PBL Netherlands Environmental Assessment Agency

GREENING THE COMMON AGRICULTURAL POLICY: IMPACTS ON FARMLAND BIODIVERSITY ON AN EU SCALE

POLICY STUDIES

Greening the Common Agricultural Policy: impacts on farmland biodiversity on an EU scale

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Greening the Common Agricultural Policy: impacts on farmland biodiversity on an EU scale

Summary

What are the potential gains in EU farmland biodiversity of greening the Common Agricultural Policy (CAP)? And what would be the trade-offs with agricultural production and farm incomes? These are the central questions of a modelling study carried out by the PBL Netherlands Environmental Assessment Agency, in cooperation with LEI and Alterra from Wageningen University & Research centre. An *ex ante* analysis of a set of five policy components was carried out for the 2014–2020 period, based on the European Commission's communication document *The CAP towards 2020* of 18 November 2010.

Greening the Common Agricultural Policy reduces the ongoing loss of farmland biodiversity

- According to this study, greening the CAP may result in approximately three per cent more species richness on EU farmland by 2020, compared with no greening of the CAP. This in itself does not mean that biodiversity would improve, as autonomous trends probably will decline by a larger percentage. Although greening the CAP would not halt biodiversity loss, it would substantially slow down the decline in farmland biodiversity over the 2014–2020 period.
- This impact on species richness follows from a calculation of five policy components, taken from the EC (2010) communication document *The CAP towards 2020* (see Table 1 of Section II). Most of the impact can be attributed to an increase in extensively managed, biodiversity-rich grassland, due to additional agri-environmental measures taken in the EU15 (old Member States), as well as greening payments conditional on ecological set-aside of an assumed five per cent of arable land throughout the EU.
- There would be a clear trade-off between biodiversity gains and production losses. According to model calculations, greening the CAP would lead to a decline in agricultural production, for example, of two per cent for grass and four per cent for cereals, by 2020, in the EU27. This is mainly due to the projected extensification of grassland and ecological set-aside on arable land.
- Despite the observed decline in production because of this greening of the CAP, average agricultural income would not decrease – it would in fact increase, slightly. As EU food demand is not expected to change substantially, EU prices are projected to rise as a result of lower production, with only small changes in EU import and export.
- Income changes would differ considerably between regions. Linking CAP payments to biodiversity would improve incomes in extensive farming regions – in particular, in those with grazing systems – and would lead to a decrease in farm incomes in areas with intensive arable farming.

The effectiveness and efficiency of greening the CAP could be improved by regional differentiation and by alleviating negative trade-offs through better targeting

- The regions with intensive and extensive farming vary substantially in current species richness and farm incomes, and also with regard to impacts of CAP measures. This would imply that a regionally differentiated policy may be more appropriate than a one-size-fits-all approach. For example, in regions with extensive farming systems, a policy that preserves all or at least part of the current biodiversity-rich agricultural land seems more adequate than mandatory ecological set-aside. This would imply a specialisation in intensively farmed areas focusing on input-efficient production, and extensively managed areas serving as source areas for agricultural biodiversity.
- There are several options to alleviate the trade-off between budget requirements, biodiversity and production. Examples are the targeting of CAP budget towards areas already rich in biodiversity, as well as the implementation of measures related to a regional 'green infrastructure' in agricultural areas, which would effectively facilitate the spread of source populations. At farm level, individual producers could reduce production losses by using the least-producing fields and field edges for agri-environmental measures and set-aside.

Greening the CAP would achieve multiple objectives

- Results from our calculations demonstrate a decrease, but no halting of farmland biodiversity loss. It should be noted, however, that biodiversity is only one of many CAP objectives – the main objectives remain securing the availability of food supplies and ensuring a fair standard of living for farmers. Greening the CAP may yield a broad range of positive impacts if greening measures are combined with stimuli from adjacent policy areas. Retaining permanent grassland prevents the emission of carbon dioxide from agricultural soils. Set-aside could form a buffer for agricultural run-off before polluted water drains into ditches or streams, thus improving water quality. Greening measures also could benefit the recreational appeal of landscapes, for example, by the construction of green infrastructure. Such infrastructure could also deliver a number of ecosystem services, such as biological pest control.

I Introduction

Policy context: the CAP and EU biodiversity strategy

How to integrate biodiversity goals into agricultural policy? This question embraces two EU policy dossiers: the Common Agricultural Policy (CAP) and the recently published EU biodiversity strategy.

Discussion on the reform of the CAP is ongoing. On 18 November 2010 the European Commission (EC) published its communication document *The CAP towards 2020: Meeting the food, natural resources and territorial challenges of the future*. This communication document outlines the challenges and future policy options for the period between 2014 and 2020. The future CAP aims at viable food production throughout the EU, to guarantee long-term food security, sustainable management of natural resources and a balanced territorial development. The EC (2010) states that agriculture plays a key role in the production of public goods, such as landscapes, farmland biodiversity and climate stability.

The *EU biodiversity strategy to 2020* of 3 May 2011 states that the forthcoming reform of the CAP presents opportunities to enhance synergies and maximise coherence with biodiversity objectives (EC 2011). With regard to agriculture, the target is to maximise areas that are covered by biodiversity-related measures under the CAP, to ensure and improve the conservation status of species and habitats that depend on or are affected by agriculture, and to provide ecosystem services, thus contributing to sustainable agricultural management.

The CAP and the biodiversity strategy both aim at enhancing the provision of environmental public goods by farmers. The European Commission suggests improvement and simplification of the Good Agricultural and Environmental Conditions (GAEC) framework as well as cross-compliance standards. The Commission also proposes to reward the delivery of environmental public goods that go beyond cross-compliance (e.g. permanent grasslands, green cover, crop rotation, ecological set-aside, Natura 2000) (EC, 2010; EC, 2011). From the CAP perspective, the objective is not only to contribute to climate and environmental policy goals, but also to increase legitimacy for CAP payments by remunerating farmers for the collective services they provide to society (EC, 2010).

Focus and aim of this study

This study by the PBL Netherlands Environmental Assessment Agency – in close cooperation with LEI and Alterra from Wageningen University & Research centre – investigates the impacts of CAP measures, as outlined by the EC, on farmland biodiversity on an EU scale.

Although a vast amount of research has been carried out on the relationship between agricultural policy and biodiversity, quantifications of farmland biodiversity impacts on an EU-wide scale are scarce. The present study fills this gap by combining economic and land-use modelling with a recently developed farmland biodiversity indicator (see Subsection 1.4.4 of the Full Results). Furthermore, literature was reviewed in order to verify and complement the modelled results.

The *aim* of this study is to quantify the effects that a number of suggested modifications of the CAP may have on farmland biodiversity in the EU. Impacts of these modifications have been compared with a reference scenario. In addition, effects on emission and sequestration of greenhouse gases have been quantified, as well as trade-offs between greening measures, and food production and farm incomes. Suggestions are presented for increasing both the effectiveness of the proposed policy modifications and the synergies with other goals.

Whether greening the CAP is the most efficient strategy to conserve and improve farmland biodiversity was not investigated in this study, as no comparison was made with alternative strategies outside the CAP.

Approach and reading guide

The steps carried out in this study involved:
- constructing a reference scenario (Baseline Scenario) and a greening scenario (Section II of the Findings; Section 1.3 of the Full Results);
- modelling the scenarios – for a description of the applied models see Section II (Findings) and Section 1.4 of the Full Results;
- explaining the results and underlying mechanisms (Section III, Chapters 2 to 4 of the Full Results);
- discussing, interpreting and complementing model results, underscoring limitations and uncertainties, aided by references to the literature reviewed (Section IV, Section 2.3 of the Full Results);
- drawing of conclusions relevant to policymakers (Section V).

II Scenarios and models

This study explores the potential impacts of a greening scenario, compared to a reference scenario (Baseline Scenario). Under both scenarios, the current two-pillar structure of the CAP is retained – the first pillar involving direct income payments to farmers, as well as market measures, and the second pillar covering rural development support. However, modifications to the first pillar are foreseen in the Greening Scenario. The total CAP

Table 1

Elements within the Greening Scenario, compared to Option 2 of the EU communication document on *The CAP towards 2020*

Elements from the description of Option 2 (EC, 2010: 14)	Stylised implementation of Option 2 in the Greening Scenario (in this study)
Introduce more equity in the distribution of direct payments between Members States.	A. A 5% budgetary shift from the first pillar of EU15 (old MS) to the first pillar of EU12 (new MS).
Adjust and complement existing rural development instruments to be better aligned with EU priorities.	B. A 5% budgetary shift from the first pillar to agri-environmental measures in the second, within the EU15.
Within direct payments: compulsory additional aid for specific 'greening' of public goods through simple, generalised, annual and non-contractual agri-environmental actions.	C. Greening the first pillar via a premium on permanent grassland, with an annual maximum of 100 euros per hectare. D. Greening the first pillar via a premium with an annual maximum of 100 euros per hectare of arable land, on the condition of a 5% ecological set-aside being implemented on this land. The greening payments are restricted to a ceiling of 30% of the first-pillar budget of each Member State.
Within direct payments: an additional payment to compensate for specific natural constraints.	E. First-pillar payments for natural constraints at an annual maximum of 150 euros per hectare; this adds to the current less-favoured area payments within the second pillar. The budget is restricted to a ceiling of 30% of the first-pillar budget of each Member State.
Within direct payments: basic rate serving as income support.	F. Basic rate serving as income support. At least 40% of direct payments per Member State are used for income support.
A voluntary coupled support component for specific sectors and regions. A new scheme for small farms. A capping of the basic rate (large farms).	*not included*
Improve and simplify existing market instruments.	*not included*
Strengthen risk management tools and introduce an income stabilisation tool.	*not included*

Source: EC (2010)

budget is the same in both scenarios and is assumed to average 59 billion euros per year (including phasing-in of subsidies for the new Member States), over the 2014–2020 period.

