Rev Agric Food Environ Stud (2017) 98:111–144
https://doi.org/10.1007/s41130-017-0051-8

RESEARCH ARTICLE

A combined approach to assess the impacts of Ecological Focus Areas on regional structural development and agricultural land use

Amanda Sahrbacher[1] · **Jordan Hristov**[2] · **Mark V. Brady**[3]

Received: 31 January 2017 / Accepted: 2 October 2017 / Published online: 27 October 2017

Abstract The 2013 reform of the Common Agricultural Policy (CAP) introduced compulsory 'greening' measures with the goal to mitigate environmental degradation caused by intensive agriculture. This paper aims to investigate how the implementation of the Ecological Focus Areas (EFA) obligation will affect regional agricultural development, the economic performance of farms and land use (including choices of EFA measures) in two representative EU regions. The research approach combines agent-based modelling (ABM) with stakeholder interactions to evaluate how farmers are likely to adapt to the new policy framework and the implications for their behaviour of the different components of the EFA obligation. Our results show that structural impacts of EFA measures are minor in both regions. The most preferred alternatives (fallow land in Sweden and catch crops in Germany) are income preserving for farmers rather than being effective for improving the environment. However, general concerns by farmers for biodiversity and the potential benefits for developing sustainable

✉ Amanda Sahrbacher
a.sahrbacher@iamo.de

Jordan Hristov
jordan.hristov@cec.lu.se

Mark V. Brady
mark.brady@slu.se

[1] Department of Structural Development of Farms and Rural Areas, Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Theodor-Lieser-Str. 2, 06120 Halle (Saale), Germany

[2] Centre for Environmental and Climate Research (CEC), Lund University, Sölvegatan 37, 223 62 Lund, Sweden

[3] Department of Economics, SLU and Centre for Environmental and Climate Research (CEC), Scheelevägen 15 D, 220 07 Lund, Sweden

agriculture were revealed during the stakeholder workshops. We conclude that the large flexibility in choice of measures, watering down of the EFA regulations, implementation at the farm scale and lack of spatial targeting will all but eliminate any potential environmental benefits of the greening measures and subsequently, undermine farmers' and citizens' confidence in the CAP and its makers.

Keywords Common Agricultural Policy (CAP) · EFA measures · Biodiversity · Ecosystem services · Stakeholder interactions · Agent-based modelling (ABM)

JEL classification Q18 (Agricultural Policy-Food policy) · Q57 (Ecological Economics: Ecosystem Services-Biodiversity Conservation-Bioeconomics-Industrial Ecology) · C63 (Computational Techniques-Simulation Modeling)

Introduction

One of the main objectives of the 2013 Common Agricultural Policy (CAP) reform is to strengthen its capacity to deliver environmental public goods and mitigate the environmental degradation caused by intensification of production in cultivated landscapes (EEA 2010). Based on this ambition and considering that the active management of natural resources by farming is an important service to maintain rural landscapes, to combat biodiversity loss as well as to limit its contribution to climate change (European Commission 2010), 30% of direct payments to farmers ('Pillar 1') are now conditioned on compliance with greening measures (EU 2013). This novelty is intended to complement actions supported via Pillar 2 schemes (especially the implementation of voluntary agri-environmental measures) to foster the competitiveness of agriculture, to promote the sustainable management of natural resources, to encourage climate actions as well as to ensure balanced development of rural areas. To be eligible for full Pillar 1 direct payments, farmers are now obligated to adopt 'greening' measures such as crop diversification, maintaining permanent grassland and creating Ecological Focus Areas (EFA). Crop diversification aims to discourage monocultures and improve soil and ecosystem resilience (Mahy et al. 2015) while maintaining permanent grassland and EFA aim to deliver habitat protection, biodiversity improvement and soil carbon retention (Matthews 2012). However, it is to question to which extent these measures defined at the European level might actually support sustainable agriculture—if at all—considering the many exemptions and local options left to European farmers' appraisal regarding on-farm implementation of greening measures. Therefore, in order to understand and assess the present and future impacts of environmental measures such as EFA, our approach combines local knowledge with simulation methods in order to (1) take local specificities, practitioners' expectations and intentions into account and (2) deliver predictions of agricultural development and land use under different policy formulations. In this research, we combine agent-based modelling (ABM) with stakeholder interactions to evaluate how the greening measures, and especially the introduction of EFA, will affect farmers' decisions and potentially the environment through changes in land use.

There are well-grounded doubts as to whether the proposed EFA measures will actually contribute to conservation of biodiversity and ecosystem services indeed. The following aspects are likely to water down any potential benefits for biodiversity: reduction of the EFA obligation from an initial 7 to 5% of farms' arable land during negotiations, various exemptions based on farm size and types and the possibility to classify for instance nitrogen-fixing crops, catch crops and short-rotation coppice as EFA (Pe'er et al. 2014). Moreover, the possibility of weighting EFA measures as a way to 'normalise' the biodiversity effects of different measures is also subject to criticism (Hart 2015; Matthews 2015). Further, farm structures have been changing rapidly in the EU and their development is, for the most part, driven by economic forces in addition to socio-demographic ones. The resultant intensification of agriculture, abandonment of marginally productive but High Nature Value farmland and changing scale of agricultural operations are all contributing to the degradation of biodiversity and associated ecosystem services, which in turn is generating land use conflicts in rural areas (Henle et al. 2008). As these changes and processes at the regional level heavily depend on complex decisions made at the individual farm level, there is a need to involve local actors from outside academia (practitioners, administrators and NGOs) early enough in a transdisciplinary research process to generate best available knowledge about real-world challenges (Lang et al. 2012). Therefore, this study contributes to the literature on sustainability science called for in Kates et al. (2001), in this case applied to issues linked to the introduction of EFA in agriculture.

The next section provides an overview on issues linked to farmers' and entrepreneurs' decision-making, including a short subsection about the role of public support in this context. Following section describes the two regions chosen for the study (one located in Sweden, the other in Germany), the main research steps, the outcomes of the stakeholder workshops in each country as well as the agent-based model AgriPoliS which was adapted to each study region and extended in order to consider the implementation of greening measures. The remainder of the paper presents some results of the modelling with respect to the scenarios defined with local stakeholders in the first workshop. The last section closes the study with a discussion around the results and implications for biodiversity enhancing policies.

Background

Paying farmers for generating public goods represents a significant change in EU agricultural policy, particularly since large amounts of Pillar 1 support are now contingent on farmers meeting greening requirements, particularly the EFA obligation. Previously, these payments have only been loosely tied to public goods. Greening is therefore likely to affect regional agricultural development as the relative profitability of different rural activities change, e.g. potentially changing focus from producing food or simply maintaining land in good agricultural condition (Brady et al. 2017). The overall effects of such a policy shift on farm structure, orientation or specialisation and rural incomes is largely unknown. Analyses and modelling work on Swiss agriculture suggest that a shift of support towards payment for specific services and combinations of services could enhance the provision of public goods without decreasing aggregate farm incomes (e.g. Zimmermann et al. 2011).

In more general terms, there is a fundamental lack of knowledge as to how policies promoting environmental public goods will impact agricultural development. Increased costs of meeting the ‘greening’ conditions for income support could heavily affect farmers’ incomes and their decision to continue with agriculture. Simulations using agent-based modelling (Brady et al. 2012) show that reductions in income support, which is equivalent to increasing costs of receiving support, could speed up the exit of farms and promote farm growth which could outweigh the potential positive effects of greening measures on the environment all other things equal. Hence, there is a fundamental need to scientifically evaluate the broader implications of the new CAP instruments on farmers’ likely adaptation to the new policy framework and consequences for agricultural development and land use and associated environmental public goods. Since recently, policy makers show growing concern about the current high level of land prices and land rents in the European agricultural sector, which make it difficult for farmers renting most of their land or young farmers to continue their activities and make ends meet (European Parliament 2016). In particular, changes in the CAP have an influence on the extent to which direct payments might be capitalised into land values and rental prices; however, this influence heavily depends on factors like the ratio of payment entitlements to the eligible land, their tradability, the share of rented land, the implementation of the decoupling model (historical vs. regional) or land market regulations—to name a few of them—the importance of which vary a lot among EU regions (Ciaian et al. 2008; Courleux et al. 2008; Kilian and Salhofer 2008). For instance, German farmland rental rates were proven to be heavily influenced by agricultural policy instruments in the past, and this statement still holds (Breustedt and Habermann, 2011; Kleiber et al. 2017). Therefore, even though EFA only requires 5% of farms’ arable land, different implementations of the EFA obligation might nevertheless have effects on land rental prices.

The EFA obligation is likely to impact farmers’ decisions through three general influences: economic determinants, administrative restrictions and farmers’ perceptions and knowledge (Lange et al. 2015; Home et al. 2014; de Snoo et al. 2013). Economic considerations are naturally central for farmers when evaluating policies, particularly minimising the opportunity and transaction costs of compliance. Farmers perceive greening restrictions as costly (Schulz et al. 2014) and therefore are expected to choose the most productive or least-cost options (Lakner and Holst 2015). However, Heinrich (2012) shows that since the costs of implementing EFA measures are clearly below the associated greening payment, farmers are expected to comply with the new conditions for direct payments. Nevertheless, the implementation of EFAs by farmers is controlled by national authorities. In case farmers do not comply with rules, they might be sanctioned and in the worst case even lose the greening payment (de Witte and Latacz-Lohmann 2014; Schmidt et al. 2014). Moreover, some EFA measures are subject to overlapping regulation as well, such as through cross compliance regulations (European Commission 2009) or the EU’s Habitats Directive. This increases business risks for farmers and might explain why they might be reluctant to establish somewhat more complicated EFA features like landscape elements for instance.

Existing practises, farm structures, available technologies and management experience can also influence farmers’ EFA choices too (Schulz et al. 2014). For instance, growing nitrogen-fixing crops such as beans and peas requires specific knowledge and particular harvesting equipment. Many farmers also have a self-perception as ‘producers’, considering their primary role to be the production of food rather than provisioning public goods (Burton et al. 2008; de Snoo et al. 2013; Home et al.

2014). Accordingly, farmers are likely to show a preference for 'productive' EFA options. Further, the literature concerning the uptake of Agri-Environmental Schemes and other programs aiming to enhance farmland biodiversity suggests that their uptake are influenced by personal attitudes, subjective norms and social interaction and control (Burton and Wilson 2006; Burton et al. 2008; Ahnström et al. 2013; Home et al. 2014; Sulemana and James 2014). For example, social pressure can influence decision-making since farmers have an interest in maintaining their fields in a productive and 'tidy' status as perceived by their peers and neighbours (Hauck et al. 2016).

Consequently, our dual approach is motivated by the need to consider factors beyond purely economic determinants, which are addressed in our agent-based modelling, but also administrative risks and farmers' preferences which we will take into consideration through multiple workshops with stakeholders. In this sense, our study is novel because other studies of greening measures have either been based on modelling (Langhammer et al., 2017; Solazzo and Pierangeli 2017) or on interactions with stakeholders (Pe'er et al., 2017), but not combined.

