shown in Figure 5 to vary substantially between regions and policy scenarios, and to differ substantially from the policy impacts on mosaic. For Jönköping the REFORM had little impact on biodiversity, unlike the impact on mosaic. This result is attributable to the similarity, as described above, of the GAEC obligation and agri-environmental schemes for semi-natural grassland. Despite a significant decline in modelled beef output under the REFORM due to decoupling of headage payments, farm-agents reorganise livestock holdings to minimise the cost of landscape management by switching to sheep from cattle. As indicated above only 49 % of the semi-natural grassland area was preserved in Jönköping under the BOND (i.e. in absence of the GAEC obligation). Additional simulations indicate that this proportion would fall towards zero if agri-environmental payments were also eliminated. In this sense Pillar II payments act to buffer the landscape impacts of decoupling, but not entirely. The substantial decline in mosaic (36 %) and land abandonment (41 %) in Jönköping under the BOND does not, however, translate into a proportional reduction in biodiversity; a result of the diminishing marginal productivity of habitat (Section 2.3.2). As shown in Figure 5 biodiversity falls by only 15 % according to our indicator (which itself is potentially serious as it represents the loss of around 26 red-listed species).

Impacts on biodiversity were similar across all scenarios for Västerbotten because coupled Pillar II national support, which remains unchanged, buffers the impacts of decoupling on production. Since arable grassland is the dominating habitat in this region, the reduction in area under the BOND (-16 %) has only a marginal impact on biodiversity (because the marginal biodiversity value of arable grassland in this region is low).

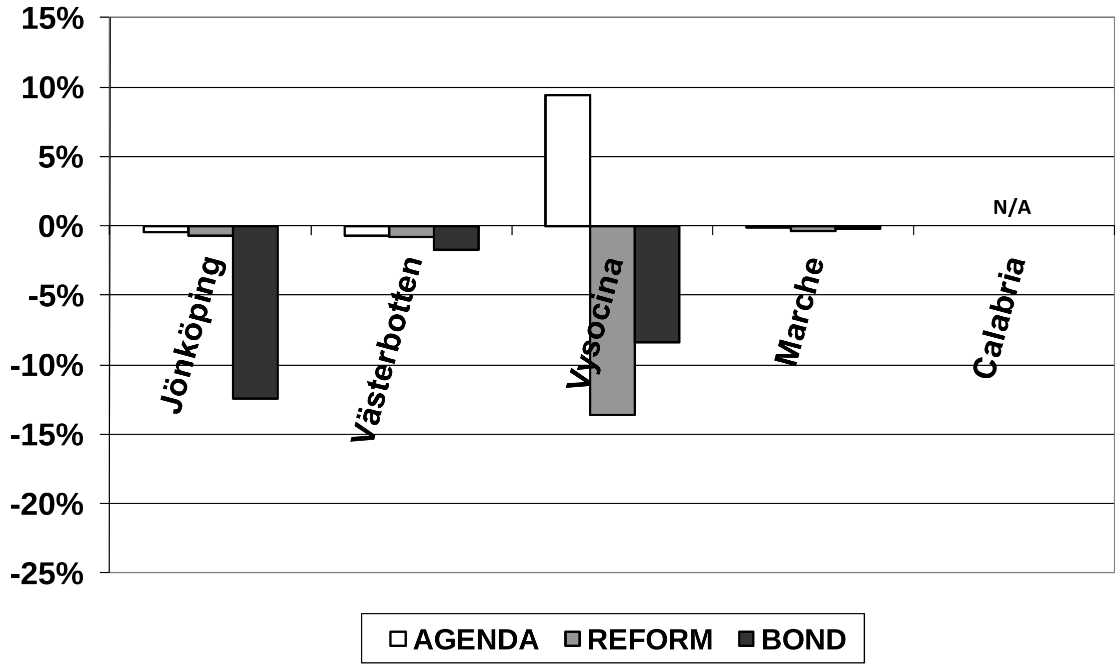

Figure 5. Relative change in biodiversity in 2013 compared to 2004 (i.e. percentage change in number of species). N/A not applicable.
Source: Brady et al. (2009)

Reduced biodiversity in the REFORM and BOND scenarios for Vysočina might seem inconsistent with the corresponding improvements in mosaic shown in Figure 4, since land use diversity is generally supposed to be important for maintaining biodiversity. The primary driver of biodiversity conservation in this region is the area of pasture. Pasture is not only the ecologically most productive habitat but it is also scarce, which translates into high marginal biodiversity value according to the species-area relationship. As such, even a small reduction in the area of pasture causes a relatively large reduction in biodiversity. In terms of mosaic, the reduction in pasture area is compensated for by increased diversity of arable crops. Continuation of AGENDA (i.e. pre-accession) results in increased biodiversity because it favours suckler/extensive beef production (due to lower payment levels) and hence a greater area of pasture. Perhaps surprisingly, the BOND is better for biodiversity than the REFORM. This result is due to two complementary effects; an increase in the relative profitability of suckler beef production which requires pasture, and the 110 €/ha agri-environmental payment to pasture/grassland which raises the relative profitability of this land use in this scenario. Hence pasture area and biodiversity decrease relatively less compared to the REFORM that is more favourable to intensive beef production.