Baseline Scenario

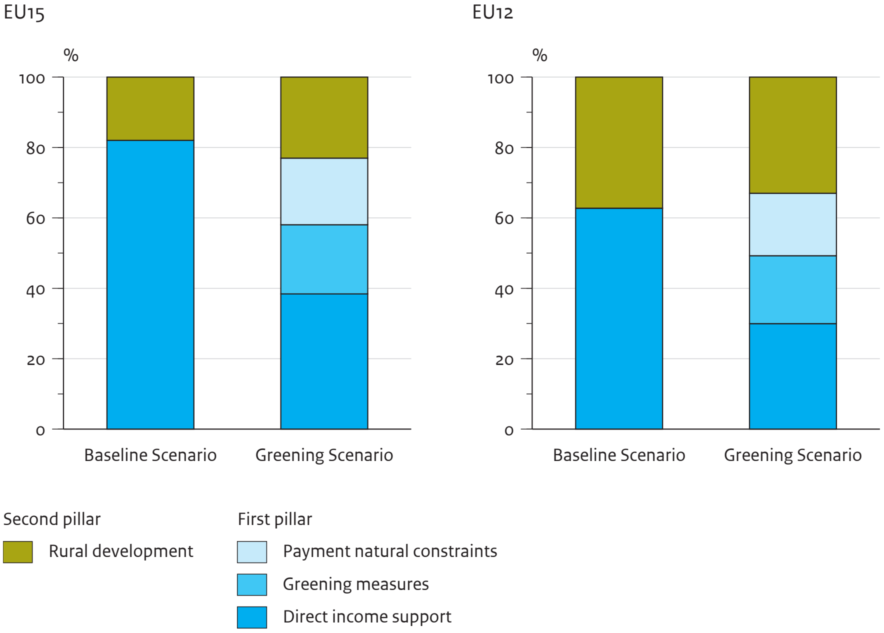
The Baseline Scenario describes the reference situation and extrapolates past and present trends towards 2020. Price developments were taken from outlook studies (e.g. (OECD and FAO, 2009). The CAP according to the reference scenario beyond 2014 is similar to that of pre-2014, with the exception of policy changes described in the *Health Check* agreement (EC, 2009), which were implemented in this scenario. These changes involve the full decoupling of income support from farm production and the abolishment of the milk quota system by 2015. In addition, the introduction of a regional flat rate (premium per hectare) is considered to be part of the Baseline Scenario.

Greening Scenario

The Greening Scenario is based on Option 2 of the European Commission's communication document on the CAP, which describes three broad policy options (EC, 2010). This second option concerns a transition towards an increased emphasis on sustainability, targeting multiple environmental goals, making the policy greener and more understandable to the general public. Our study concentrates on the impacts of this option, as this contains a rich mix of greening measures.

The Greening Scenario includes assumptions taken from the Baseline Scenario as well as additional elements from Option 2. It should be stressed that the Greening Scenario is our interpretation of the EC document, as the policy options have not been described in detail. Within the context of Option 2, policy elements were selected that have a known effect on biodiversity, which could be quantified with the available modelling instruments. Consequently, budget resources were attributed to the various elements in a plausible manner. This of course was done arbitrarily, as no political decision had been

Figure 1
Allocation of CAP budget in EU27, 2014 – 2020



EU15 – Old Member States
EU12 – New Member States

Source: LEI

made yet at the start of our study; neither on the size of the total EU budget which includes the CAP budget (Multiannual Financial Framework 2014-2020) nor on the distribution to the various elements within the CAP. Table 1 gives an overview of the elements within the Greening Scenario, and Figure 1 shows the average budget allocation per policy component, following from the assumptions made. Under the Greening Scenario, half of the first-pillar budget is allocated to greening measures in the first pillar. Analysis of the scenario provides information on the relative importance of the individual policy elements.

Models used

Calculations were made for the European Union (EU27). The following set of five models was applied:

- The Common Agricultural Policy Regionalised Impact Modelling System (CAPRI), a partial equilibrium model for the agricultural sector at NUTS2 level. This economic model uses an aggregated regional farm approach (see Subsection 1.4.1 of the Full Results).
- Dyna-CLUE (Conversion of Land use and its Effects), a dynamic, spatially explicit model on changes in land use and land cover (Subsection 1.4.2).
- Land-use intensity calculation model, processing results from CAPRI in order to obtain input for the farmland biodiversity model (Subsection 1.4.3).
- A newly developed farmland biodiversity model for species richness in EU agricultural areas (Subsection 1.4.4).
- A carbon budget model for calculating carbon dioxide emissions from land-use changes (Subsection 1.4.5).

Limitations

The strength of the methodology lies in the fact that impacts of policy instruments on performance of the agricultural sector can be linked with changes in land use and land-use intensity, and dominant drivers in farmland biodiversity. However, this approach has some limitations, too. The economic calculation (CAPRI) was carried out on a regional scale (NUTS2), which could not capture specifics on local details and farm types. Likewise, the assumed biodiversity measures were applied at field or farm level, which excludes the level of the wider landscape.
In addition, species richness calculations were based on land-use intensity, which left out certain aspects, such as crop diversity and winter cover (see Section IV, Discussion). Furthermore, areas classified as semi-natural lands often were excluded from our analysis, mainly due

Table 2

Species richness relative to its potential occurrence on a 50 x 50 km grid, EU27 average by 2020

	Baseline Scenario	Greening Scenario		
	%	%	Change in percentage points	Change %
Arable land	39.1	40.3	+1.2	+3.1
Grassland	66.4	69.0	+2.6	+3.9
All agricultural land	48.5	50.1	+1.6	+3.3

Source: PBL

to the fact that they were left out of the EU agricultural survey. Finally, our indicator consists of typical farmland species and is not intended for calculating effects on biodiversity in nature areas.

III Results

Agri-environmental measures and ecological set-aside have positive effects on biodiversity

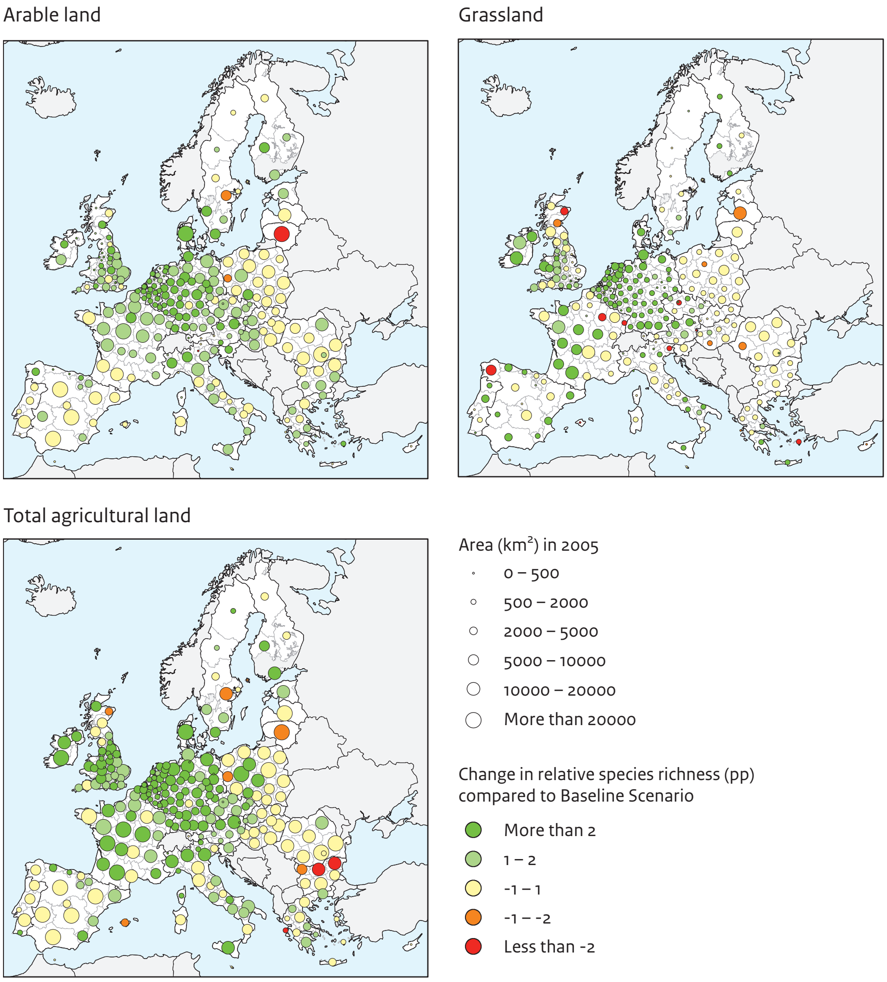
The Greening Scenario will result in approximately three per cent more species richness on EU farmland, by 2020, compared with the Baseline Scenario (Table 2). This would slow down the rate of decline in farmland biodiversity to half of the expected decline, over the 2014–2020 period, at least when recent trends of the European Farmland Bird Index (EFBI) are used as a proxy for future, autonomous trends. Note however, that our farmland biodiversity indicator measures species richness for all 145 selected animal and plant species, whereas the EFBI measures the abundance of farmland birds. Both are only comparable to a certain degree.

For arable land, more than half the increase in species richness may be explained by ecological set-aside (measure D in Table 1), as a set-aside of five per cent of the arable area would facilitate colonisation and recolonisation of these areas as well as migration of species across the landscape. With regard to grassland, increases in biodiversity mainly would be driven by an increase in agri-environmental measures, due to a five per cent budgetary shift from the first pillar towards these measures in the second pillar, in the EU15 (measure B). Under the Greening Scenario, the greening payment for permanent grassland (measure C) would have little effect on biodiversity, relative to the Baseline Scenario. Although this payment is a stimulus for not converting grassland into arable land, the premium related to arable land that is conditional on a five per cent ecological set-aside would have an opposite effect, caused by indirect land-use impacts, as arable set-aside in place X may lead to conversion of grassland into arable land in place Y. Also, ecological set-aside would lead to some intensification of surrounding grassland, in order to compensate for decreased fodder production on arable land. Furthermore, species-rich semi-natural grasslands were excluded from both the Baseline and the Greening Scenarios. These areas could significantly contribute to agricultural biodiversity when preserved through CAP measures.

Greening measures increase farmland biodiversity in intensive farming regions, less impact in extensively farmed regions

The proposed greening measures appear to be mainly effective in intensively farmed regions (Figure 2) on the time horizon of our analysis. This is particularly the case for ecological arable set-aside; biodiversity would increase in north-western Europe, with its large share of intensive farming, whereas little change is foreseen for eastern and southern Europe for 2020. This mainly would be due to the fact that arable land in the last two areas is already under low or intermediate management. Consequently, set-aside would have only a limited effect on biodiversity here. Additionally, arable set-aside would lead to some conversion of grassland into arable land and intensification of the use of remaining grasslands. For grassland, the positive effects also would be most evident in the EU15 (Figure 2), due to the previously mentioned five per cent shift from the first pillar to agri-environmental measures in the second (Table 1). The Greening Scenario does not assume a similar shift in the EU12 because the rural development budget (including agri-environment schemes) is already relatively high for these new Member States. However, it should be noted that, compared to the Baseline Scenario, positive effects might be more profound in the EU12 over longer periods of time. The permanent grassland premium as well as payment for natural constraints would particularly protect high ecological values that might otherwise be at risk, for example, due to conversion, intensification or abandonment.