Materials and methods

Description of the case study regions

Two case study regions were chosen for analysis, the 'Mittelsächsische Platte' in the central part of Saxony (eastern Germany) and a subregion of 'Götalands södra slättbygder' which occupies the southern plains of the south and west coasts of Scania in southern Sweden, to be referred to as 'Saxony' and 'Scania', respectively. In eastern Germany, animal production is being progressively abandoned in favour of field-crop farming. Moreover, due to historical reasons, large farm structures dominate rural landscapes. In Saxony, the concentration of intensive field-crop farming on very large and fertile fields and the resulting increasing uniformity of the rural landscape might both contribute to a continuing decline in biodiversity and environmental quality. The plains of Scania are a highly productive field-cropping region. Specialised crop production occurs on large, inter-connected fields where historical removal of field borders and other impediments has resulted in a relatively homogeneous landscape. The intensity and scale of production has also increased over time, putting additional pressure on the environment through increases in fertiliser and chemical use, simplified crop rotations and lack of organic amendments to soils. In both regions, these developments have led to nitrogen leaching, soil degradation and declines in biodiversity and ecosystem services. Table 1 gives an overview of the two selected regions. More information about the regions as well as detailed figures on regional farm structures can be found in Sahrbacher et al. (2016b).

Overview of the research approach

Figure 1 below illustrates the four steps implemented to investigate the impacts of the EFA obligation in Scania and Saxony.

The following subsections describe in detail the sequence and content of the workshops as well as the modelling procedure.

Table 1 Size and structure of the case study regions

	Scania	Saxony
Total UAA (ha) of which	201,577	168,259
- Arable land (ha)	194,082	148,253
- Permanent grassland (ha)	7495	17,649
Number of farms	2690	858
Average farm size (ha)	75	196
Share of grassland of total UAA (%)	3.7%	10.5%

Source: LfULG 2013 (on request); SJV (2009)

UAA utilised agricultural area

Stakeholder workshops and scenario definition

A first series of workshops involving stakeholders from the agricultural sector, public institutions and environmental organisations were organised in Nossen (Saxony, Germany) on 5 November 2014 as well as in Höör (Scania, Sweden) on 13 November 2014 (step 1, Fig. 1). The objective of the workshops was to ascertain which measures are preferred by stakeholders to reach ecological as well as economic goals. The

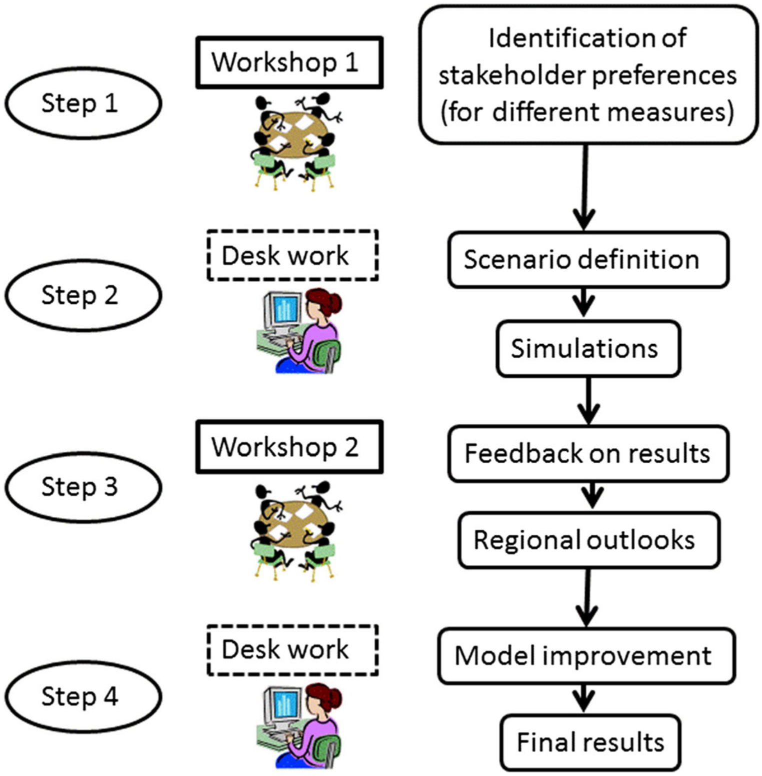

Fig. 1 Overview of the research approach used for impact assessment of EFA measures. Source: own figure

starting point for discussions was the proposed greening measures at that time as well as agri-environmental measures to be implemented in the next programming period 2014–20. The measures were assessed by the participants regarding the perceived opportunities and barriers that each presented for reaching ecological and agricultural goals. At the same time, solutions to tackle potential problems were discussed (for more details, see Sahrbacher et al. 2016b). First, participants were asked to identify themselves as belonging to one of the following groups: Farmers, Administrators or Environmentalists (see Table 2).

Then, in order to (1) select preferred greening measures to be modelled in AgriPoliS and (2) to assess the relevance of each of the measures in respect to their effectiveness for both biodiversity conservation and agricultural production, participants were given a questionnaire to be filled in anonymously. Each participant had the opportunity to formulate how much (in percent of the total EFA obligation) and why they preferred specific EFA measures.[1] Apart from this, participants in Saxony were asked whether they would have implemented any of the greening measures in any case (i.e. without a greening payment) or not. Farmers were also asked about their own assessment of how much landscape elements already shape their arable land; non-farmers were asked to assess how much arable land they believed farmers would allocate to such elements. In Scania, participants were asked to assess the percentage of small biotopes on their arable land. As the number of questionnaires to be attributed to each group was rather similar in both regional workshops, each questionnaire counted for 1, i.e. questionnaires were not balanced.

In the Swedish case, 18 out of 21 questionnaires were sufficiently different from each other to define six alternative EFA scenarios by combining some or all of the following five EFA measures in different shares: fallow, field margins, short-rotation coppice, leguminous crops and undersown grass. The cost-efficiency aspects of the measures as well as factors such as location, economics and production orientation were cited as highly relevant for participants of the 'Farmers' group to motivate which EFA measures could be implemented and to what extent. Together with fallow, uncultivated field margins were most positively rated in all groups regarding their benefits for biodiversity. While the importance to link them to watercourses was mentioned in the 'Environmentalist' group, the 'Administrators' group highlighted their roles as natural corridors and their importance for recreational activities. Participants in the 'Farmers' group assessed them as being area-effective; however, they agreed with members of the 'Environmentalist' group to criticise their limited size, where fallow would certainly be more appropriate for contributing to biodiversity on a larger scale.

In the German case, 20 out of 28 answers could be used to define four alternative scenarios by combining the following four EFA measures: fallow, flower strips, catch crops and leguminous crops. Similar to Scania, economic considerations in the 'Farmers' group were decisive in the choice of measures as well as farmer's own management concept, objectives and location. Therefore, catch crops and leguminous crops, even though considered as irrelevant to maintain or increase on-field biodiversity, were preferred because of their positive agronomic properties (positive impact on

[1] Farmers were asked about the implementation of EFA on their farm; non-farmers were asked about their perceptions of which EFA measures and shares could be relevant for conserving biodiversity.

Table 2 Overview of participating stakeholders and questionnaires used for the scenario definition study in the first series of workshops in Scania and Saxony

	Scania				Saxony			
	Participants		Questionnaires		Participants		Questionnaires	
	Number	%	Number	%	Number	%	Number	%
Farmers	9	43%	7	39%	7	25%	6	30%
Administrators	5	24%	7	39%	11	40%	7	35%
Environmentalists	7	33%	4	22%	10	35%	7	35%
Total	21		18		28		20	

soil fertility, reduction of nitrate leaching and erosion). Still, according to participants of the 'Farmers' group, land left fallow would contradict agriculture's primary goal (produce food and fibre) as well as expectations of private and institutional land owners aiming to reach high returns on agricultural land. Problems specific to crop farming (increasing pest pressures such as insects and weeds, and re-cultivation costs) constituted an additional source of concern for farmers when considering measures like flower strips. On the contrary, members of the 'Environmentalist' group highlighted the benefits of these measures to slow down the loss of birds, insects and pollinators on large-scale agricultural fields.

Based on these outcomes, alternative implementations of the EFA obligation were developed for both regions (step 2, Fig. 1). Together with an additional scenario involving the non-introduction of the EFA obligation to serve as a benchmark and a larger share of EFA to be implemented on arable land to test the sensitivity of the impacts to the area requirement, a total of five scenarios per case study region were evaluated (Table 3).

The REF scenario consists of the implementation of the 2014-20 CAP reform while excluding the EFA obligation. The main components of the reform that we model in each region are the following. Sweden has chosen to equalise SPS (Single Payment Scheme) payments within the country by 2019 and fully exploit the possibility to implement coupled livestock payments (with a maximum of 13% of the country's Pillar 1 budget). Therefore, from 2015, farmers in Scania have to cope with a step-wise reduction in Pillar 1 payments from 330 Euros per hectare (€/ha) in 2014 (including any top-up payments) to 193 €/ha in 2019 and onwards (including the greening component), while livestock producers receive an additional payment of 91 Euros for cattle older than 1 year.

In Germany, a SPS payment per hectare of agricultural land was gradually implemented between 2009 and 2013 at the federal state level. From 2014, payments will be progressively equalised in order to reach the same level throughout the country in 2019. In this period, farmers in Saxony will face a 38 €/ha decrease in Pillar 1 payments to 260 €/ha in 2019 and onwards. For further details on policy frameworks considered in both regions, see Sahrbacher et al. (2016a).

All other scenarios (FLEX5, FLEX15, ENV and FARM) include the obligation for farms to implement EFA according to the specifications indicated in Table 3. In the two scenarios, 'FLEX5' and 'FLEX15', farmers are free to choose which EFA measures

Table 3 Description of the scenarios implemented in AgriPoliS

Implementation of EFA measures	Name of scenario	Description
No EFA	REF	Baseline scenario (CAP reform 2014-20, without EFA obligations)
Flexible choices of measures	FLEX5	5% EFA
	FLEX15	15% EFA
Mandatory measures at 5%	ENV	Scania, 20% fallow, 40% field margins, 40% undersown grass
		Saxony, 40% fallow, 40% flower strips, 10% catch crops, 10% leguminous crops
	FARM	Scania, 10% field margins, 35% leguminous crops, 55% undersown grass
		Saxony, 80% catch crops, 20% leguminous crops

(a) For simplification purposes, we only kept two stakeholder scenarios in this paper (ENV and FARM). To have access to all scenarios defined after the first round of workshops, see Sahrbacher et al. (2016b). (b) The stipulated weighting factors for each EFA measure were considered in all simulations: fallow (1 ha equals 1 ha EFA), field margins (1 ha equals 9 ha EFA), catch crops and undersown grass (1 ha equals 0.3 ha EFA), flower strips (1 ha equals 1.5 ha EFA) and leguminous crops (1 ha equals 0.7 ha EFA).

they would like to implement on 5 or 15% of their arable land, from 2015 and onwards. On the other hand, in the scenarios classified as 'mandatory', farms are forced in the simulations to implement the specific EFA measures and shares according to Table 3 on 5% of their arable land during the whole simulation, from 2015.

In Saxony the 'FARM' scenario is characterised by a focus on production and cost minimisation with the growing of leguminous crops and catch crops. In contrast, 80% of EFA would be used for environmental purposes in the scenario 'ENV' with the establishment of flower strips or fallow, which have a much more positive impact on biodiversity than leguminous crops and catch crops. In Scania, legumes are currently mostly used as fodder. However, increased production could stimulate human consumption of legumes as well as provide residues for biogas production, both representing potential economic profits ('FARM' scenario). However, their cultivation could increase nitrogen leaching and the production of nitrous oxide, in contrast to fallow and field margins which could stop nutrient leaching and run-off, increase humus content and sequester carbon in the soils, thus contributing to more sustainable agriculture and the conservation of biodiversity ('ENV' scenario). Subsequently, the identified scenarios were simulated with AgriPoliS (step 2, Fig. 1) to assess the potential impacts of the different implementations of EFA's on future farm incomes and structural development and land use in Scania and Saxony.