The modelled losses in biodiversity in Vysočina illustrate the problem of having a minimum land management obligation when biodiversity is dependent on preserving specific habitats. Even though agricultural activity is maintained, important habitats might still be lost, denying the general proposition of joint production between farming and the environment.

For Calabria both decoupling scenarios result in significant reductions in the area of managed olive plantation, however due to uncertainty about the importance of agriculture for biodiversity conservation in this region we do not present a biodiversity index (i.e. we have not been able to investigate the ecological consequences of ceasing to manage perennial habitat). A similar effect was not found for Marche because of the relatively small area of olives. Reduced mosaic value for Marche under the BOND did not translate to lower biodiversity value because different arable crops in the region were assumed to have equivalent habitat value (i.e. can substitute for each other). Since the total area of arable habitat remained unaffected by decoupling, so did biodiversity value according to our indicator.

3.7 Impacts on pollution risk

The impacts on pollution risk were found to be fairly arbitrary across all regions, which imply that decoupling has no general implications for pollution; see Brady et al. (2007) for detailed results. This is because pollution is a function of crop specific characteristics (given the biogeophysical characteristics of a region) and the balance between crop and livestock output rather than production per se. This result was expected for more intensively cultivated regions such as Vysočina and the Mediterranean regions, since cultivation of crops was expected to remain profitable despite decoupling of support. Instead in these regions, decoupling altered the mix of crops as it became more profitable to increase the area of previously unsupported crops. This substitution of crops implied that the pollution characteristics of the crop mix changed and hence levels of pollution as measured by nitrogen surplus, Figure 6. In regions where the area of more pollution prone crops increased as a result of decoupling (i.e., Marche and Vysočina) so did nitrogen surplus. On the other hand a reduction in the area of nitrogen intensive crops resulted in a lower nitrogen surplus in Calabria. However the concomitant increase in area of vegetables which consume more chemicals and water resulted in increased chemical (not shown) and water inputs in Calabria, Figure 7.