Figure 2
Relative species richness on agricultural land, Greening Scenario, 2020

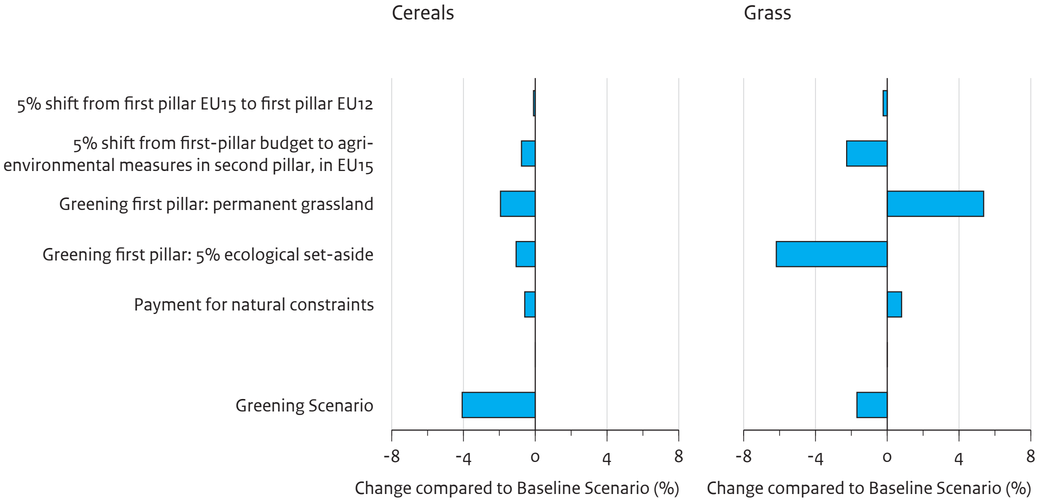


Source: PBL

No clear-cut conclusion regarding the threats to permanent grassland

Maintaining permanent grassland– at least the extensively managed grasslands – is important for biodiversity and for sequestration of carbon in soils. Additionally, grasslands also play a major part in limiting soil erosion. Given the vast quantities of carbon stored in European soils and the limited potential of soils to fix additional carbon, preventing soil carbon loss by limiting the conversion of grasslands and peatlands is crucial. The impacts of the greening measures on total grassland area are positive, but limited. Under the Baseline Scenario, the total grassland area in 2020 is 94% compared with the 2005 level, and under the Greening Scenario this is 95%. This leads to a 0.5 to 1 million tonnes lower carbon dioxide emissions from soils under the Greening Scenario, compared with that under the Baseline Scenario. This outcome, however, is also influenced by the fact that a stable share of permanent grassland in total grassland was assumed. Conversion from grassland to arable land (and vice versa) was included in the model calculations, but changes between permanent and temporary grassland were not included in the economic, carbon and biodiversity modelling. From a biodiversity perspective, the effects of the permanent grassland premium would be rather limited, as stated before.
It also should be noted that a permanent grassland premium does not place any restrictions on management intensity, which makes intensively farmed, species-poor permanent grassland eligible, too. Meanwhile, many biodiversity rich, extensively managed grasslands are not eligible for CAP payments, because of the presence of non-herbaceous vegetation.

Figure 3
Effects on cereals and grass production, compared to Baseline Scenario in EU27, 2020



Source: LEI

The contribution under the Greening Scenario to the reduction in global greenhouse gas emissions is close to zero

The measures implemented in the Greening Scenario lead to just a small reduction in greenhouse gas emissions from agricultural activities. Most pronounced is the 1.3% reduction in nitrous oxide emissions. This is explained by the 5% ecological set-aside, which results in a reduction in mineral fertiliser input. Methane emissions are reduced by 0.5%; in particular, due to a small reduction in the stock of beef cattle. As EU imports of, for example, oil seeds, cereals and beef, are slightly up in the Greening Scenario from those in the Baseline Scenario, leading to some increase in emissions outside the EU, it would be fair to say that overall emission reduction is close to zero.

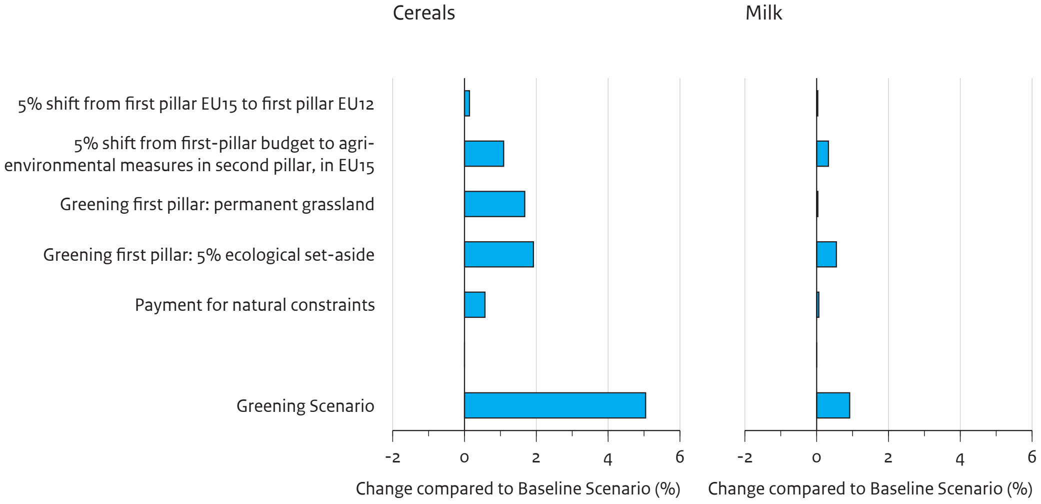
The Greening Scenario leads to lower EU production and a slight change in self-sufficiency

Agricultural production is lower under the Greening Scenario, compared with the Baseline Scenario, mainly because of extensification of grassland use (agri-environmental measures in the EU15) and ecological set-aside on arable land. As stated before, this could lead to intensification on some of the remaining agricultural area, extra imports (in particular of oil seeds) and fewer exports (in particular of cereals). All in all, in the EU cereal production will go down by 4% and grass production by 2% (Figure 3), the latter particularly affecting beef production. Effects on land use outside the EU – due to increasing EU imports – would be relatively small. For example, under the Greening Scenario, the 2020 production outside the EU would be higher by 0.2% for cereals and 0.65% for oil seeds, relative to the Baseline Scenario.

Price increases counteract the negative impact of production losses on average farm incomes

The average farm income does not decrease under the Greening Scenario, compared with the situation under the Baseline Scenario. In fact, the Greening Scenario predicts an increase of 2% in average income, due to the fact that production loss is combined with producer price increases (Figure 4). The impact would be quite large, as food demand would barely change as a result of price changes (inelastic demand). However, the price impact should be interpreted with care, as interaction with world markets could diminish EU price increase more than is assumed in the CAPRI calculations. Moreover, supply effects could be overestimated as it is assumed that yield losses on ecological set-aside equal average yields, whereas, in actual practice, farmers may use the least-productive land on their farms as set-aside. All in all, the income increases resulting from price changes might be less than two per cent.

Figure 4
Changes in producer prices of cereals and milk, compared to Baseline Scenario in EU27, 2020



Source: LEI

Linking CAP payments with biodiversity improves incomes in extensive farming systems and regions, and leads to a decrease in farm incomes in intensive farming areas

With regard to direct payments, the CAP options aim for a 'better targeting of support to add value and quality in spending. There is a widespread agreement that distribution of direct payments should be reviewed and made more understandable to the taxpayer. The criteria should be both economic, in order to fulfil the basic income function of direct payments, and environmental, so as to support for the provision of public goods' (EC, 2010: 8). Biodiversity, which is considered an important public good, is one of these environmental criteria. Greening the CAP leads to a better link between CAP payments and the biodiversity performance of farming systems. Under the Greening Scenario, a shift in payments occurs from old to new Member States and from intensive to extensive farming regions (Figure 5). Most pronounced income losses will take place in regions with predominantly intensive arable farming systems with low biodiversity scores, whereas regions with more extensive livestock farming systems and high nature values show income gains (for a graphic representation of intensities, see Figure 2.1 of the Full Results).

IV Discussion

This study provides spatially explicit, quantitative results on the impact of the CAP greening options. Before drawing conclusions on policy implications (Section V), results are discussed in this section.

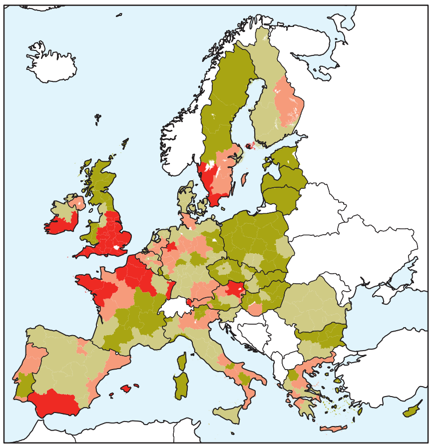
Crop rotation, winter cover and payments to small farms – not included in this study – may have positive biodiversity impacts

Not all elements of the EC communication document on the CAP were incorporated in this study (Table 1), because of limitations of the applied modelling instruments. These elements include winter cover, crop rotation and extra payments for small farms. These measures could result in an additional biodiversity impact – probably smaller than those calculated for the five modelled policy components – although this is difficult to quantify. Winter cover or cover crops are known to activate an extensive set of agro-ecosystem processes, such as fixing nutrients and adding organic material, thereby facilitating the development of soil biota. Also, seed-producing cover crops could increase food availability for birds in winter. Crop rotation contributes to heterogeneity, a strong driver of biodiversity. Payment to small farms may have an indirect, positive effect on biodiversity. As, for example, these farms normally have smaller land parcels and thus more field edges, which are relatively species-rich.