Adaptation and extension of the agent-based model AgriPoliS

To simulate the potential impacts of the different EFA scenarios, we adapted and extended the AgriPoliS model. AgriPoliS is a spatially-explicit and dynamic agent-based model (Balmann 1997; Happe 2004; Happe et al. 2006; Kellermann et al. 2008) that enables the simultaneous consideration of some explanatory factors of structural change such as competition for land, profitability of farming, human capital and policy

(Piet et al. 2012). It integrates key components of regional agricultural structures: heterogeneous farm enterprises (different operating sizes, managerial abilities, etc.) of various and regionally relevant technical orientations, space, markets for products and production factors. This bottom-up approach rests on the assumption that an agricultural region is a complex adaptive system in which individual agents, the farms, are the key decision-making units, indirectly interacting on land rental markets. From year to year, farms are able to grow or shrink, hire or fire workers, invest or disinvest and continue farming or quit the sector. Accordingly, AgriPoliS simulates endogenous structural change. The model provides results at the farm, group or regional levels; this enables the researcher to observe the development of specific farms, groups of farms or whole agricultural regions, i.e. doing economics in a test tube.

AgriPoliS assumes farm agents aim to maximise their total household income by family members working either on or off the farm. The action space given to farm family members is defined by on-farm factor endowments (land, labour, fixed assets, liquidity), the situation on markets for production factors and products, the vintage of existing fixed assets, technical production conditions, overall economic framework conditions (work opportunities outside the farm, interest rate levels, access to credit) and the policy framework. The model is initialized based on regional statistics and empirical farm data specific to a chosen year. Randomness is introduced during this initialisation phase in order to create a heterogeneous population of agents. Several independent parameters such as farmsteads' location in space, vintage of assets, age of the farmer and managerial ability (i.e. lower variable costs for better farm managers as a way to mimic variation in farmers' managerial fitness) are varied by AgriPoliS in the initialisation phase across specific ranges, which enables the creation of heterogeneous agents (as in reality) without human bias. The most important actions undertaken by a farm agent are renting land (renting additional land and disposing of unprofitable land), investing (machinery, buildings, and hired workers), producing, farm accounting and the decision whether to quit farming or stay in the sector.

The optimisation problem is solved using mixed-integer programming (MIP), the solution to which gives the optimal combination of action possibilities subject to the given policy framework. Especially, land rental markets play a central role in the model. Initially, each farm agents is endowed with a certain amount of land consisting of owned and rented land based on empirical data used to create the regional model. During simulations, farms may expand by bidding for more land on the land rental market. Farms calculate their bid based on the shadow price calculated for an additional, specific plot/field taking into account distance costs between this plot/field and farmstead, soil type (arable land or grassland in Saxony, high- or low-quality arable land and seminatural grazing land in Scania) and potential economies of scale. Available land—due to farms closing or expiration of rental contracts—is allocated among farmers via a sequential first-price auction. Rental contract run for a fixed period of time, and are assigned a duration period depending on the regional ranges considered (see Table 4). Rental contracts are binding during the entire contractual period, and current contract ages randomly assigned during model initialisation. See Kellermann et al. (2008) for technical details of the optimisation problem as well as on behavioural foundations of farm agents and the functioning of land rental markets in AgriPoliS.

Costs for hired labour and salaries from off-farm employment are assumed to increase at rates mentioned in Table 4 ('Labour cost trend (per annum)') and farms

Table 4 Overview of general parameters used in AgriPoliS for Saxony and Scania

	Mittelsächsische Platte ('Saxony')	Götalands södra slättbygder ('Scania')
Calibration year	2013	2008
Generation change*	25 years	25 years
Labour (per annum)		
Hired labour (€/AWU)	20,700	35,640
Off-farm labour (€/AWU)	17,000	31,680
Labour (€/h)		
Hired labour (€/h)	12.65	21.33
Off-farm (€/h)	8.50	16.00
Labour cost trend (per annum)	+ 0.5%	0%
Interest rates (%)		
Long-term	5.5	3.5
Short-term	8	4.5
Farm's savings	4	3
Plot size	3 ha	3 ha
Equity finance share	30%	25%
Useful life (years)		
Buildings	20 years (pigs and sows) 25 years (cattle)	25 years (cattle, suckler cows, ewe, pigs and sows)
Machinery	12 years	22 years (dairy cows) 12 to 20 years
Withdrawals (€/year)	16,000	22,222
Duration of rental contracts**	between 12 and 24 years	between 9 and 18 years

AWU annual working unit, *h* hour, € Euros, *ha* hectare

[a] It is assumed that after 25 years, a farm agent is handed over to the next generation. In case of such a generation change, opportunity costs of labour are set 25% higher than it would have been the case at the end of a production year. This reflects the comparable industrial salary a successor could potentially earn if he/she would not take over the farm. Accordingly, a successor would only take over the farm if the farm were able to generate income that is at least as high as the (increased) opportunity costs

[b] Ranges based on Sahrbacher (2011) and expert knowledge. Durations of rental contracts are randomly attributed within these ranges (1) to each rented plot during the initialisation phase and (2) to plots made available during the simulation on the rental market after their previous rental contract terminated

are assumed to be price-takers, i.e. output prices are exogenous during simulations. Since the EFA obligation has been found to have very small impacts on output (Gocht et al. 2016), we assume constant prices during simulations. Four interest rates are used in the model: Long-term interest rates concern loans to finance investments in farm buildings and machinery. Short-term interest rates concern liquidity credit to be repaid at the end of each simulation period. Farms' short-term savings (surplus cash) earn bank interest and can be invested in the farms' operations in the following period and a long-term saving rate is used for fixed-term deposits at 1% higher than the farm's short-term savings rate. Farms quit agriculture at the end of a period in case of bankruptcy (illiquidity) or if farm-owned production factors such as family labour and working capital earn higher income outside farming. Own land is valued using the average regional rent; family labour is valued at the level of off-farm income and opportunity costs of working capital at the long-term savings rate. If expected household income does not exceed these opportunity costs of own labour and capital, farms will close down. Farms' owned/rented land is then released to the rental market, where all other farms can formulate bids and expand—provided it is profitable for them.

Empirical data have been used for calibrating the model to the two case study regions based on a selection of typical farms[2] that are scaled up to match the structural characteristics of each region (Sahrbacher and Happe 2008). Though the basic rules and routine sequences of the model remain unchanged, each new modelled region implies the consideration of specific regional parameters as indicated in Table 4. Additional activities representing selected EFA measures, including relevant costs and revenues, needed to be defined, details of which are provided in Sahrbacher et al. (2016a). The introduction of EFA measures in the model was achieved by extending the MIP according to Table 5. As indicated there, and with respect to the EU regulation regarding CAP 2014-2020 (EU 2013), farms with less than 15 ha do not have to implement EFA. Similarly, farms with more than 75% permanent grassland or growing grass fodder on more than 75% of their arable land and not exceeding 30 ha of arable land are also exempted from implementing EFA.

Feedback on first simulation results and validation of the modelling approach

A second workshop was organised in Nossen (Saxony) on 24 February 2016 and Höör (Scania) on 15 March 2016 (step 3, Fig. 1).[3] The aim was to present first simulation results based on the scenarios jointly defined with stakeholders during the first round of workshops as well as to use this material to further discuss the general and long-term importance of EFA measures.

In Saxony, the participants of the second workshop insisted on the current and future relevance of catch crops as EFA in the region for at least two reasons: first, farmers are familiar with growing catch crops, and second, catch crops are easy to combine with spring-sown crops. Flower strips raised some discussion as well. Whereas some participants criticised their relevance at all, others highlighted their qualitative, long-term impacts on biodiversity. Especially during winter and similarly to fallow land, flower strips would provide shelter to many species, not only insects but hares, foxes and other small vertebrates too. On the other hand, because seed mixes are expensive and because the compensation does not seem to be appropriate, there is little chance that such measures would be implemented in the future—although benefits for biodiversity were not contested. Even though it was acknowledged that catch crops would not contribute much to biodiversity conservation, little would be done at the moment to

[2] For Scania, 27 typical farms and Saxony 39 typical farms weighted between 5 and 514 times in Scania and 1 and 158 times in Saxony guarantee the coverage of aggregate regional capacities. Those 'clones' are further differentiated during the initialisation phase in AgriPoliS in order to obtain a heterogeneous farm population, yet representative of each region. For more information, see Sahrbacher and Happe (2008).

[3] In Scania (Saxony), out of the 17 (31) participants of the second workshop, 4 (8) of them had attended the first workshop. In both regions, stakeholders of the first workshop who could not participate in the second workshop sent another person at their place, demonstrating stakeholders' interest to continue discussions about regional issues linked with EFA.

Table 5 Implementation of EFA obligation in the MIP, based on the example of the German case for the year 2015

	Production activity I	Production activity II	Production activity III	Field beans	Alfalfa	Fallow land	Flower strips	Catch crops	Undersown grass
Objective function	GM	GM	GM	GM	GM	GM	GM	GM	GM
Arable land	1	1		1	1	1	1		
Grassland			1						
Basic payment	− 87	− 87	− 87	− 87	− 87	− 87	− 87		
Greening component	− 187	− 187	− 187	− 187	− 187	− 187	− 187		
EFA min.	0.05	0.05		− 0.65	− 0.65	− 0.95	− 0.95	− 0.3	− 0.3
Greening_yes > 15 ha	1	1		1	1	1	1		
Greening_no < 15 ha									
Greening_yes < 75% GL	0.75	0.75	− 0.25	0.75	− 0.25	0.75	0.75		
Greening_no > 75% GL									
Greening_yes > 30 ha	1	1		1		1	1		
Previous crop from CC	− 1			− 1	− 0.33			1	
Subsequent crop from CC		− 1		− 1				1	1
Undersown grass		− 1							1
Subsequent crop of leguminous crops	− 1			1	0.33			− 1	

Table 5 (continued)

	Basic payment	Greening payment	Greening yes > 15 ha	Greening no < 15 ha	Greening yes < 75% GL	Greening no > 75% GL		
Objective function	1	1	0	0	0	0		RHS
Arable land							≤	Farm's arable land
Grassland							≤	Farm's grassland
Basic payment	1						≤	0
Greening component		1					≤	0
EFA min.				-∞		-∞	≤	0
Greening_yes > 15 ha			-∞				≤	15
Greening_no < 15 ha			1	1			≤	1
Greening_yes < 75% GL					-∞		≤	0
Greening_no > 75% GL					1	1	≤	1
Greening_yes > 30 ha					-∞	− 30	≤	0
Previous crop from CC							≤	0
Subsequent crop from CC							≤	0
Undersown grass								
Subsequent crop of leguminous crops								

GM gross margin, *RHS* right-hand side, *GL* grassland, *CC* catch crops

Source: Own figure based on Günther (2015) identify 'hot spots' (fields, relevant zones) to target together with farmers. Without incentive to spatially plan interventions in a concerted manner, farmers would therefore rather choose uncomplicated EFA options with low administrative costs (simple measures, low controlling efforts) and reduced business risks. The discussion with participants during this second workshop in Saxony certainly provided insights on barriers and difficulties linked to the current EFA scheme in addition to the economic ones. However, it revealed farmers' interest in implementing initiatives for the environment provided concerted and/or coordinated initiatives could help out designing spatially meaningful measures at the local level.