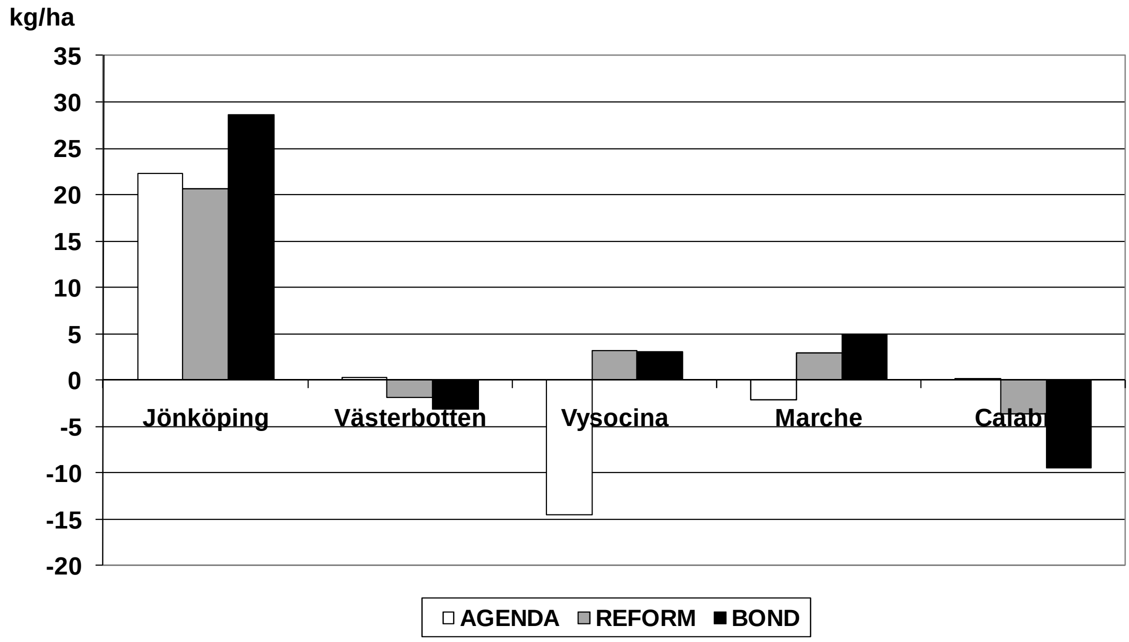

Figure 6. Change in nitrogen surplus kg/ha utilized agricultural area

In high-cost regions it seemed more reasonable a priori that pollution risk would decrease in tact with the rate at which the cultivated area was taken out of production and managed as minimum GAEC—the least polluting land use—rather than seeing a switch in the output mix. The Jönköping region illustrated however that this might not necessarily be the case for nutrient surpluses and hence water quality. Unlike chemical inputs, nutrient surplus is not a function of land use alone but also livestock production. Livestock introduce additional variables into the equation; the source of fodder, manure stockpiles and the area of land available for spreading manure. In Jönköping's case both livestock and crop production decreased as a result of decoupling but the amount of manure generated decreased proportionately less than the area of land suitable for spreading manure, i.e. land in cultivation and excluding GAEC, hence nutrient surplus in total and as measured in kg/ha increased compared to 2004 (but lower than in the AGENDA scenario). Ultimately the impact on water pollution will depend on the geophysical capacity of the region to assimilate the excess nutrients. In Jönköping this capacity is quite high due to heavy soils and long water pathways to the sea.

Finally model results indicate that that REFORM and BOND scenarios lead to accelerated soil loss in Vysočina, Figure 7 (NB erosion risk was only modelled for Vysočina since it is not a significant issue in the other regions). This result is explained by substitution to more erosion prone crops rather than decoupling per se. Given the serious nature of soil erosion problems in the Czech Republic this result should be of great concern. There seems therefore to be a pressing need to coordinate erosion prevention measures and CAP payments.

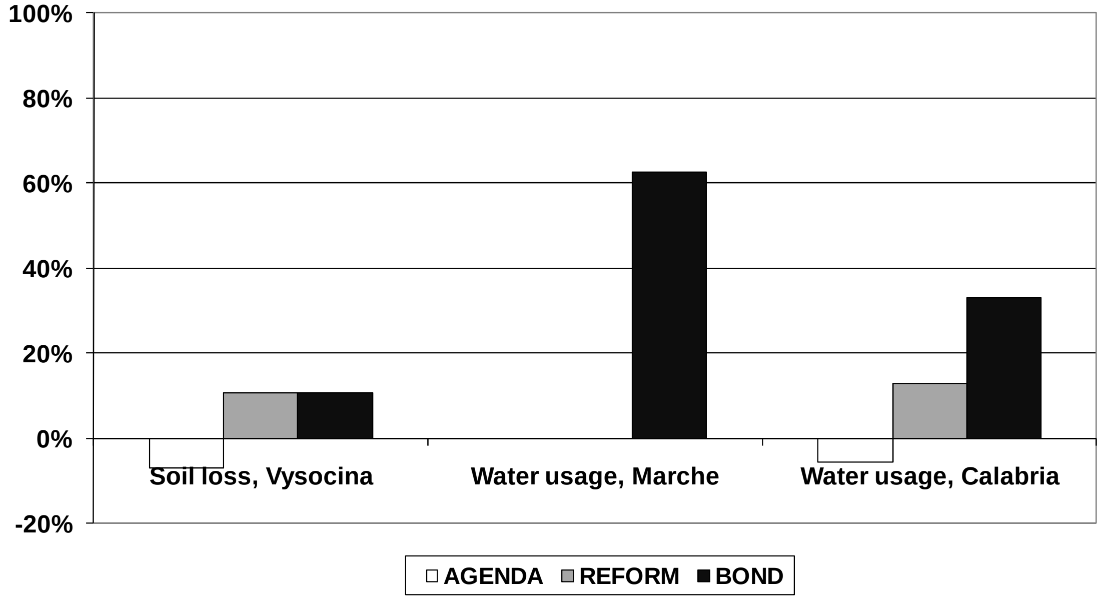

Figure 7. Change in soil loss (Vysočina) and water input (Marche & Calabria)

4 Discussion and conclusions

The environmental impacts of decoupling EU agricultural support from production presented in this paper were assessed as part of the IDEMA project. Both the 2003 CAP reform and a more extreme Bond scheme were analysed. The central element in the 2003 reform was the introduction of the Single Payment Scheme (SPS) which is linked to land via the obligation to keep land in *good agricultural and environmental condition* (GAEC), but decoupled from production. In the hypothetical Bond scheme we test the implications of the GAEC obligation by allowing farmers to collect the Bond payment even if they leave the agricultural sector, and hence break the link between payments and land.