Trade-off between biodiversity and yields

The modelling results evidently demonstrate a trade-off between increasing biodiversity and decreasing yields. Less-intensive farming facilitates higher nature values but lowers average crop yields. Regarding the ecological

Figure 5
Changes agricultural income EU27, Greening Scenario, 2020



Source: LEI and PBL

set-aside measures, a number of ways exist to soften the effects of this trade-off. First of all, set-aside should preferably be implemented on field edges, as these areas are often less productive due to soil compaction and the amount of shade. Consequently, reduction in total agricultural production due to ecological set-aside could be lower than the 5% assumed in this study. Secondly, field strips used as set-aside could be used in such a way that they deliver so-called ecosystem services, such as providing habitats for pest control species and pollinators, which may raise production in the longer term. Finally, set-aside should not necessarily be left fallow; extensively managed, low-input strips also contribute to biodiversity, while limiting yield losses.

Valuation of results depends on policy perspective

How the various results that are presented in this study would be valued very much depends on the viewpoint from which they are considered:

- From a perspective of legitimacy, greening the CAP would be an improvement. It would lead to payments that are more targeted to public goods, such as biodiversity, than is the case with current income support. The study shows income shifts from intensive farming systems to more extensive, biodiversity-rich systems. This could be perceived by the taxpayer as a fitting reward for these farmers' efforts.
- From a biodiversity perspective, the three per cent higher species richness under the Greening Scenario (compared with the Baseline Scenario) would contribute to halting losses of farmland biodiversity by 2020. However, this scenario would reduce only the rate of decline in agricultural biodiversity.
- From an efficiency point of view, the positive results for biodiversity could be interpreted as small in light of the vast amount of CAP money being spent on greening payments under the Greening Scenario. Payments for specific agri-environmental measures – associated with multi-annual contracts, targeted, on a regional basis, at locations with high biodiversity and involving robust monitoring and evaluation – could increase the efficiency of measures.

Greening the CAP's first pillar or increasing the second?

From the perspectives described above, no clear and decisive answer can be given to the question of whether to promote greening through the first or the second pillar. Greening the first CAP pillar seems an attractive option as it pairs simplicity with CAP legitimisation. However, it holds few possibilities for targeting specific biodiversity in specific areas (e.g. most-threatened red-list species). Agri-environmental measures from the second pillar would offer more possibilities in that respect, although transaction costs would be relatively high – at least under the current bureaucratic regime.
A clear answer is also not provided by this modelling study. In our study it is assumed that policies will succeed in stimulating farmers to take biodiversity measures and that these would lead to an increase in species richness – regardless of whether the policy belongs to the first or second pillar. The practical implementation may decide

whether to go for greening of the first pillar or increasing the budget for the second pillar.
Possible arguments are:

1. Farmer participation. Farmers may not always be inclined to participate, as measures often are not economically profitable. This would be particularly the case for second-pillar measures, as the terms of EU State Aid prohibit government bodies from paying farmers anything over the actually incurred costs. First-pillar payments, having income support as their primary goal, do not fall under this EU State Aid regime.
2. Continuity of measures. To yield a long-term effect on biodiversity, long-term contracts that span decades would be preferable. As first-pillar payments are annual and non-contractual, they score lower than agri-environmental payments in the second pillar, which have six-year contracting periods.
3. Optimal locations for implementing measures. Second-pillar measures can be better targeted than first-pillar measures, from a biodiversity point of view. Because of general implementation of first-pillar measures, some of the payments may not be effective if measures are implemented in ways and at locations that are not very effective for maintaining biodiversity.
4. Knowledge and skills. Merely imposing measures will not suffice; farmers require knowledge about how to influence the effectiveness of measures. On average, farmers who are faced with mandatory measures in the first pillar are expected to be less receptive to information than those who are implementing voluntary measures in the second pillar. At the very least, this will require a different communication strategy.

Increasing efficiency of biodiversity policy

The efficiency and effectiveness of CAP measures may be improved in various ways, with regard to agricultural contributions to nature values. For example, when agri-environmental measures are implemented at isolated locations in a region with predominantly intensive farming, the benefits will be relatively small, as species will be unable to migrate and establish sustainable populations. However, measures that increase landscape heterogeneity through the construction of green infrastructure could further increase farmland biodiversity. Source populations could be tapped by offering migratory routes through landscape elements, also increasing the resilience of agro-ecosystems to perturbations such as climate change. Instruments to improve biodiversity impacts could coordinate measures at a regional level, stimulating farmers in a specific area to adopt tailor-made measures, covering many years, through regional covenants. Evaluation of farmland biodiversity measures is essential to continually improve the cost-effectiveness of greening the CAP. This is not an easy job to do. For example, the lack of a standardised approach hinders the comparability of results.

Positive impacts of greening measures for objectives other than those of biodiversity

Measures aimed at improving conditions for biodiversity may also support ecosystem functioning and, therefore, the provision of ecosystem services, such as carbon sequestration, water purification, soil management and ecological pest control. Increasing species richness would lead to the preservation of resilient agro-ecosystems with a high degree of functional diversity. Multiple species would be able to deliver specific ecosystem services; their sheer numbers reducing the impact on ecosystem functioning if one or more of them would diminish, either permanently or temporarily. In addition to these environmental goals, biodiversity measures could also contribute to the recreational potential, character and attractiveness of landscapes. This would also apply to the aforementioned framework of regionally tailored green infrastructure located around areas of high ecological quality. This, in turn, could enhance both recreational and residential potential, thus contributing to the vitality of rural areas (EC, 2010). However, these positive side effects can only be obtained by finding synergies with adjacent policy areas and policies. A clear example is the case of ecological pest control that uses the strips of land along arable fields that have been designated as ecological set-aside. This measure could potentially lead to a decrease in the use of pesticides as well as to yield increases, in the long term. However, this ignores the incentive caused by the wide range of affordable pesticides that is currently available. Therefore, changes to the CAP will not yield much impact on ecosystem services while other policies, in this case the current EU pesticide authorisation regime, remain in place.

V Policy implications

- Greening the CAP would contribute to farmland biodiversity. In this study, an average three per cent increase in species richness, by 2020, was calculated for the Greening Scenario, relative to that of the Baseline scenario. This could halve the ongoing farmland biodiversity loss within the 2014–2020 period, albeit with a very large degree of uncertainty due to a lack of knowledge of autonomous trends in species richness. Although the result could be interpreted as being modest, it should be noted that the main purposes of the first pillar remain securing the availability of food supplies and ensuring a fair standard of living for farmers, with increased biodiversity as one of many environmental side effects. From the perspective of the EU biodiversity strategy, the CAP is the most important – if not the only – instrument for improving biodiversity in agricultural areas.

- Substantial differences exist between the regions with intensive and extensive farming. Although extensive farming regions are richer in biodiversity, greening the first pillar of the CAP would lead to greater improvement in EU farmland biodiversity in intensive farming regions within the 2014–2020 period. The consequences of greening the CAP are demonstrated in regional diversities not only regarding biodiversity but also in farm incomes. This implies that a regionally differentiated policy may be more appropriate than a one-size-fits-all approach. For example, in extensive farming regions, a policy that preserves all or at least part of the current biodiversity-rich, extensive agricultural land seems more adequate than mandatory ecological set-aside.
- A strategic policy choice could be a further specialisation of areas with intensive production systems focused at input-efficient production. In addition, areas with extensive farming would serve as source areas for agricultural biodiversity and have several other positive impacts. The proposed changes to the CAP seem not to include further specialisation, as the largest increase in species richness resulting from proposed measures would be in intensive, currently biodiversity-poor areas.
- A trade-off exists between budgets, biodiversity and agricultural production. Therefore, careful consideration needs to be given to effective biodiversity measures. There are several options to alleviate the trade-off between biodiversity and production. Examples are the targeting of CAP budget towards areas already high in biodiversity, as well as the implementation of measures related to a regional 'green infrastructure' in agricultural areas, which would effectively facilitate the spread of source populations. The proposed greening payment for permanent grassland could be targeted at already biodiversity-rich grasslands. At farm level, individual producers could reduce production losses by using the least-producing fields and field edges as set-aside and for implementing other agri-environmental measures.
- Greening the CAP may yield a broad range of positive impacts if they are combined with stimuli from adjacent policy areas. Retaining permanent grassland would prevent the emission of carbon dioxide from agricultural soils. Set-aside could form a buffer for agricultural run-off, before polluted water drains into ditches or streams, thus improving water quality. Greening measures also could benefit the recreational appeal of landscapes; for example, by the construction of green infrastructure. Furthermore, they may also favour a number of ecosystem services, such as biological pest control.

FULL RESULTS

ONE

Policy context, scenarios and models

1.1 Common Agricultural Policy

1.1.1 General overview

The Common Agricultural Policy (CAP) is a policy with a long history. Many adaptations have been made since its establishment in 1962. The current CAP has a number of goals, ranging from contributing to farm incomes to the sustainable management of natural resources. CAP expenditures in 2009 were over 50 billion euros, which equals around 100 euros per EU citizen. Approximately 80% of the budget was used for income subsidies to farmers (decoupled direct payments); around 20% was spent in the second pillar (Rural Development Programmes). Implementation of the CAP has varied significantly between Member States. The current CAP ends in 2013. Therefore, a revised policy will be effective from 2014 onwards.

The current design of the CAP

At present, most EU farmers receive an annual payment (single farm payment), based on the number of hectares of farmed land. This is the main component of the first pillar of the CAP. The amount per hectare varies strongly per Member State or even per farm. In order to receive such a payment, farmers must comply with a number of requirements (cross-compliance), such as meeting a certain environmental standard and maintaining their land in a good agricultural condition. For a number of commodities, elements of price and market regulation are still in place, such as milk quotas for the dairy sector (to be abolished in 2015), intervention prices and import tariffs. Through the rural development policy (second pillar) farmers may receive additional funds, often depending on the region where they are located. This can be in the form of additional payment per hectare in case of less-favoured areas, payment for the delivery of agri-environmental benefits, and non-recurring payments for the modernisation of their farms.

Evolution of the CAP

The CAP has evolved greatly since its introduction in 1962. The original purpose of the CAP was to encourage agricultural productivity in order to guarantee a stable food supply at affordable prices and to ensure a viable agricultural sector. The CAP replaced national agricultural policies, to facilitate an open, common EU market. At that time, the main policy instruments where price and market policies (guaranteeing high prices to farmers) and financial assistance for farm restructuring.
During the 1962–1992 period, the price and market policies were continually adapted to address changing conditions, such as increasing agricultural production and developments of the global market. In 1992, the price and market policies were transformed for cereals and some other crops into a system of income support on a hectare basis (MacSharry reform). This transformation occurred under the influence of pressures from non-EU countries in the World Trade Organization (WTO) and from within the EU, to slow down the rapid increase in the EU budget. During the mid-term review of 2003, income subsidies were almost completely decoupled from the actual production of most commodities.