In Scania, participants confirmed that the planned convergence of direct payments would reduce direct payments significantly and that this would be the main driver of impacts due to the policy changes. Even though a possible increase in the production of legumes at the regional level could be expected with the implementation of EFA, participants showed nevertheless some concerns about possible future significant reductions in average farm incomes due to this greening measure. However, participants generally welcomed the EFA concept, provided it would fulfil the following requirements in the future:

- Make use of all opportunities to improve EFA management at the farm and field levels through customised rules, system simplification, better advice to exploit for instance fallow land and field edges, in order to maximise environmental effects
- Better reward efforts made by farmers to unilaterally improve the current EFA measures (for instance by sowing flowering plants on field edges)
- Do not weaken the Rural Development Policy which is better tailored to take local conditions into account
- Revise weighting coefficients to not favour measures that (1) primarily improve soil structure and humus content (catch crops and undersown grass), (2) do not benefit the environment as such (e.g. uncultivated field edges), rather than benefitting biodiversity

Another outcome of this second workshop was that participants' feedback and remarks helped improving both regional models as local stakeholders could:

- Provide a plausibility check of simulation results in the middle and long-term to help us to reconsider and recalibrate some model data
- Provide opinions on shares of EFA measures after implementation of greening measures (supported by official figures available in the German case) to better calibrate AgriPoliS to observed EFA choices in the FLEX5 scenario ('real world' scenario)

Table 6 shows that the refined calibration of the EFA areas in Scania and Saxony came fairly close to the statistics obtained from the Swedish Board of Agriculture (SJV) and Saxony's Federal Office of Environment, Agriculture and Geology (LfULG), respectively. In Scania, because of absence of empirical data to model undersown crops, expert knowledge was used. However, due to the profit maximising behaviour of the farm agents in AgriPoliS, neither catch crops nor willow is chosen by the farm agents because of their relatively low profitability and low weighting factor (0.3)

Table 6 Calibrated vs. real EFA areas in the regions and the respective EFAs weighting factors

EFA (weighting factor)	Scania				Saxony			
	SJV		AgriPoliS - FLEX5		LfULG		AgriPoliS - FLEX5	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Fallow land (1)	3819	22%	6780	42%	11,116	14%	1714	9.4%
Leguminous crops (0.7)	7289	43%	8895	56%	15,587	19%	1514	8.3%
Undersown grass/catch crops (0.3)	5395	31%	–	0%	51,332	64%	15,022	82.3%
Field margins/flower strips (9 times 1 m long strip/1.5)	308	2%	315	2%	955	1%	–	–
Salix/short-rotation coppice (0.3)	321	2%	–	0%	109	0.1%	–	–
Total	17,132		18,825		80,128		18,250	

En dash indicates that the EFA is not observed in the region. In the German case, real data was for the whole federal state of Saxony, whereas only a subregion was modelled with AgriPoliS

Source: SJV (2016), LfULG (2016)

compared to fallow or leguminous crops. As a consequence, the areas of these EFA measures are underestimated and fallow land and leguminous crops have larger shares compared to reality. In Germany, data on short-rotation coppice are provided for information as in both the real and modelled cases, this option was hardly chosen by farmers.

The next section presents results of improved model regions (step 4, Fig. 1) and policy scenarios presented above (Table 3).

Results

The results presented below focus on consequences of the different EFA scenarios compared to introducing the new policy without an EFA obligation until 2020. However, even though AgriPoliS is for the most part, a deterministic model, there are four instances of randomness as mentioned in section 3.4: farmsteads' location in space, vintage of assets, age of the farmer and managerial ability, all of which are set at the outset of the model. Results of independent model replications using different seeds for these random allocations at setup did not show any significant abnormalities or extreme values in terms of development in the structural indicators, number of farms and average farm size (see Appendix 1). For this reason, but also because the calibration of the virtual landscape to statistical properties of the real landscape is a time-consuming procedure, only a single random initialisation (particularly the location of farmsteads in the grid) is used as the basis for calibrating the entire model to observed production decisions and farm development in the real region, and subsequently for simulating the different scenarios. That is, despite certain parameters being randomly assigned at the outset, the subsequently calibrated model is a validated model of the real region and consequent simulations of the different scenarios deterministic.

Interested readers will find instructions to reproduce the simulation experiments in Appendix 2.

Overview of reform impacts without EFA obligation

As shown in Table 7, even though there is no EFA obligation, the equalisation of SPS payments in Scania (reduced by 41% per hectare compared to 13% in Saxony) accelerates structural change compared to Saxony, leading to substantial increase in average farm size. This confirms the main concern raised by the participants during the second workshop that equalisation of the payments will be the main driver of the policy impact by speeding up structural change in the region. Because of the large reduction in the payment, profits per hectare decline substantially compared to Saxony, but the large increase in farm size is able to compensate in the most part lost income at the farm level. However, none of the farms quit agriculture because of illiquidity problems, but rather because of failure to recover their opportunity costs. Actually, 68% of farms quit farming because farm-owned production factors earn higher income outside the sector. The remaining 32% close down because of higher opportunity costs for labour outside farming due to generation change (see section 3.4 and Table 4). Although EFA are not compulsory in this scenario, we observe an increase in the areas used as fallow between 2014 and 2020 by 10% of the arable area due to the decline in support caused by the national equalisation of payments (see Appendix 3 for details of land use changes in each region). With decreasing payments, (marginal) land made available by closing farms and rented by remaining farms is not necessarily used for crop or fodder production, but rather turned to fallow. Land abandonment though is less than 1%, indicating that the equalised payment level is sufficient to keep virtually all land in agricultural use.

In Saxony, we observe a much smaller decline in the number of farms between 2014 and 2020, and parallel increase in the average farm size. Similar to Scania, no farms close down due to illiquidity. Among the farms closed in 2020, 50% quit farming because of higher returns outside farming for own production factors and the other 50% because the farm successor decided not to take over the farm. Whereas farm profits decrease in 2020 due to the decrease in payments per hectare, farm incomes decrease as well but to a lesser extent because of higher returns for some factors outside farming. Consequently, the payment level is shown in both regions to impact the strategic choice whether to continue the farm or quit agriculture and release land that might become available to farms wishing to expand.

Table 7 Relative changes for selected indicators in the REF scenario between 2014 and 2020 (in %)

	Saxony	Scania
Number of farms	− 5.6%	− 23.5%
Average farm size	5.9%	30.1%
Profit per hectare	− 8.9%	− 27.5%
Average farm income	− 3.7%	− 4.6%

Source: own figure

Impacts on farm structures and incomes: little impacts due to EFA

Figure 2 shows the impacts of the different EFA scenarios on structural change: number of farms and average farm size in the year 2020 for (a) Saxony and (b) Scania. The actual EFA implementation (FLEX5) has negligible impacts in both regions. Even the alternative and potentially stricter EFA obligations have minor impacts on farm structure in Saxony (FLEX15, ENV and FARM), which is due to cost-minimising choices made at the farm level (fallow land) and/or well-known, to some extent already widespread, alternatives (catch crops, leguminous crops). This strategy preserves farms in Saxony from any great financial or managerial pressures.

The negligible effect on farm structure of the EFA obligation in FLEX5 and FLEX15 in Scania is because already in the REF scenario as a result of the equalisation of support, farmers choose a large area of fallow land which can automatically contribute to meeting the EFA obligation (see Appendix 3). In addition, farmers are able to dynamically adjust their production activities over time by allocating low productive (marginal) land to meet the EFA requirements. That is farms can continue to use their most productive land in production, while offsetting the potential costs from EFA restrictions through acquiring marginal land (which is made available through structural change). In addition, the generous scaling factors for field margins (1 ha of uncultivated field margin counts towards 9 ha of EFA) together with crops that are already grown by farmers (e.g. leguminous crops) waters down the EFA requirements, thus minimising potential negative impacts on incomes (see Fig. 3 below). However, the relatively stricter EFA requirements in the ENV scenario result in considerably faster structural change since farmers have less flexibility to minimise their costs. Interestingly, there is a slightly higher impact of the FARM scenario on structural change compared to the flexible choice of EFA measures as observed in FLEX5. This shows that a mandatory combination of measures, even though chosen by local practitioners, does not necessarily fit all farm structures in the region, hence the advantage of full flexibility for minimising farmers' costs.

The EFA scenarios have more substantial impacts on farm profits and incomes than on structural change in Saxony (Fig. 3a, c) because they result in higher costs, but not sufficiently high to increase the rate of farm exits (FLEX5). Costs are limited by the flexibility available in choices of EFAs, i.e. the possibility to implement productive (leguminous crops), agronomic relevant (catch crops) or fallow land as EFA measures. This flexibility in the choice of EFA measures enables farmers to even limit financial losses when the EFA obligation increases, but some cost increases are unavoidable when a greater area of EFA is required (FLEX15).

Surprisingly, the ideal combination of EFA measures which was selected by farmers at the first workshop in Saxony (FARM scenario with 80% catch crops and 20% leguminous crops and 5% EFA obligation, see Table 3) leads to higher decreases in average profits per hectare and farm average incomes in the future compared to the flexible selection of EFA measures made at the individual level (FLEX5). Actually in the FARM scenario, farms do not have the possibility to turn land fallow, which seemed to be an important option for many farms in reality: indeed, fallow land was implemented on 14% of the regional EFA area (see Table 6). This measure enables farms to at least save costs in case other EFA measures are too expensive to implement. This explains why the mandatory implementation of measures better designed for favouring

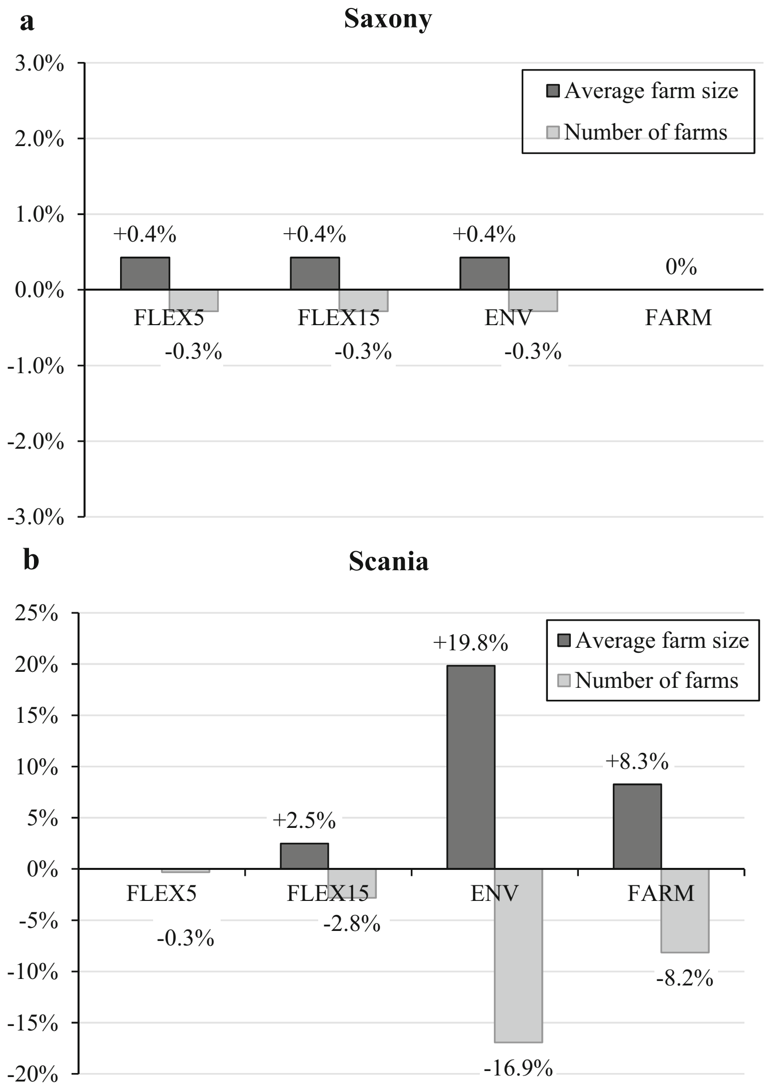

Fig. 2 Relative changes in the number of farms and average farm sizes (in %) in the EFA scenarios compared to reference scenario in 2020. Source: own figure

biodiversity (ENV scenario including 40% fallow) causes a decrease in average profits per hectare compared to the FARM scenario.