4.1 Decoupling and implications for the environment

Our results demonstrate that the 2003 reform could have negative consequences for the environment—principally landscape values—but only under particular circumstances. In the most extensive regions (Jönköping and Västerbotten) with relatively high production costs, the reform was shown to have a negative impact on landscape mosaic compared to continuation of the Agenda 2000 framework. Since the GAEC obligation for arable land represents a minimum management requirement, the SPS provided an incentive to homogenize land use—increase the area of the dominating land use, grass (i.e. grass-sown fallow/set-aside). On the other hand the GAEC obligation for semi-natural grassland by mimicking existing agri-environmental schemes, ensured preservation of biodiversity values associated with this land (by requiring annual grazing by ruminants). Existing agri-environmental schemes and national support were also shown to reduce or *buffer*, to some degree, the full potential impacts of decoupling direct payments from production in these regions.

Impacts were least in regions with favourable conditions for agriculture (Vysočina and Mediterranean), because most land continued to be used in commodity production despite the 2003 reform. Hence in these regions GAEC was a redundant obligation in view of the fact that market prices were sufficient to keep land in commodity production and hence meet payment requirements. Environmental outcomes of decoupling were, as a result, capricious in these regions depending on crop choices and environmental heterogeneity. Under these circumstances the SPS merely raises land rents—see Brady et al. (2010) in these proceedings—without contributing to environmental quality. In the Czech region where the intensity and scale of arable farming is recognised as being detrimental to landscape value we found nothing in the design of the GAEC obligation that provides incentive to improve the situation. On the contrary, things became worse for biodiversity and soil erosion due to EU accession and the accompanying higher payment levels: GAEC is after all a minimum standard and hence does not prevent over use. So even though agricultural activity is maintained, important habitats might still be lost despite continuation of direct support.

Our overall conclusion regarding pollution risk is that it will be largely unaffected by decoupling. Our results indicated however that change in the ratio of livestock to cultivated area could induce undesirable pollution effects (via concentration of manure spreading) in high-cost regions. In situations where there is a direct relationship between input levels and cultivated area, such as the use of chemicals, then inputs would obviously decrease in tact with the area taken out of production. This effect was significant in high-cost regions. Otherwise arbitrary factors are most critical for pollution such as crop characteristics, choices of agricultural management practices and biophysical features of the landscape. As such the need for non-point source pollution policy seems unchanged as a result of decoupling, especially in intensively cultivated regions.

In summary the GAEC obligation (as modelled here) did not prove to be a sufficient measure to avoid all the negative environmental consequences of decoupling. Rather our results imply that the SPS has serious weaknesses as a means of procuring environmental stewardship, which is also supported in theory. Any flat-rate payment scheme—as the SPS clearly qualifies—will be inefficient when either the costs or benefits of environmental provisioning are heterogeneous (Fraser, 2009). Under these circumstances, cost-effectiveness calls for spatially differentiated environmental policy instruments (Wätzold and Drechsler, 2005). The *key* problem is the immense heterogeneity of agri-environmental conditions in the enlarged EU. Insufficient flexibility is available under the stipulations of Pillar I support—by definition a common policy—to handle environmental heterogeneity. What's more, the stricter the environmental conditions associated with GAEC obligations, the higher the costs to farmers of meeting payment obligations; and hence the less the SPS will support farm incomes, the overriding goal of direct support. The SPS is therefore not generally justified as an efficient environmental instrument. More efficient (and effective) environmental policy instruments are needed to match the local requirements for conservation and landscape enhancement than is provided by the SPS. This flexibility is available under the auspices of Pillar II agri-environmental schemes.

4.2 Environmental public goods from agriculture: what to pay for?

The argument for taxpayers financing the provisioning of environmental public goods by farmers is compelling: under provisioning of public goods is a classical market failure. The relevat *empirical* questions that remain to be answered are therefore;

a) Where are these goods being generated by farmers?
b) What levels are being generated? and
c) How much risks being lost if direct payments (i.e. SPS) are reduced?

In some regions of the EU the existence of environmental public goods is unequivocal, e.g. semi-natural grasslands in Jönköping County in Sweden provide habitat for several hundred endangered plants as do other extensive grassland regions in the EU. In other regions there is no compelling evidence of a link to public goods, as the case for a large, intensively farmed wheat field where the overriding concern is the generation of negative externalities such as nitrate pollution and soil erosion (e.g. Vysočina). There is in general insufficient knowledge about the effects of agricultural practices on biodiversity (Kleijn & Sutherland 2003) and the ecosystem services provided by biodiversity (Zhang et al. 2007). It is therefore of the utmost importance—given limited budgets for environmental protection and other imperative societal goals— that claims of public good provisioning are backed up by *evidence*. Otherwise there is a real risk that purported payments for public goods (e.g. a general payment to all EU farmers) will in fact simultaneously support the continued degradation of the environment that has been brought about by the intensification of agriculture over recent decades, while providing insufficient environmental support in regions or situations where it is genuinely motivated.

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