Creation of the second pillar of the CAP

The restructuring component of the CAP initially was aimed at individual farms and did not address the regional dimension of their problems. To rectify this, experiments with a more regional approach were set up in the 1970s, which after various steps finally resulted in the rural development programmes of the second pillar of the CAP.
Also included in the second pillar are agri-environmental measures. In the 1980s, a number of Member States started implementing agri-environmental measures at their own initiative. These were subsequently adopted by the European Community in 1985, but continued to have a voluntary character. Under the MacSharry reform of 1992 these measures were introduced as 'accompanying measures' for all Member States.

Enlargement of the EU

Over the last 50 years, the number of Member States has increased from 6 to 27. When the United Kingdom, Ireland, Denmark, Greece, Spain and Portugal joined the European Community they more or less fully adopted the CAP. Sweden, Finland and notably Austria, which joined the EC in 1995, did put more emphasis on the second pillar. The 12 countries that joined the EU between 2003 and 2008 also put more emphasis on the importance of the second pillar.

1.1.2 Communication document by the European Commission The CAP towards 2020

Goals of the future CAP

In their 2010 communication document, *The CAP towards 2020; Meeting the food, natural resources and territorial challenges of the future*, the European Commission elaborates the ideas for post-2013 CAP reform. Basically, the future CAP should remain a strong common policy structured around the two-pillar structure, and address the three challenges of global food security, environmental protection and climate change, maintaining a territorial balance between rural areas in the EU. Given these challenges, the three following goals of the future CAP are proposed:

- viable food production, in order to contribute to farm incomes and limit farm income variability, to improve the competitiveness of the agricultural sector and enhance its value share in the food chain, and to compensate for production difficulties in areas with specific natural constraints;
- sustainable management of natural resources and climate action, in order to guarantee sustainable production practices and secure the enhanced provision of environmental public goods, to foster green growth through innovation, and to pursue climate change mitigation and adaptation actions;
- balanced territorial development, in order to support rural employment and maintaining the social fabric of rural areas, to improve the rural economy and promote diversification, and to allow for structural diversity in the farming systems.

In order to address these goals, the European Commission, in its communication document, makes some suggestions about how the present CAP instruments for direct payments, market measures and rural development could be adapted.

Adaptation of direct payments

According to the European Commission, redistribution of direct payments is a necessary adaptation, to make direct payments more understandable to the taxpayer, and to improve the targeting of payments, as both income support and remuneration for the provision of so-called public goods. The EC further states that major disruptive changes should be avoided in the process of moving towards a more equitable distribution of direct payments. According to the EC (2010), future direct payments could be based on the following elements:

- basic income support through decoupled direct payments;
- a mandatory 'greening' component for actions addressing climate and environmental goals in the form of simple, non-contractual and annual payments for, for example, permanent pasture, green cover, crop rotation and ecological set-aside;
- area-based payments to promote the sustainable development of agriculture in areas with specific natural constraints, which are complementary to the support for less-favoured areas (LFA) in the second pillar;
- voluntary coupled support to take account of specific problems in certain regions with particular types of farming;
- simplification of cross-compliance rules.

Adaptation of market measures

Despite the overall market orientation of the CAP, some intervention instruments that act as a safety net in cases of price crises or market disruptions are desirable. The EC refers to the upcoming legal proposals for the dairy sector, and reaffirms the abolishment of the dairy quotas by 2015. It also announces some future proposals for the sugar and isoglucose sectors, the current regime of which is set to expire in 2014/2015, and it refers to its intention to improve the functioning of the food supply chain, especially the problem of the steadily decreasing share of agricultural value added in the food supply chain.

Table 1.1
Policy options for a future CAP

Option 1 **Gradual change of the current policy framework and more equity in the distribution of direct payments between Member States**		
Direct payments	***Market measures***	***Rural development***
– no change of system – more equity in direct payments between Member States	– strengthen risk management tools – streamline and simplify existing market instruments	– maintain Health Check orientation with increased funding for new challenges of climate change, water, biodiversity and renewable energy, and innovation
Option 2 **A shift towards a more sustainable CAP and a better balance between the different policy objectives, farmers and Member States, to be achieved by targeted payments**		
Direct payments	***Market measures***	***Rural development***
– change in the design of direct payments; new payments are composed of: a. a basic rate serving as income support b. a compulsory additional aid for specific 'greening' of public goods c. an additional payment to compensate for specific natural constraints d. a voluntary, coupled support component for specific sectors and regions – more equity in direct payments between Member States	– improve and simplify existing market instruments	– more focus on environment, climate change and/or restructuring, innovation, and regional/local initiatives – strengthen existing risk management tools – some redistribution of funds between Member States could be envisaged
Option 3 **A far-reaching CAP reform with a strong focus on environmental and climate change objectives, moving away from income support and market measures**		
Direct payments	***Market measures***	***Rural development***
– phasing out of direct payments – limited direct payments for environmental public goods and payments to compensate for specific natural constraints	– abolish all market measures, except for a safety net in times of severe crisis	– measures are mainly focused on climate change and environmental aspects

Source: EC (2010)

Adaptation of rural development policy
The current rural development policy in the second pillar can be maintained, contributing to the competitiveness of agriculture, including innovation, sustainable management of natural resources and a balanced territorial development. Environment, climate change and innovation should be guiding principles. In addition to the current menu of rural development measures, a risk management toolkit should be included to deal more effectively with income uncertainties and market volatility (EC, 2010).

Three broad policy options
Finally, the EC presents three possible post-2013 directions for the CAP, reflecting the main orientations within public debate, which are not mutually exclusive and merit further consideration (Table 1.1).

After discussion of the main orientation of the CAP post-2013 with Council, Parliament and other stakeholders, the European Commission hopes to present legislative proposals in autumn 2011 for the future CAP that is 'a more sustainable, more balanced, better targeted, simpler and more effective policy, [and] more accountable to the needs and expectations of the EU citizens' (EC, 2010: 13).

1.2 Biodiversity policy

1.2.1 General overview

EU biodiversity headline target and sector targets
In March 2010 the European Council endorsed the 2020 headline target for biodiversity: 'Halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restoring them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss'. The tenth Conference of the Parties (CoP10) to the Convention on Biological Diversity (CBD), held in 2010, adopted a global Strategic Plan for Biodiversity 2011 – 2020. In May 2011 the European Commission published an *EU biodiversity strategy to 2020* that responds to both mandates (EC, 2011).

Table 1.2
Actions in the EU biodiversity strategy dedicated to agriculture

Action 8		**Enhance direct payments for environmental public goods in the EU Common Agricultural Policy**
	8a	The Commission will propose that CAP direct payments will reward the delivery of environmental public goods that go beyond cross-compliance (e.g. permanent pasture, green cover, crop rotation, ecological set-aside, Natura 2000).
	8b	The Commission will propose to improve and simplify the GAEC (Good Agricultural and Environmental Conditions) cross-compliance standards and consider including the Water Framework Directive within the scope of cross compliance once the Directive has been implemented and the operational obligations for farmers have been identified in order to improve the state of aquatic ecosystems in rural areas.
Action 9		**Better target rural development to biodiversity conservation**
	9a	The Commission and Member States will integrate quantified biodiversity targets into rural development strategies and programmes, tailoring action to regional and local needs.
	9b	The Commission and Member States will establish mechanisms to facilitate collaboration among farmers and foresters to achieve continuity of landscape features, protection of genetic resources and other cooperation mechanisms to protect biodiversity.
Action 10		**Conserve Europe's agricultural genetic diversity**
		The Commission and Member States will encourage the uptake of agri-environmental measures to support genetic diversity in agriculture and explore the scope for developing a strategy for the conservation of genetic diversity.

Source: EC (2011: 13)

The EU strategy provides the policy framework for achieving the headline target and global commitments. It contains six targets with corresponding actions. In addition to the full implementation of the EU Nature Directives, the strategy also contains a sector target for agriculture (Target 3a): 'By 2020, maximise areas under agriculture across grasslands, arable land and permanent crops that are covered by biodiversity-related measures under the CAP so as to ensure the conservation of biodiversity and to bring about a measurable improvement in the conservation status of species and habitats that depend on or are affected by agriculture and in the provision of ecosystem services as compared to the EU2010 Baseline, thus contributing to enhance sustainable management' (EC, 2011: 6; Baseline from EEA, 2010).

EU biodiversity baseline and actions
Improvement of biodiversity through the actions described in the EU strategy is to be measured by the European Commission, together with Member States, against the EU2010 Baseline (EEA, 2010), using a set of updated EU biodiversity indicators. For the major ecosystem types, the baseline provides information on status and trends, pressures and threats, and services. Relevant to areas covered by the CAP are the types: agro-ecosystems and grassland ecosystems.

The EU biodiversity strategy to 2020 includes several actions related to agriculture (Table 1.2).

The achievement of the sector target for agriculture in the EU biodiversity strategy to 2020 is quantitatively assessed against the criteria set out in Target 1 for species and habitats, and in Target 2 for ecosystem services. Target 1 speaks of a significant and measurable improvement of the status of habitats and species covered by EU nature legislation, so that, by 2020, compared to current assessments: (i) '100% more habitat assessments and 50% more species assessments under the Habitats Directive show an improved conservation status'; and (ii) '50% more species assessments under the Birds Directive show a secure or improved status'. Target 2 states that, by 2020, ecosystems and their services are maintained and enhanced, by establishing green infrastructure and restoring at least 15% of degraded ecosystems. For Target 1 limited baseline statistics are available, for Target 2 these are mostly still lacking.

The improvements made by the agricultural sector regarding biodiversity measured over the Target-1 criteria apply to farmland designated as Natura 2000 areas, only. For the wider agricultural landscape, the criteria of Target 2 apply. These are ecosystem function criteria not yet clearly defined and quantified. Apart from the criteria mentioned under the targets of the 2020 strategy, the EU2010 Baseline (EEA, 2010) provides a common farmland bird indicator, consisting of monitoring information on 36 species.

Framework for action
Actions to be taken in agriculture, mentioned in the EU biodiversity strategy to 2020, have been formulated on a level of planning and policy output, while targets have been defined on the level of changes in the state of biodiversity. Although the desired policy effects have not yet been sharply defined, their direction is clear. As such,

the EU biodiversity strategy to 2020 is above all a framework programme for further action that needs more detailing. As the European Commission mentions in the plan, this is the collaborative task of the EU, Member States and regional and local authorities. The greening of the CAP is one of the pathways mentioned in the strategy that should contribute to achieving the EU biodiversity headline target and underlying targets. Not the least of the policy pathways because of the key role the agricultural sector plays for biodiversity.