Scania on the other hand shows contrasting effects on profit per hectare and average farm incomes compared to the REF scenario (Table 7) with the introduction and strengthening of the EFA measures (Fig. 3b, d). Although the increasing rigidness of the FLEX15 and ENV scenarios results in lower profits per hectare, average farm incomes increases (Fig. 3d). This is thanks to the induced structural change; increases in average farm size (Fig. 2d) allow farmers to offset income losses by taking advantage of economies of scale. Thus to some extent counteracting the known effect of the SPS slowing structural change (Brady et al. 2011, Nordin, 2014) through increasing the

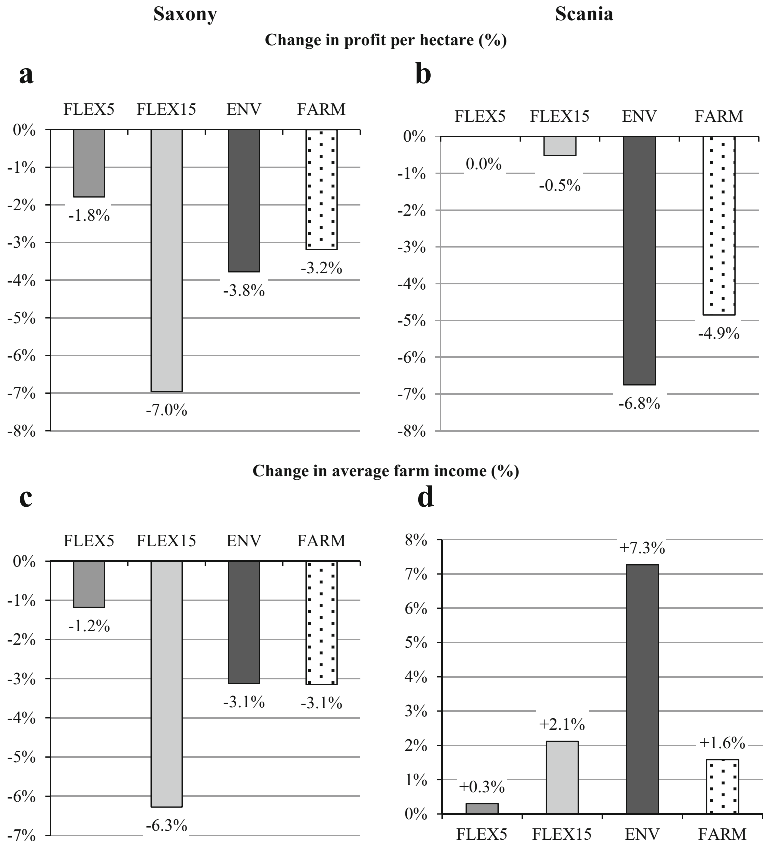

Fig. 3 Comparison of profits per hectare and average farm incomes (in %) in Saxony and Scania in 2020 with profits and incomes observed in 2020 without an EFA obligation (REF scenario). Source: own figure

costs of farming. The particularly large reduction in average profits per hectare in ENV is due to the elimination of leguminous crops as an EFA option. In the FARM scenario, the 35% EFA of leguminous crops (profitable on high productive arable land) to some extent offset the reduction in profit per hectare. Still, eliminating the fallow land as an EFA choice, which was preferred in the REF scenario, contributes to the reduction in profit per hectare.

Figure 4 provides an overview of the impacts on land rental prices in both regions in 2020 compared to REF. The FLEX5 scenario has the lowest impact on rental prices in Scania and the second lowest in Saxony because of (1) the low area requirement of EFA and (2) the possibility for farms to continue production in accordance with their technical orientation. However, results show that in Saxony land rental prices are indirectly influenced by developments in livestock production for which leguminous crops, also recognised as an EFA measure, can be used as fodder. Such measures create artificial incentives to invest in production activities which would otherwise not have been chosen as an option, therefore creating pressure on rental prices for grassland (needed for grazing livestock, Fig. 4c) as well as on rental prices for arable land (due to leguminous crops, Fig. 4a). Especially,

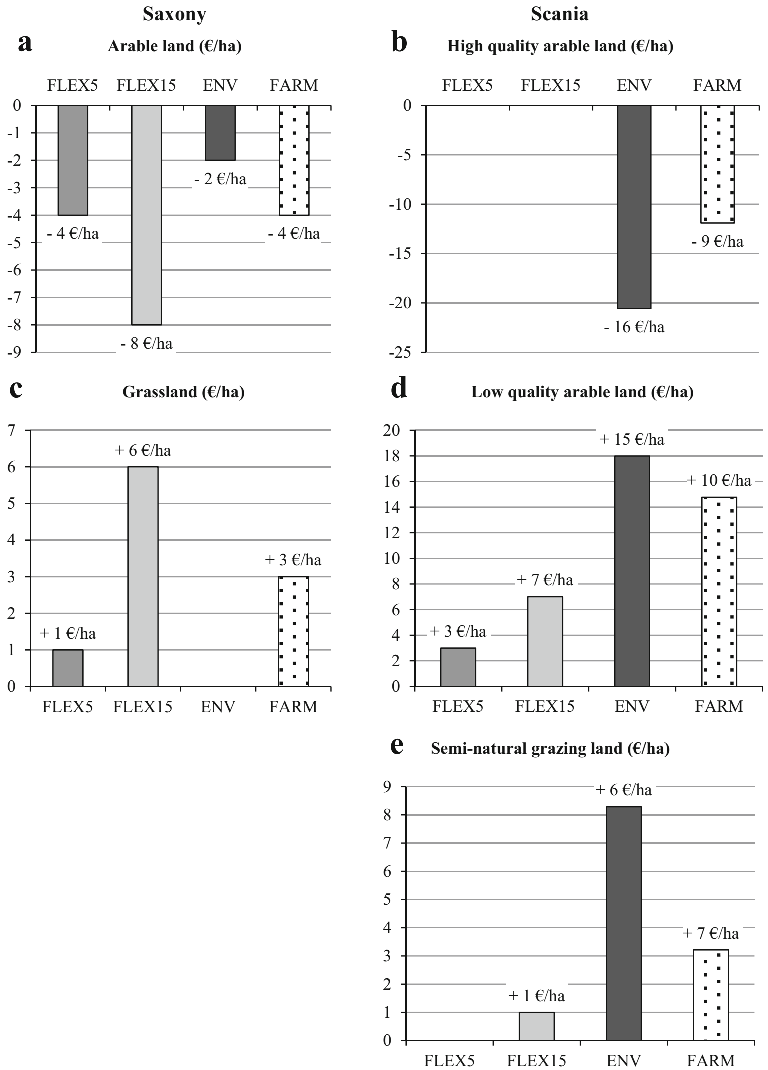

Fig. 4 Change in land rental prices for the different land quality types in 2020 in all scenarios compared with REF (in €/ha). Source: own figure

EFA as implemented in scenario FLEX15 encourages dairy and beef cattle production.[4] The higher rental price for grassland in FARM is an indirect effect of the compulsory implementation of catch crops (80% of EFAs) which encourages the grassland-based activities. On the other hand, the obligation to implement flower strips and fallow in the ENV scenario in Saxony (instead of catch crops in FLEX) has no impact on attractiveness of land compared to REF as changes in rental prices are the lowest in this scenario.

[4] Without consideration of value chains in the region, particularly milk prices, which might not favour such investments as confirmed by stakeholders in Saxony during Workshop 2.

In Scania, the rental price for low-quality arable land (Fig. 4d) is increasing with the rigidness of the EFA restrictions. This is because of increasing demand for low-quality arable land to comply with the EFA obligations, which is less costly than creating EFA on high-quality land (Fig. 4d, ENV and FARM). Conversely, high productive land becomes less profitable to farm, which results in lower rental prices compared with scenarios where the implementation of EFA measures is flexible (FLEX5 and FLEX15). That is, some farms release some of their high-quality land when it is not profitable to meet the EFA requirement considering that rental prices for low-quality arable land increase, resulting in a decrease in rental prices for high-quality arable land (Fig. 4b). This is especially the case for relatively small farms (< 50 ha) which are more sensitive to the higher costs of stricter EFA regulations. One indirect, general effect of EFA is that intensive production remains located in certain areas, which may offset the environmental benefits expected and the original purpose to have high productive land used less intensively. Consequently, when farms can freely choose the combination and placement of EFA measures, it can be expected that land rental prices for high productive arable land will not change much since mainly low-quality land will be used to comply, which reduces potential environmental benefits. This dynamic adjustment occurs because the EFA obligation is not spatially targeted, but implemented at the farm scale. Rental prices for semi-natural grazing land rise in the ENV and FARM scenarios (Fig. 4e): as the EFA restriction makes crop production relatively less profitable than grass production, it favours livestock, especially dairy production is relatively more profitable in combination with the coupled support. Thus, the more ruminant numbers increase the higher demand for the already small area of seminatural grazing land.

Land use changes and implementation of EFA measures

Figure 5 provides an overview of land use changes brought about by the EFA scenarios in 2020 compared to a situation without an EFA obligation (REF scenario). In Scania, the reference scenario generated a significant increase in fallow land due to the decline in support caused by the national equalisation of payments (see explanation on scenario definition in section 3.3). That is, the area of fallow increases in the region in any case due to equalisation and since fallow qualifies as EFA it is the automatic or zero-cost choice of EFA in FLEX5 and FLEX15. Consequently, the flexible implementation of EFA measures will not necessarily imply much change in land use compared with the REF scenario (Fig. 5, FLEX5 and FLEX15) and consequently allow the income level to remain similar to the REF scenario (Fig. 3d). In scenarios ENV (20% fallow, 40% catch crops and 40% field margins) and FARM (80% catch crops, 20% leguminous crops), fallow land which would have been preferred in the flexible scenarios is shifted to some extent into grass production (silage and pastures—though on a small area) as well as for crop production.

Moreover, the increased use of grassland in the mandatory scenarios is also an indirect effect of the coupled livestock support which leads farms to use parts of their arable land as pastures and silage. However, in Scania, around 10% of the total arable area is abandoned (Fig. 5b) because of the mandatory implementation of EFA measures. Such large abandonment is a combination of the reduction in support, the strict proportions of EFA mix, but also the weighting factors as well as landscape characteristics. For example, in the ENV scenario, for each hectare of fallow (20%) there should be twice as much area

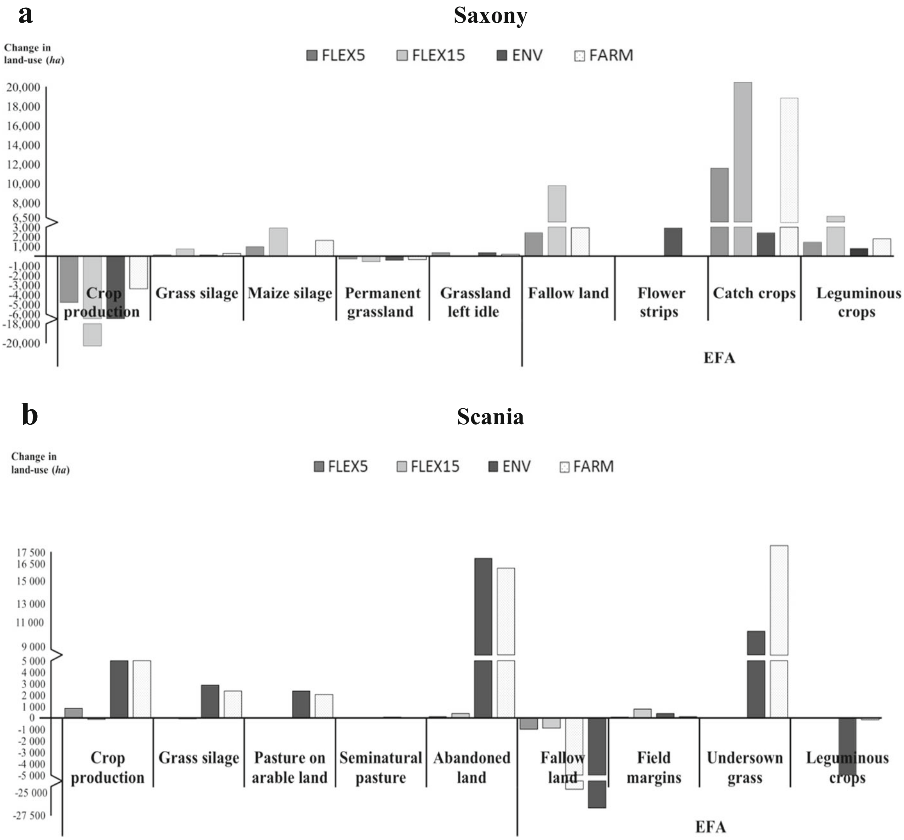

Fig. 5 Changes in land use in Saxony and Scania in 2020 compared to REF. Source: own figure

of catch crop (40%) but given the low weighting factor of 0.3 for undersown grass relative to 1 for fallow, the requirement is 3.3 times more area in real terms. This also indicates that a flat rate greening payment (such as the equalised SPS) is also problematic for achieving environmental benefits because farmers with high compliance costs cannot be adequately compensated. Therefore, those farmers withdraw land from the system, which conflicts with the CAP goal to preserve agricultural landscapes.

Interestingly, field margins gain in importance in Scania with the expanded EFA in scenario FLEX15, at the expense of fallow land. Note that neither undersown grass nor short-rotation coppice were chosen, mainly because of their relative lower profitability and low weighting factor (0.3). Regarding the dynamic development of EFA, an interesting aspect is the immediate strong effect in 2015, especially for field margins in FLEX5 and FLEX15 scenarios. But over time, as the payments are converged and reduced, farmers reconsider their farm practices and shift to fallow land and provide even more EFA area than necessary. Hence, this increase in fallow is to a greater extent an indirect effect of the national equalisation of support. Even though EFA restrictions are imposed, the reduction in support by around 130€ provides incentives to farmers to allocate low productive arable land as fallow to offset the losses in profits and income.

In Saxony, no land abandonment occurs in any of the scenarios (Fig. 5b). In the case of flexible implementation of EFA measures, fallow land becomes an interesting alternative for farms in scenario FLEX15 to limit income losses due to the decreasing area potentially interesting for crop production (Fig. 5b). The importance of leguminous crops as EFA increases in FLEX15 as well, but to a lesser extent compared to fallow. Results show as well that flower strips are never preferred or even chosen as an alternative in farms' portfolio of EFA measures in both FLEX5 and FLEX15 scenarios because flowers are costly to sow but not mandatory (see Appendix 3).

Discussion and conclusion

The structural impacts of the current EFA obligation were found to be minor in both regions. Far more important were indirect consequences of 'productive' EFA measures: leguminous crops for instance drove up livestock production in Saxony. Such indirect impacts reveal some policy failure when greening measures that are intended to enhance biodiversity end up encouraging the production of leguminous crops for fodder or provide additional support for applying meaningful agricultural practices (for instance catch crops in the German case).

Moreover, fallow land was found to be a preferred EFA measure because it minimised incomes losses caused by the mandatory implementation of EFA on arable land, or in the case of a larger area requirement. This is thanks to the induced structural change; increases in average farm size allow farmers to offset income losses by taking advantage of economies of scale and renting low productive land for EFA measures. However, measures of potentially greater benefit for the environment such as flower strips, field margins and short-rotation coppices were not profitable enough for farms in the model and would therefore hardly be implemented in practice. In case of a strict obligation to implement specific EFA measures (as favoured by our environmentalist group), this could lead to land abandonment since the uniform greening payment and assigned weighting factors for the EFAs cannot be adjusted to compensate farmers for higher costs, which could result in reduced environmental benefits in absolute terms. It is therefore questionable whether this outcome would meet policy expectations, despite it being based on the environmentalists' preferences. Thus, according to our results, farmers are likely to use marginal land to meet the EFA requirements, and keep on using their most productive land intensively, which makes it unlikely that current EFA obligations will generate environmental benefits commensurate with greening payments.

Together with present results on land use changes, other research shows poor environmental outcomes for current EFA measures on biodiversity, biological control potential and pollination services (Hristov et al. 2016). The main reason for this is that farmers are not incentivised to optimise their land use decisions and in field management practices by considering the environmental benefits or the impact on ecosystem services, but rather to minimise the cost of achieving the EFA obligation. There seems to be both a need for the farming sector to recognise the long-term benefits upon (supporting and regulating) ecosystem services at the farm level as well as a necessity for all regional actors to agree on a spatial targeting of environmental measures without which a large share of payments would not meet initial expectations. But such a targeting is hardly possible under the general conditions that must characterise Pillar 1 support for it to qualify as a common policy.

During the workshops organised in Sweden and Germany, local stakeholders revealed a strong interest in learning and discussing extensively about EFA measures allowed in their regions as well as about the situation and stakeholders' opinions in the other case study region. There were concerns about the actual impacts of regionally relevant EFA measures on biodiversity and the environment. The evidence for the absence of a 'one size fits all' solution at the regional level somewhat surprised stakeholders; modelling results actually revealed that spatial and structural farm heterogeneities definitely play a role in determining impacts of EFA. Conversely, researchers benefitted from fruitful insights about the constraints implied by the different EFA scenarios they were presented with.

For instance, from the farmers' point of view, economic and business risks linked to EFA measures (e.g. an EFA crop fails to establish) as well as contractual commitments with land owners were cited as reasons not to engage in measures more obviously beneficial to biodiversity. However, increased flexibility called for during the workshops (number, combination of possibilities and time scale) regarding measures contributing to biodiversity conservation was soon confronted with potential difficulties for local offices to efficiently support, monitor and control more complex measures than the current ones. In both case study regions, the importance of local constraints and opportunities lead stakeholders to suggest that (1) measures should target places where they would have the greatest effect and (2) farmers should be rewarded accordingly when their efforts (and management costs) would justify it. To this extent, variable, flexible and transparent public support would be acceptable in order to reward commitments according to outcomes. Consequently, the inability of Pillar 1 support to be spatially targeted and payments differentiated is a major limitation for implementing an environmentally beneficial single payment scheme, because as shown by our dynamic results, it simply rewards farmers to concentrate measures on low-quality land, thereby leaving land use and intensity largely unchanged in the most environmentally damaged areas.

The dual approach applied in this research, combining modelling and interactions with stakeholders, helped going beyond borders between practitioners, researchers and local authorities. It is to hope similar research can further contribute to reducing gaps between decision makers, local practitioners, national authorities and citizens in order to facilitate a dialogue to support development towards sustainable European agriculture.

Acknowledgements This research has been conducted in the framework of the ERA-NET project MULTAGRI and benefited from support from the German Federal Ministry of Education and Research (BMBF). We are also deeply grateful to the many stakeholders who took their time to participate in the workshops in both countries.

Appendix 1. Overview of average results of 20 replications of both regional models

To test the sensitivity of AgriPoliS to different random initializations and therefore test the validity of scenarios' results, 20 independent simulation runs (or replications) for each region and each scenario were carried out (200 simulations in total). For each of those replications, several parameters have been attributed random values across specific ranges as indicated in Table 8.

Figure 6 below shows small differences in the magnitude of the relative changes, except for FARM scenario in Scania. Actually after the random initialization of farm locations in the virtual landscape, a calibration procedure ensures that the statistical properties of the resulting AgriPoliS (virtual) landscape match those of the real landscape, specifically the distribution of field size and fragmentation of agricultural land. This is achieved by varying the landscape initialization parameters: NO_OF_SOILS, PLOT_SIZE, OVERSIZE and NON_AG_LAND which is explained in Brady et al. (2012, Table 1 p.1367). This means that while the location of farm centres are randomly spread across the landscape the resulting virtual landscape—size distribution and configuration of fields/blocks—is steered via the calibration procedure. Thus the virtual landscape is not truly random but influenced to match the properties of the real landscape. This abstract representation of the landscape is then used as a basis for calibrating AgriPoliS farms to observed production decisions and farm development in the real region. For this same reason any alternative random initialization of the location of farm centres would need to be followed by the landscape calibration procedure in order to obtain a virtual landscape representative of the real landscape.