1.2.2 Interactions between agriculture and farmland biodiversity

General trends

European agricultural landscapes developed over the course of centuries as a result of the interaction between farming and ecological as well as physical constraints imposed by the environment. Natural species and early agricultural crops imported from the Near East have adapted themselves to the open, semi-natural conditions prevailing in the extensively managed farmlands. Conservation of European biodiversity is partly dependent on farming and farmers, as approximately half of the EU currently is under agricultural management (BISE, 2010) and 55 of the 231 habitats under the Habitats Directive require agricultural management (EEA, 2010). Moreover, these landscapes are not only important from an environmental or agricultural perspective, but are also highly appreciated by the public for their recreational and cultural value.

The last decades, however, have shown a profound intensification of European agricultural practices. Nevertheless, biodiversity policy challenges for the agro-sector are large. This as a result of decreasing crop diversity, simplification of cropping methods, use of fertilisers and pesticides and homogenisation of landscapes, all of which have negative effects on biodiversity in agricultural areas (Le Roux et al., 2008). Biodiversity in agricultural areas has declined over the past decades (EEA, 2007; Cooper et al., 2010). For example, the European Union's common farmland birds declined by 20% to 25%, between 1990 and 2007, whereas common bird populations decreased by about 10% during the same period (EEA, 2007). Trends differ between farming areas with intensive and extensive production. Species connected to farming systems are vulnerable to intensification of agriculture in intensively farmed regions as well as in situation where land is no longer being used for agriculture in extensively farmed areas (Bignal and McCracken, 1996; EEA, 2004b)

Intensively farmed regions

Generally, there is a trend of intensification in farmland areas with a high potential for agricultural production (EEA, 2005). The main reason for this is that agricultural production costs are generally lower in an efficiently organised landscape, while important natural values thrive more in traditionally farmed, cultural landscapes. As a result of a stronger intensification, the decline in farmland bird populations has been larger within the EU15 than in other EU Member States (Donald et al., 2002).

CAP price support has encouraged increases in yields, and in the use of inputs and marginal lands, as well as caused destruction of unfarmed habitats, loss of unfarmed features, and land-use changes, mostly from grassland to arable land (Donald et al., 2002). However, it is unclear how intensification would have developed without the CAP. Other important drivers are increasing labour costs in combination with the availability of labour-saving technologies, which are largely autonomous processes.

Extensively farmed regions

In areas with extensive production systems there is a tendency towards extensification and land no longer being used for agriculture (Strijker, 2005). Extensive or traditional agricultural management, with a mosaic of arable fields, landscape elements and extensive grazing, is both important for biodiversity and as a traditional agricultural landscape. However, over-extensification would lead to replacement of these systems with more monotonous scrubland or forest land. Awareness of this problem has increased since the concept of High Nature Value (HNV) farmlands was introduced in 1993. This concept recognises the causality between biodiversity and low intensity, low input farming systems. Often, semi-natural vegetation utilised by livestock, in combination with the presence of other semi-natural features, are main characteristics of these systems (IEEP, 2007). It is estimated that roughly 15% to 25% of the European countryside qualifies as High Nature Value farmland. These areas consist of semi-natural grasslands and are relatively abundant in mountainous regions. Almost one third of this type of farmland is located within Natura 2000 sites (EEA, 2004b). The concept of High Nature Value farmland is increasingly being used in international biodiversity strategies and statements. Areas of High Nature Value have not been officially assigned yet; Member States are working on identification of these areas.

So far, the CAP has not specifically focused on combating land abandonment in High Nature Value farmlands. Currently, conservation largely relies on measures under the second pillar of the CAP, notably in the support to less-favoured areas and agri-environment schemes. Less-favoured areas largely overlap the areas of High Nature Value farmland, but there is no relation between actual expenditure on these less-favoured areas (LFA) and agri-environment schemes (AES) in the various countries and their share of High Nature Value farmland (EEA, 2004a). Furthermore, extensive farming areas receive a relatively small share of the first-pillar budget. Since income support is determined on the basis of historical production levels, most of the support is granted to regions with intensive production systems.

1.3 Description of Baseline and Greening Scenarios

1.3.1 Derivation of scenarios

The European Commission's communication document (EC, 2010) provides no detailed blueprint for a future CAP. The three outlined policy options for the CAP post-2013 cover a wide range of potential pathways, varying from maintaining the status quo with some slight adaptations, to shifts towards a greening of the CAP and a more radical reform with a phasing out of direct payments. In addition, the EU document makes no reference to the size of a future CAP budget or to the distribution of this budget over the first and second pillars. Perhaps the clearest indications for the future design of the CAP are the wishes expressed in the document:

- to maintain the two-pillar structure;
- to increase the emphasis on the new challenges of climate change, water management, biodiversity, renewable energy, and innovation, as already indicated in the Health Check of the CAP agreement;
- to strive for more equity in direct payments between Member States;
- to use direct payments also for environmental support, thereby making them more understandable for the taxpayer.

However, details of redistribution of direct payments over Member States or of the level of payments for pubic goods have not been given. As such, the communication document leaves much room to manoeuvre for designing scenarios for a future CAP.

This study focuses on the provision of public goods by agriculture, in particular, the contribution to a richer biodiversity on farmlands. Therefore, particular attention is given to features that may contribute to an increase in biodiversity and to a certain extent also to lowering greenhouse gas emissions. Biodiversity may be improved by increasing habitat diversity in intensive agricultural areas; for example, by extensification of small parts of these areas, and by supporting farmers in extensively farmed regions (Subsection 1.2.2).

This section describes the design of two scenarios for a CAP post-2013; the Baseline Scenario and the Greening Scenario, which has been derived from the second policy option as outlined by the European Commission (EC, 2010). This policy option is described in rather global terms, which leaves a certain degree of freedom in the design of the Greening Scenario. However, as the results from the scenarios have been estimated by using the models CAPRI and Dyna-CLUE, there were certain restrictions regarding this freedom. The scenarios, thus, could use only the variables defined in CAPRI and Dyna-CLUE. Furthermore, given the emphasis on assessing biodiversity impacts, our scenarios specifically include biodiversity elements, leaving out issues such as innovation and competitiveness.

In this study, for the Greening Scenario, most of the policy components in the EC communication document that are related to a more biodiversity-targeted CAP have been translated into concrete measures. The results presented in the study are no precise predictions of the outcome of a new CAP, but show the direction (positive or negative) and order of magnitude of the options in their effect on biodiversity (Chapter 2). Our interpretation of the EC options was fuelled by proclaimed views of European stakeholders and by consultation with Dutch stakeholders. The shift in budget from the EU15 to the EU12 gives an idea of its effects. As the overall EU budget for the 2014–2020 period was not known at the time of this study, the current total budget (in nominal terms) for the CAP was taken as a starting point, including the phasing in (until 2016) of payments to farmers in the new Member States.

1.3.2 Baseline Scenario

The Baseline Scenario describes the reference situation for 2020. Price developments were taken from other outlook studies. The CAP post-2013 was presumed similar to the content of the CAP before 2013, with the exception of policy changes described in the Health Check agreement (EC, 2009). This means that income support is to be fully decoupled from production, and milk quotas to be abolished in 2015.

Introduction of a regional flat rate for direct income support was considered part of the Baseline Scenario. In the storyline of this scenario, it has been assumed that Member States that currently use payments systems based on historical payments, have implemented the recommendation in the EC Health Check agreement to apply a regional flat rate.

The CAPRI model uses the year 2004 as the historical base year. Development in prices of agricultural products and yields per agricultural activity, from 2004 up to 2020, was derived from extrapolation of past trends and price developments as projected by OECD and FAO (2009). These developments are expected to lead to a number of changes in relative prices and revenues, which will affect the behaviour of farmers. Nominal prices of fertilisers, feeds and other variable inputs will increase. Prices of agricultural products also will go up (with the exception of pork, poultry meat and eggs), although not at an equal rate to the input prices. Yields of most product categories are also expected to rise between 2004 and 2020, up to almost 20% for cereals (Helming and Terluin, 2011).

1.3.3 Greening Scenario

In a first step for the Greening Scenario, two elements were added to the Baseline Scenario. These are referred to in the results in Chapter 2 as *moderate shift measures*:

- reduction in disparities between direct payments in the EU15 and EU12 Member States were modelled by reducing the first-pillar budget in the EU15 by 5%, and by adding this budget to first-pillar payments in the new Member States (which led to an increase in the first-pillar budget in the EU12 of 20%);
- addressing the new challenges named in the Health Check, by shifting 5% of the first-pillar budget in the EU15 Member States towards agri-environmental measures in the second pillar (e.g. pillar 2, axis 2, measure 214) without national co-financing.

In a second step, the resulting first-pillar budget per Member State was being made more targeted. A variety of targeted measures could be taken, although few of these farmers' actions are really 'simple, generalised, annual and non-contractual' as the EC communication document (EC, 2010) states. For the Greening Scenario, the budget was divided over the three elements of Option 2 of the EC proposal, that is, basic income support, greening measures and payments for farms in areas with natural constraints. Member States are expected to have some freedom to allocate funds to the various measures, as considerable differences between regions exist, both from an agro-ecological and a societal point of view. Therefore, in our stylised interpretation of Option 2 the EC is expected to prescribe limits within which Member States are allowed to manoeuvre, in order to avoid considerable disturbances of the level playing field of the EU market. These could concern maximum payments per hectare or maximum shares of the first-pillar budget dedicated to certain payments – similar to what is currently the case in the second pillar.

For the calculations, certain assumptions were made regarding these limits. The following principles were followed in the Greening Scenario:

- farmers are eligible for payment for all types of agricultural lands;
- the maximum payment for permanent grassland is 100 euros per hectare;
- the maximum payment for arable land under greening conditions is also 100 euros per hectare, with the precondition of 5% ecological fallow for the benefit of biodiversity (crop rotation requirements and winter cover also fit in this scenario, but were not included in the calculations);
- maximum budget for permanent grassland and arable land, together, is 30% of the first-pillar budget per Member State;
- first-pillar payment for natural constraints is a maximum of 150 euros per hectare; maximum budget is 30% of the Members State budget; payments are allocated to less-favoured (LFA) areas, until the budget is exhausted or farmers in all LFA areas have received the maximum payment; current LFA payment from the second pillar remains in place, thus new payments for natural constraints add to the old second-pillar payments;
- the remaining budget is used for a basic-rate income support (minimum of 40% of the first-pillar budget, resulting from the above).