Table 8 Parameters randomly attributed during the initialization phase

	Model parameter varied	Variation range	
		Saxony	Scania
Farmstead location	Spatial arrangement of farmsteads in the virtual region	–	–
Managerial ability	Variable costs are multiplied by a factor randomly assigned to each farm and constant during the simulation[1)]	0.95–1.05	No variation
Vintage of assets (years)			
Buildings	Vintage of stables used for animal productions typical of the case study region	1–20 (pigs for fattening breeding sows) 1–24 (vealer) 1–25 (extensive and intensive cattle, dairy)	1–22 (dairy) 1–25 (beef, suckler cows, lamb, fattening pigs, breeding sows)
Machinery	Vintage of machinery sets adequate to farm X hectare of wheat equivalent	1–12	1–12 (200-800 ha) 1–15 (100–150 ha) 1–20 (30–60 ha)
Duration of rental contracts (years)		12–24	9–18

Note: when a rental contract is terminated for a specific plot during the simulation, the duration of the new rental contract is randomly assigned as well within ranges indicated in the Table. 1): for more explanation about this parameter see Happe (2004)

Source: Own figure

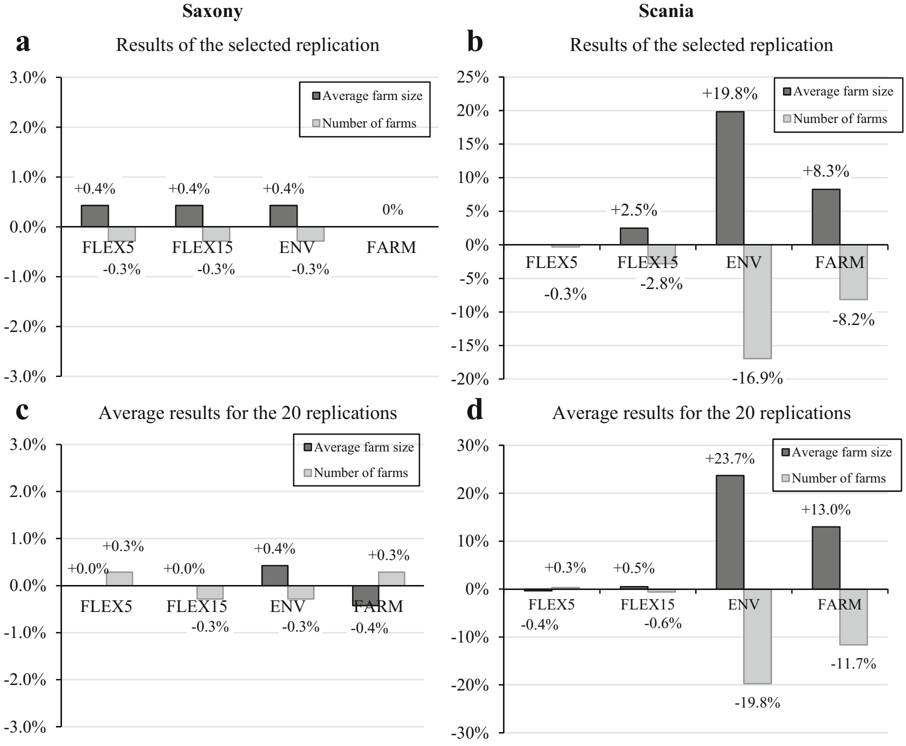

Fig. 6 Comparison between results of simulation runs based on one replication and average results of model replications based on 20 different random initializations for each scenario and region. Source: Own figure

Therefore in the paper we consider one specific, calibrated landscape that is statistically similar to the real landscape but afterwards, as all processes are basically deterministic during the simulation to this extent, differences between scenarios remain unchanged.

Appendix 2. How to run simulations with AgriPoliS and reproduce experiments as presented in this paper

- Please copy/paste this link in your browser: https://bitbucket.org/dongiamo/impacts_of_efa. This link shall redirect you the Bitbucket website.
- In the "Navigation" menu on the left-hand side of the webpage, please click on "Download", then on "Download repository" in order to download files you will need to run simulations.
- Download the zip file "dongiamo-impacts_of_efa-310d574a79c9".
- Unpack the content of the folder "dongiamo-impacts_of_efa-310d574a79c9" and save it on your PC in a folder with the name "Impacts of EFA". You will find a file named "Read me.pdf" there, please open it and follow the instructions in order to reproduce experiments and get simulation outputs for EFA scenarios presented in this paper directly on your PC.
- Should you have any problem please send an email to agripolis@iamo.de

Appendix 3. Land-use (in ha) and EFA proportions in 2015 and 2020 between scenarios in both regions

Table 9 Land use in both regions for each scenario in 2015 and 2020 (in ha)

		Arable land					EFA area						
Scania	Scenario	*Cereals*	*Rape-seed*	*Sugar beet*	*Grass*	*Total arable land*	*Fallow land*	*Legumi-nous crops*	*Undersown grass*	*Field margin*	*Total EFA*	Pasture	Abandoned land **
2015	REF *	117,593	17,895	26,662	7866	170,016	6853	8936	0	0	15,789	7006	104
	FLEX5	117,207	17,871	26,653	8083	169,814	6781	8897	0	313	15,991	7046	65
	FLEX15	116,164	17,721	26,649	8069	168,603	6706	8611	0	1885	17,202	7067	43
	ENV	121,877	17,902	26,705	12,535	179,019	1801	0	12,005	400	14,206	7039	4656
	FARM	117,940	18,097	26,716	12,734	175,487	0	5486	20,115	122	25,723	7033	4787
2020	REF *	102,089	15,673	26,734	7004	151,501	27,382	5234	0	0	32,616	6982	1816
	FLEX5	102,823	15,760	26,734	6993	152,309	26,382	5288	0	71	31,741	6944	1921
	FLEX15	101,984	15,651	26,731	6868	151,232	26,471	5274	0	778	32,523	6967	2193
	ENV	109,174	16,456	26,701	12,228	164,559	1662	0	11,081	369	13,113	7040	19,284
	FARM	107,453	16,736	26,709	11,392	162,290	0	5067	18,578	113	23,757	7027	18,420
Saxony	Scenario	*Cereals*	*Rape-seed*	*Sugar-beet*	*Maize silage*	*Total arable land*	*Fallow land*	*Legumi-nous crops*	*Catch crops*	*Flower strips*	*Total EFA*	Grassland	Idle grassland
2015	REF *	93,880	43,810	4381	3581	145,652	0	382	0	0	382	15,949	2848
	FLEX5	90,472	43,810	4381	4144	142,807	1713	1514	15,021	0	18,249	16,080	2856
	FLEX15	76,063	43,810	4381	5102	129,356	7188	9490	26,493	0	43,172	16,056	2874
	ENV	87,326	43,810	4381	3537	139,054	2903	1174	2419	2903	9399	16,094	2812
	FARM	91,019	43,810	4381	4660	143,870	0	2164	19,345	0	21,508	15,781	2917
2020	REF *	94,971	43,810	4381	2532	145,694	0	340	0	0	340	17,190	1523
	FLEX5	90,151	43,810	4381	3497	141,839	2410	1786	12,077	0	16,272	16,980	1880
	FLEX15	74,680	43,810	4381	5447	128,318	10,259	7456	20,994	0	38,710	17,358	1501

Table 9 (continued)

	Arable land					EFA area						
ENV	88,345	43,810	4381	2548	139,085	2904	1141	2420	2904	9369	16,868	1894
FARM	91,582	43,810	4381	4136	143,909	0	2125	19,348	0	21,473	17,066	1682

Note: * in the REF scenario, EFA obligation is not binding but we show the land use types that would qualify as EFA. ** total utilised agricultural area in Scania 192,915 ha

Source: own calculations

Table 10 Area of EFA in 2015 and 2020 between scenarios in Saxony

Saxony	Area (ha)		Proportion (%)	
FLEX5	2015	2020	2015	2020
Fallow land	1714	2410	23.5	33.1
Flower strips	1514	1786	14.6	17.2
Catch crops	15,022	12,076	61.9	49.7
Leguminous crops	0	0	0	0
Total (ha)	18,250	16,272	*7280*	*7283*
FLEX15	2015	2020	2015	2020
Fallow land	7188	10,260	33	47.1
Flower strips	9490	7456	30.5	24
Catch crops	26,494	20,994	36.5	28.9
Leguminous crops	0	0	0	0
Total (ha)	43,172	38,710	*21,779*	*21,777*
ENV	2015	2020	2015	2020
Fallow land	0	0	0	0
Flower strips	2164	2126	20.7	20.4
Catch crops	19,344	19,348	79.3	79.6
Leguminous crops	0	0	0	0
Total (ha)	21,508	21,474	*7318*	*7293*
FARM	2015	2020	2015	2020
Fallow land	2902	2904	39	40
Flower strips	1174	1142	11.2	10.9
Catch crops	2420	2420	10	10
Leguminous crops	2902	2904	39.5	39.6
Total (ha)	9398	9370	*7352*	*7333*

Note: total areas in italics are calculated considering weighting factors for the EFA measures selected
Source: own calculations

Table 11 Area of EFA in 2015 and 2020 between scenarios in Scania

Scania	Area (ha)		Proportion (%)	
FLEX5	2015	2020	2015	2020
Fallow land	6780	26,380	42.8	85.9
Leguminous crops	8895	5290	39.2	12.1
Undersown grass	0	0	0	0
Field margins	315	70	18	2
Total	15,990	31,740	*15,842*	*30,713*
FLEX15	2015	2020	2015	2020
Fallow land	6705	26,470	39	81.4
Leguminous crops	8610	5275	50	16.2
Undersown grass	0	0	0	0
Field margins	1885	780	11.1	2.4
Total	17,200	32,525	*29,697*	*37,183*
ENV	2015	2020	2015	2020
Fallow land	1801	1662	20	20
Leguminous crops	0	0	0	0
Undersown grass	12,005	11,081	40	40
Field margins	400	369	40	40
Total	14,206	13,113	*9003*	*8311*
FARM	2015	2020	2015	2020
Fallow land	0	0	0	0
Leguminous crops	5486	5067	35	35
Undersown grass	20,115	18,578	55	55
Field margins	122	113	10	10
Total	25,723	25,757	*10,972*	*10,133*

Note: total areas in italics are calculated considering weighting factors for the EFA measures selected

Source: own calculations

References

Ahnström, J., Bengtsson, J., Berg, Å., Hallgren, L., Boonstra, W. J., & Björklund, J. (2013). Farmers' interest in nature and its relation to biodiversity in arable fields. *International Journal of Ecology, 2013*, 617352.

Balmann, A. (1997). Farm-based modelling of regional structural change: a cellular automata approach. *European Review of Agricultural Economics, 24*, 85–108.

Brady, M., Ekman, S., & Rabinowicz, E. (2011). The impact of decoupling and modulation in the European Union: a sectoral and farm-level assessment. In C. Moreddu (Ed.), *Disaggregated impacts of CAP reforms proceedings of an OECD workshop* (pp. 15–33). Paris: OECD Publishing.

Brady, M., Sahrbacher, C., Kellermann, K., & Happe, K. (2012). An agent-based approach to modeling impacts of agricultural policy on land use, biodiversity and ecosystem services. *Landscape Ecology, 27*, 1363–1381.

Brady, M., Hristov, J., Sahrbacher, C., Söderber, T., & Willhelmsson, F. (2017). Is passive farming a problem for agriculture in the EU? *Journal of Agricultural Economics*. https://doi.org/10.13140/RG.2.1.1699.4008.

Breustedt, G., & Habermann, H. (2011). The incidence of EU per-hectare payments on farmland rental rates: a spatial econometric analysis of German farm-level data. *Journal of Agricultural Economics, 62*, 225–243.

Burton, R. J. F., & Wilson, G. A. (2006). Injecting social psychology theory into conceptualisations of agricultural agency: towards a post-productivist farmer self-identity? *Journal of Rural Studies, 22*, 95–115.

Burton, R. J. F., Kuczera, C., & Schwarz, G. (2008). Exploring farmers' cultural resistance to voluntary agri-environmental schemes. *Sociologia Ruralis, 48*, 16–37.

Ciaian, P., Kancs, D., Swinnen, J. F. M. (2008). Static and dynamic distributional effects of decoupled payments: single farm payments in the European Union. LICOS Discussion Paper 207/2008, Centre for Institutions and Economic Performance (LICOS), Leuven.