1.4 Models

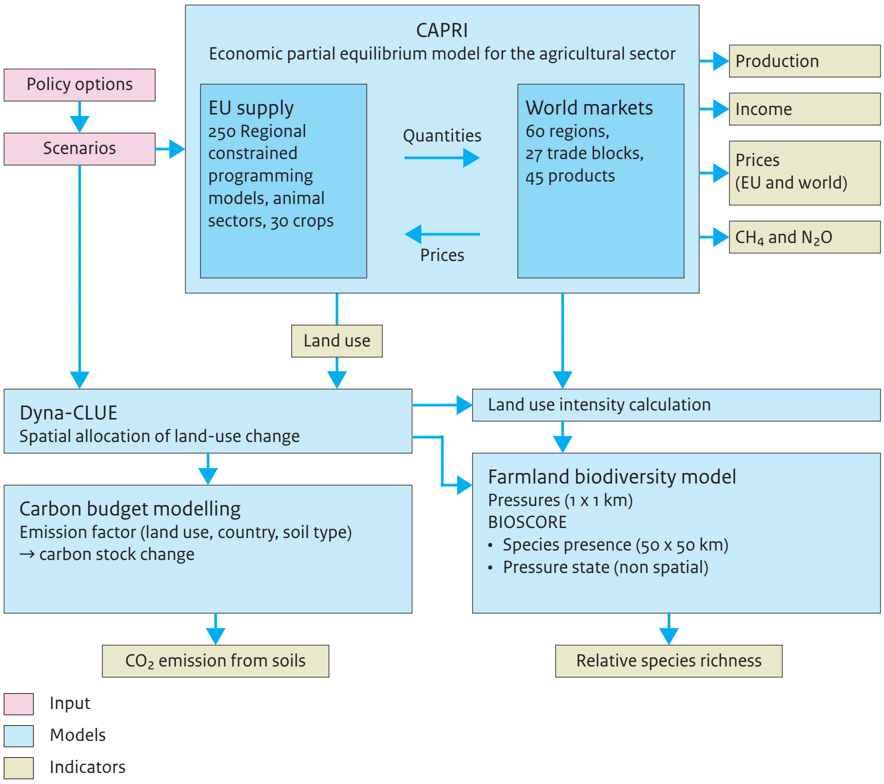
This section describes the models that were used for translating the scenarios into indicators of biodiversity and carbon storage. Figure 1.1 presents a graphical picture of the models as well as the relations between models and indicators. Detailed information on assumptions made when translating scenario storylines into model input – in particular CAPRI input – are provided in a background document by LEI Wageningen UR (Helming and Terluin, 2011).

1.4.1 CAPRI

The Common Agricultural Policy Regionalised Impact modelling system (CAPRI) was applied to analyse the impact of the different scenarios described above, among other things on agricultural production, income, land use, and nitrogen application in the EU27. The CAPRI model is an EU27 partial equilibrium model for the agricultural sector at NUTS2 level (aggregated regional farm approach). The model consists of a supply module and a global market model:

- The CAPRI supply module comprises around 280 regional farm models (one farm model for each NUTS2 region in the EU27, Norway, Western Balkans and

Figure 1.1
Modelling CAP scenarios



Turkey) covering about 50 crop and animal activities for each of the regions, and including about 50 inputs and outputs. Each regional farm model optimises regional agricultural income at given prices and subsidies, subject to constraints on land, policy variables and feed and plant nutrient requirements in each region. An interesting feature of the CAPRI supply module is that agricultural activities are divided into an extensive (low input, low yield) and an intensive type or variant (high input, high yield), albeit in a stylised way. In the CAPRI model, both high en low farming intensities have been assumed for each crop. For low farming intensity, it is assumed that yields per hectare, per crop, are 20% below average and variable inputs are 25% below average. For high farming intensity, yields are assumed to be 20% above average and inputs are 25% above average. This applies to all inputs, except for plant protection per hectare, which is either 40% below or above average.

- The CAPRI global market model is a comparative static multi-commodity model. It covers 47 primary and secondary agricultural products.

The CAPRI supply module and global market model are iteratively linked. Equilibrium ensures cleared markets for products and young animals (e.g. calves that are reared to replace older cows), and matches feed production to feed requirements for the total animal stock on national scale www.capri-model.org).

The CAPRI output that was used in the calculations on land use, land-use intensity and biodiversity consists of land-use per crop/grassland, (including land-use types under agri-environment schemes) and nitrogen levels for the intensive and extensive farming types, both per crop and for grassland. These CAPRI outputs were adapted manually for use in Dyna-CLUE and the biodiversity indicator, to match the different model set-ups (e.g. regions, categories). Categories in the biodiversity indicator are extensive grassland systems (fertilisation of less than 50 kg N per ha) and intensive grassland systems, extensive arable land systems (less than 50 kg N per ha), moderately intensive arable land systems (between 50 and 150 kg N per ha) and intensive arable land systems (> 150 kg N per ha).

1.4.2 Dyna-CLUE

The Dyna-CLUE model (Dynamic Conversion of Land Use and its Effects) (Verburg and Overmars, 2009) is an adapted version of the CLUE-s model (Verburg et al., 2002). In comparison with CLUE-s, the Dyna-CLUE model includes an option by which the quantity of land-use types may change endogenously (Overmars et al., 2007), for example, as a result of succession, and includes an option for regionally specified demands.

Dyna-CLUE is a land allocation model in which a predefined area size for several land-use types can be allocated to a specific study area (e.g. country, region). To be able to assign a land-use type to a location, suitability of such a location is determined by statistically relating historical land-use data to a suite of drivers. In addition, several mechanisms (neighbourhood suitability, conversion elasticity, conversion restrictions, and area specific restrictions) may be added to this suitability, in order to express other process information, such as policies or biophysical relations. In this version, bottom-up processes in demand may be included, for example, natural succession from grassland to forest.

To be able to model the EU 27, we used the Dyna-CLUE model in an EU setting. This model application originates from work within the EURURALIS project (www.eururalis.eu) (Eickhout and Prins, 2008; Verburg et al., 2008; Verburg et al., 2006). The version that we used was the EU-ClueScanner (Pérez-Soba and Banse, 2010). For this analysis, the demand input was calculated based on the results from the CAPRI model (see Figure 1.1). Land-use information was used as input for calculating land-use intensity. Land use is one of the pressures in the biodiversity calculation and land use is an important input for carbon budget modelling.

1.4.3 Calculation of land-use intensity

For biodiversity on agricultural land, land-use intensity is one of the most important drivers. The land-use intensity map used in this study was based on (Overmars et al., 2011; Temme and Verburg, 2011). The land-use types of arable land and grassland that resulted from the land-use modelling exercise were reclassified into three classes of intensity of agricultural management of arable land and two classes for grassland. In the methodology of Temme and Verburg (2011) and Overmars et al. (2011) point data on land-use intensity is statistically combined with data on drivers covering the whole of the EU27 to extrapolate the point data to maps covering the EU27.
Land-use intensity comprises various elements, such as disturbance, harvesting, toxic pollutants, trampling, and nitrogen input. Nitrogen application is used as an approximate indicator for the intensity of agricultural land management. High nitrogen application relates to high intensity of the other elements of intensity: disturbance, harvesting, toxic pollutants, and trampling (Herzog et al., 2006). For arable land, three classes of nitrogen application were identified: low (<50 kg/ha); medium (50-150 kg/ha) and high (>150 kg/ha). These categories are based on the relevance of nitrogen levels to biodiversity (Kleijn et al., 2009). For grassland, two categories were used: intensive grassland management with > 50 kg N/ha, and extensive grassland management with < 50 kg N/ha. A map showing land-use intensities of 2005 is presented in Figure 2.1.

1.4.4 Calculation of farmland biodiversity

Summary

The farmland biodiversity model applied in this study combined data on species occurrence (on a 50 x 50 km grid); including their relation to environmental pressures from the so-called Bioscore database (www.BIOSCORE.eu) with spatially detailed information (on a 1 x 1 km grid) on these pressures (data on land cover, land-use intensity and fragmentation). The species occurrence data set included 145 species, representative of farmland-dependent plants and animals. By combining species occurrence maps with spatial data on the considered pressures for all 145 species, the aggregated indicator was constructed. The resulting averages and variations are shown in Figure 2.4. The aggregated species richness indicator is expressed as a relative number compared to the total number of species included in the procedure at a specific location, and is presented in maps. The value of the indicator is that it contains representatives from many species groups, which makes it responsive to changes in environmental pressures, meaningful to all ecosystem niches and thus representative of farmland biodiversity as a whole, and suitable for a large and heterogeneous study area, such as the EU territory.

In-depth explanation of the relative species richness indicator

The indicator that was used in this study is called *relative species richness* (Overmars et al., 2011). This indicator was developed specifically for the purpose of studying the impacts of land-use policies (e.g. the CAP) on biodiversity on agricultural land in the EU. The calculation of the indicator has three main components:

1. The database of the BIOSCORE project (www.BIOSCORE.eu) provided the relation between species presence and their sensitivity to a variety of pressures (Delbaere et al., 2009).
2. Species distribution information in maps with a coarse grid (50 km). Within the BIOSCORE project, data on the spatial distribution of these species was collected. For birds, their presence in 50 x 50 km areas was available from the EBCC atlas (Hagemeijer and Blair, 1997), for mammals, amphibians and reptiles

data were available from various sources (Gasc et al., 1997; IUCN et al., 2006a, b, c; Linnell et al., 2007; Mitchell-Jones et al., 1999; Temple and Terry, 2007). Plant data was based on Jalas and Suominen (1972).

3. Spatially detailed maps (1 km grid) on three pressures: land use (via Dyna-CLUE/EU-ClueScanner modelling described above), land-use intensity (see also above) and fragmentation.

The BIOSCORE data comprises a set of 754 terrestrial species and is considered representative of European (terrestrial) biodiversity (Louette et al., 2010). For this indicator we selected species (terrestrial vertebrates and vascular plants) that depend on open grassland or arable land as well as species that mainly have agricultural land as their habitat. A second selection criterion was that data on species presence had to be available. In total, 145 species (mammals, reptiles, amphibians, birds and vascular plants) were selected.
For each of these 145 species the relation with the three pressures was extracted from the BIOSCORE database. With the use of this information, the species presence data (at a 50 km grid) was overlaid in GIS with the data on the three pressures (at 1 km). The resulting 145 maps provided a species presence at 1 km grid, based on pressures existing in 2005.