Courleux, F., Guyomard, H., Levert, F., Piet, L. (2008). How the EU single farm payment should be modelled: lump–sum transfers, area payments or... what else? Working paper structures et Marchés Agricoles, Ressources et Territoires—Agricultural Structures and Markets, Resources and Territories (SMART)—Laboratoires d'Etudes et de Recherches en Economie—Economic Studies and Research Unit (LERECO) No. 08–01. Rennes: Institut National de la Recherche Agronomique – National Institute of Agronomic Research (INRA).

de Snoo, G. R., Herzon, I., Staats, H., Burton, R. J. F., Schindler, S., van Dijk, J., Lokhorst, A. M., Bullock, J. M., Lobley, M., Wrbka, T., Schwarz, G., & Musters, C. J. M. (2013). Toward effective nature conservation on farmland: making farmers matter. *Conservation Letters, 6*, 66–72.

de Witte, T., & Latacz-Lohmann, U. (2014). Was kostet das Greening? *Top Agrar, 4*, 36–41.

EEA, European Environment Agency (2010). The European Environment State and Outlook – Land Use. http://www.eea.europa.eu/soer. Accessed 19 Mai 2017.

EU (2013). Regulation (EU) No 1307/2013 of the European Parliament and of the Council of 17 December 2013 establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy and repealing Council Regulation (EC) No 637/2008 and Council Regulation (EC) No 73/2009 [2013] OJ L347/608. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:347:0608:0670:EN:PDF. Accessed 19 Mai 2017.

European Commission. (2009). *Council regulation (EC) No. 73/2009 of 19 January 2009 establishing common rules for direct support schemes for farmers under the common agricultural policy and establishing certain support schemes for farmers*. Brussels: European Union.

European Commission (2010). "The CAP towards 2020: Meeting the food, natural resources and territorial challenges of the future." COM(2010) 672 final, Brussels, 18 November.

European Parliament (2016). Draft report on the state of play of farmland concentration in the EU: how to facilitate the access to land for farmers (2016/2141(INI)), Committee on Agriculture and Rural Development (Rapporteur: Maria Noichl), PE592.416v01–00, 10.11.2016.

Gocht, A., Ciaian, P., Bielza, M., Terres, J. M., Röder, N., Himics, M., Salputra, G. (2016). Economic and environmental impacts of CAP greening: CAPRI simulation results. Joint Research Centre, European Commission, 2016.

Günther, J. (2015). *Modellierung der Agrarregion Mittelsächsische Platte in dem agenten-basierten Modell AgriPoliS und Analyse der Auswirkungen der Bereitstellung Ökologischen Vorrangflächen*. Masterarbeit: Martin-Luther-Universität Halle-Wittemberg.

Happe, K. (2004). Agricultural policies and farm structures—agent-based modelling and application to EU-policy reform. Studies on the Agricultural and Food Sector in Central and Eastern Europe, Vol. 30, Halle (Saale): IAMO.

Happe, K., Kellermann, K., & Balmann, A. (2006). Agent-based analysis of agricultural policies: an illustration of the agricultural policy simulator AgriPoliS, its adaptation and behavior. *Ecology and Society, 11*(1), 49.

Hart, K. (2015). The fate of green direct payments in the CAP reform negotiations. In J. F. M. Swinnen (Ed.), *The political economy of the 2014–2020 common agricultural policy—an imperfect storm* (pp. 277–306). Brussels: Centre for European Policy Studies and London: Rowman and Littlefield International.

Hauck, J., Schmidt, J., & Werner, A. (2016). Using social network analysis to identify key stakeholders in agricultural biodiversity governance and related land-use decisions at regional and local level. *Ecology and Society, 21*(2), 49.

Heinrich, B. (2012). Calculating the 'Greening'-effect—a case study approach to predict the gross margin losses in different farm types in Germany due to the reform of the CAP. Discussion paper 1205 of the

Department of Agricultural Economics and Rural Development. Göttingen, Georg-August-University Göttingen.
Henle, K., Alard, D., Clitherow, J., Cobb, P., Firbank, L., Kull, T., McCracken, D., Moritz, R., Niemelä, J., Rebane, M., Wascher, D., Watt, A., & Young, J. (2008). Identifying and managing the conflicts between agriculture and biodiversity conservation in Europe—a review. *Agriculture, Ecosystems & Environment, 124*(1–2), 60–71.
Home, R., Balmer, O., Jahrl, I., Stolze, M., & Pfiffner, L. (2014). Motivations for implementation of ecological compensation areas on Swiss lowland farms. *Journal of Rural Studies, 34*, 26–36.
Hristov, J., Brady, M.V., Clough, Y., Sahlin, U., Smith, G.H., Stjernman, M., Olsson, O., Sahrbacher, A. (2016). Future effects of CAP's greening reform on farm structure and ecosystem services in contrasting agricultural landscapes. Working paper, August 2016.
Kates, R. W., Clark, W. C., Corell, R., Hall, J. M., Jaeger, C. C., Lowe, I., McCarthy, J. J., Schellnhuber, H. J., Bolin, B., Dickson, N. M., Faucheux, S., Gallopin, G. C., Grübler, A., Huntley, B., Jäger, J., Jodha, N. S., Kasperson, R. E., Mabogunje, A., Matson, P., Mooney, H., Moore III, B., O'Riordan, T., & Svedin, U. (2001). Sustainability science. *Science, New Series, 292*(5517), 641–642.
Kellermann, K., Happe, K., Sahrbacher, C., Balmann, A., Brady, M., Schnicke, H., Osuch, A. (2008). AgriPoliS 2.1 - Model documentation. IAMO, Halle (Germany). http://projects.iamo.de/agripolis/documentation/agripolis_v2-1.pdf. Accessed 19 Mai 2017.
Kilian, S., & Salhofer, K. (2008). Single payments of the CAP: where do the rents go? *Agricultural Economics Review, 9*(2), 96–106.
Klaiber, H. A., Salhofer, K., & Thompson, S. R. (2017). Capitalisation of the SPS into agricultural land rental prices under harmonisation of payments. *Journal of Agricultural Economics*. https://doi.org/10.1111/1477-9552.12207.
Lakner, S., & Holst, C. (2015). Farm implementation of greening requirement: economic determinants (in German). *Natur und Landschaft, 90*, 271–277.
Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M., & Thomas, C. J. (2012). Transdisciplinary research in sustainability science: practice, principles and challenges. *Sustainability Science, 7*(Supplement 1), 25–43.
Lange, A., Siebert, R., & Barkmann, T. (2015). Sustainability in land management: an analysis of stakeholder perceptions in rural northern Germany. *Sustainability, 7*, 683–704.
Langhammer, M., Grimm, V., Pütz, S., & Topping, C. J. (2017). A modelling approach to evaluating the effectiveness of ecological focus areas: the case of the European brown hare. *Land Use Policy, 61*, 63–79.
LfULG - Landesamt für Umwelt, Landwirtschaft und Geologie Sachsen (2016). Infodienst Landwirtschaft 1/2016. http://www.smul.sachsen.de/lfulg/download/2016_01_Infodienst_LfULG_Doebeln_neu.pdf. Accessed 19 Mai 2017.
Mahy, L., Dupeux, B. E. T. I., Van Huylenbroeck, G., & Buysse, J. (2015). Simulating farm level response to crop diversification policy. *Land Use Policy, 45*, 36–42.
Matthews, A. (2012). *Environmental public goods in the new cap: Impact of greening proposals and possible alternatives. Committee on Agriculture and Rural Development*. Brussels: European Parliament.
Matthews, A. (2015). "What biodiversity benefits can we expect from EFAs?" Online blog. http://capreform.eu/what-biodiversity-benefits-can-we-expect-from-efas/. Accessed 19 Mai 2017.
Nordin, M. (2014). Does the decoupling reform affect agricultural employment in Sweden? Evidence from an exogenous change. *Journal of Agricultural Economics, 65*(3), 616–636.
Pe'er, G., Zinngrebe, Y., Hauck, J., Schindler, S., Dittrich, A., Zingg, S., Tscharntke, T., Oppermann, R., Sutcliffe, L., Sirami, C., Schmidt, J., Hoyer, C., Schleyer, C., & Lakner, S. (2017). Adding some green to the greening: improving the EU's ecological focus areas for biodiversity and farmers. *Conservation Letters*. https://doi.org/10.1111/conl.12333.
Pe'er, G., Dicks, L., Visconti, P., Arlettaz, R., Báldi, A., Benton, T., Collins, S., Dieterich, M., Gregory, R., & Hartig, F. (2014). EU agricultural reform fails on biodiversity. *Science, 344*(6188), 1090–1092.
Piet, L., Latruffe, L., Le Mouël, C., & Desjeux, Y. (2012). How do agricultural policies influence farm size inequality? The example of France. *European Review of Agricultural Economics, 39*(1), 5–28.
Sahrbacher, C. (2011). Regional structural change in European agriculture: effects of decoupling and EU accession. Studies on the agricultural and food sector in Central and Eastern Europe, Vol. 60, Halle (Saale): IAMO.
Sahrbacher, C., Happe, K. (2008). A methodology to adapt AgriPoliS to a region. Technical Report, IAMO, Halle (Germany). http://projects.iamo.de/agripolis/documentation/adaptation_v1.pdf. Accessed 19 Mai 2017.

Sahrbacher, A., Hristov, J., Brady, M., Sahrbacher, C., Günther, J. (2016a). Deliverable no. 4.2: modelling agri-environmental measures in AgriPoliS and data update. Report of the MULTAGRI project. https://www.iamo.de/fileadmin/user_upload/Bilder_und_Dokumente/04-forschung/Forschungsprojekte/multagri/MULTAGRI_Modelling_agri-environmental_measures_in_AgriPoliS_and_data_update.pdf. Accessed 19 Mai 2017.

Sahrbacher, A., Sahrbacher, C., Hristov, J., Brady, M. (2016b). Deliverable no. 4.1: stakeholders' positions and identified policy measures. Report of the MULTAGRI project. https://www.iamo.de/fileadmin/user_upload/Bilder_und_Dokumente/04-forschung/Forschungsprojekte/multagri/MULTAGRI_Deliverable_4.1.pdf. Accessed 19 Mai 2017.

Schmidt, T., Röder, N., Dauber, J., et al. (2014). *Biodiversitätsrelevante Regelungen zur nationalen Umsetzung des Greenings der Gemeinsamen Agrarpolitik der EU nach 2013*. Braunschweig: Thünen Institute for Agricultural Research, Working Paper.

Schulz, N., Breustedt, G., & Latacz-Lohmann, U. (2014). Assessing farmers' willingness to accept "greening": insights from a discrete choice experiment in Germany. *Journal of Agricultural Economics, 65*, 26–48.

SJV – Jordbruksverket (Swedish Board of Agriculture) (2009). Data extracted by request from Swedish Agricultural Statistics for Production Region 61–22 F.d. Malmöhus län, slättbygden. Swedish Board of Agriculture, Jönköping.

SJV- Jordbruksverket (Swedish Board of Agriculture) (2016). Personal communication - Torben Söderberg, June 10th, 2016.

Solazzo, R., & Pierangeli, F. (2017). How does greening affect farm behaviour? Trade-off between commitments and sanctions in the Northern Italy. *Agricultural Systems, 149*, 88–98.

Sulemana, I., & James, H. S. (2014). Farmer identity, ethical attitudes and environmental practices. *Ecological Economics, 98*, 49–61.

Zimmermann A., Möhring A., Mack G., Mann S., Gennaio, M.P. (2011). Die Auswirkungen eines weiterentwickelten Direktzahlungssystems. Modellberechnungen mit SILAS und SWISSland. Forschungsanstalt Agroscope Reckenholz-Tänikon (Ed.), *ART-Bericht 744*. Tänikon, Switzerland.