In a next step to construct the indicator, the 145 maps were summed into one species richness map. The result of this calculation provided a number of species per (agricultural) grid cell based on the 145 species included. The question here would be if this number represented actual species richness and, if so, what did that tell us about the policy? To answer the first question: the method included data on 145 species taken from a larger data set that is assumed to represent their spatial distribution as well as their response to the pressures included (Louette et al., 2010). Since we used a subset of the original data set, this may not have been completely true. Whether the figure told us what we wanted to know, required the following consideration. Locations do not all have the same potential number of species (tropical rainforest has higher species richness than desserts). Therefore, we had to consider if we wanted to assess locations for their total number of species, or for the number of species relative to what would be their possible maximum (the potential).
To compensate for the potential species richness and to compensate for unwanted errors in spatial representativeness, we used the relative species richness. The simulated number of species is presented as the percentage of the potential number of species in a certain location. The indicator shows the performance of a location in terms of biodiversity relative to what would be possible. This can also be interpreted as the relative influence of the pressures on the number of species.

1.4.5 Carbon budget model

Carbon budgets were modelled with a bookkeeping approach developed for European-scale applications (Schulp et al., 2008). In a bookkeeping model for carbon sequestration, stock changes are calculated in discrete time steps using empirical data on stock changes. This is a common approach to model the effect of LUC on carbon stocks for large-scale studies and has been used, for example, by Gitz and Ciais (2004), Houghton et al. (1999), Padilla et al. (2010) and Kuemmerle (2011).

The total carbon budget for each grid cell consists of emissions or sequestration from the soil and emissions or sequestration from biomass. Carbon stock changes in biomass (vegetation) are only considered in forests and land use under succession, including abandoned farmland. The annual change in soil carbon stocks is a land-use-specific, country-specific emission factor (EF) [Mg C yr^{-1}]. Emission factors for cropland, grassland, peatland and forest were derived from Janssens et al. (2005), Karjalainen et al. (2003). For other land-use types, the emission factors were derived from these EFs (Schulp et al., 2008). For cropland, the emission factors were corrected for the soil organic carbon (SOC) content, as carbon emissions from croplands depend on the SOC content (Bellamy et al., 2005; Sleutel et al., 2003). Generally, grassland soils and nature take up carbon, while soils of arable land emit carbon. Managed grasslands on peat soils, however, also can emit large amounts of carbon. In the model, carbon sequestration in vegetation is taken into account for forest and land use under succession (including abandoned farmland), because of the large carbon stocks in biomass and the significant changes in biomass carbon, compared to changes in SOC stocks (according to data from Schlesinger and Andrews, 2000).

As our study only concerns agricultural land-use changes, the carbon budget model was used solely for calculating carbon dioxide emissions from, and carbon sequestration in agricultural soils.

TWO

Impacts on farmland biodiversity

This chapter provides the modelling results for agricultural land use (Section 2.1) and farmland biodiversity (Section 2.2). Section 2.3 discusses results, complemented by insights from literature.

2.1 Agricultural land use

2.1.1 Historical background

Globally, conversion of natural areas to agricultural land is the most important driving factor of biodiversity loss (PBL, 2010). In Europe, half of terrestrial biodiversity has been lost, compared to what would be the natural potential. Agriculture is the most important cause, accounting for more than half of the biodiversity loss (MNP, 2008). However, traditional agricultural land can be an important habitat for biodiversity. Agriculture in Europe has a long history, going back several thousands of years, facilitating the development of agro-ecosystems with numerous species specifically adapted to farming practices. Initially, opening up land for farmland actually increased biodiversity because of increased habitat diversity (e.g. see Donald et al., 2002). During the last three centuries, in particular, agricultural practices resulted in highly diverse agricultural landscapes. As such, farmland has become an important environment for biodiversity in Europe. However, mainly due to the conversion of natural grasslands over the last century, as well as the general intensification of agricultural practices over the last decades, agricultural biodiversity currently is in decline. In addition, the abandonment of often biodiversity-rich, extensively managed grasslands also poses a threat to specific biodiversity associated with European agricultural land (Subsection 1.2.2.).

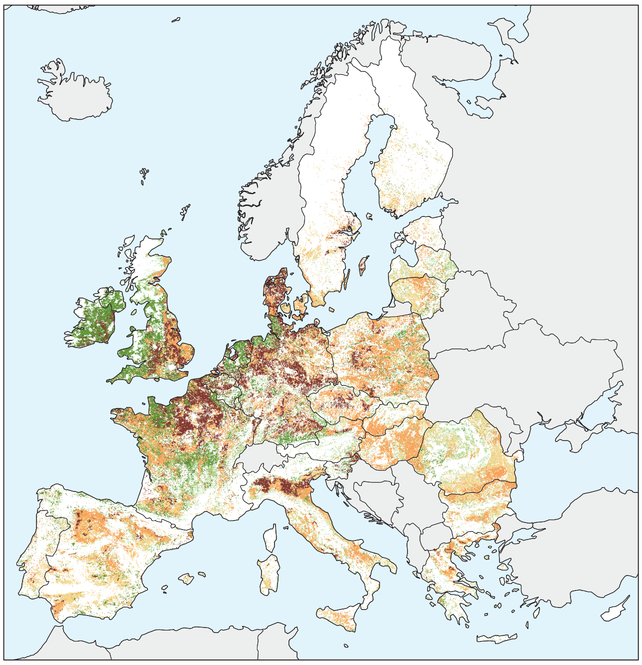
2.1.2 Reference situation 2005

In the 2005 reference situation, the agricultural area in the EU27 amounted to approximately 55 million hectares of grassland, 121 million hectares of arable land and 14 million hectares of permanent cropland. These figures have been based on modelled land-use data of 2005, derived from the Corine land-cover 2000 database (www.eea.europa.eu). The various land-use types are scattered throughout Europe, however, with large areas of highly intensive agriculture concentrated in north-western Europe (Figure 2.1). The total mapped area has been divided as follows:

- 13% less intensively managed grassland, with a fertilisation of less than 50 kilograms of nitrogen (N) per hectare (ha);
- 16% highly intensively managed grassland (more than 50 kg N per ha);
- 21% less intensively managed arable land (less than 50 kg N per ha);
- 28% moderately intensively managed arable land (between 50 and 150 kg N per ha);
- 15% highly intensively managed arable land (more than 150 kg N per ha);
- 8% permanent cropland.

The division into crop types and intensities is important for the biodiversity calculation, as grassland generally has a higher biodiversity level than arable land, and

Figure 2.1
Agricultural land use intensities, 2005



Source: PBL, derived from Corine

extensively managed areas generally have a higher biodiversity level than intensively managed areas (see Section 2.2).

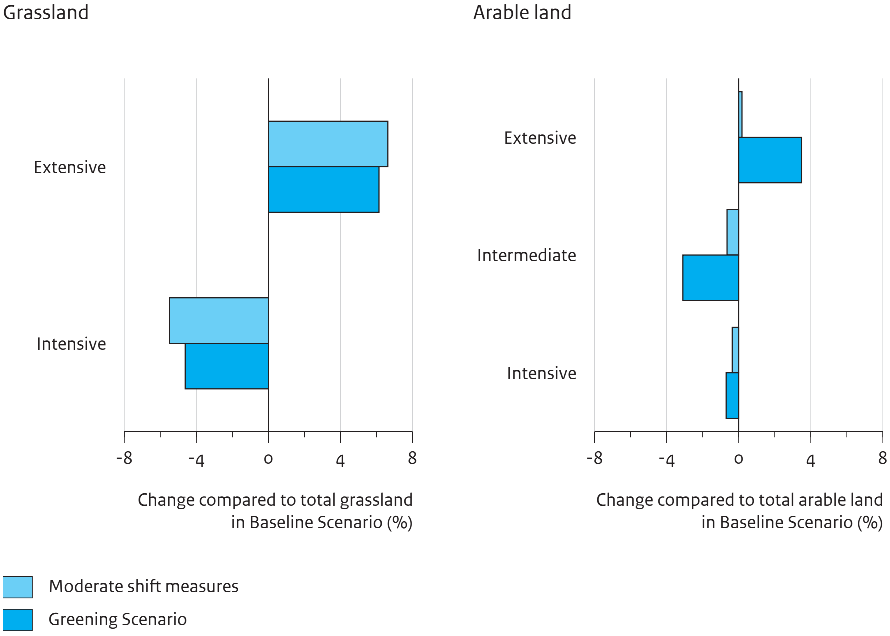
2.1.3 Land-use changes

Total agricultural area hardly varies between the scenarios. Extensification, according to the policy scenarios, does not lead to conversion of nature into agricultural area. Extensification in one location is absorbed by intensification elsewhere, or by using fallow land (e.g. agricultural land that, in the Baseline Scenario, is temporarily out of production). However, changes within the agricultural area do occur. The Greening Scenario clearly would lead to an increase in extensive use of grassland and arable land (Figure 2.2).
In order to understand the impacts of the individual components, Figure 2.2 introduces an intermediate step, *moderate shift measures*, between the Baseline and Greening Scenarios. This is shown to lead to an increase in extensively managed grassland (Figure 2.2) in the EU15. This may be explained by a shift from first-pillar payments to agri-environmental measures in the second pillar, in the EU15. In the model calculations this shift was implemented as an increase in the current package of agri-environment schemes, which is more focused on grassland than on arable land.

Moving from the *moderate shift measures* to the Greening Scenario, a pronounced change occurs in the amount of extensively managed arable area (Figure 2.2). This is caused by the assumption of 5% ecological set-aside in the Greening Scenario, a condition for receiving the greening premium for arable farming. Compared with the situation after implementation of the *moderate shift measures*, the amount of (extensively managed) grassland is somewhat lower, despite the greening premium on permanent grassland. This is due to the fact that ecological set-aside leads to increased pressure to produce more food on the remaining arable area, leading to less animal fodder production on arable land, intensification of grassland production and some conversion of grassland into arable land. However, without the premium on permanent grassland, the amount of land conversion would be larger.

Figure 2.2

Changes in agricultural land-use intensity, compared to Baseline Scenario in EU27, 2020



Source: LEI and PBL

The moderate shift measures *are a subset in the Greening Scenario, representing a 5% budgetary shift from the first-pillar to agri-environmental measures in the second pillar, in the EU15, and a 5% shift from the first-pillar of the EU15 (old Member States) to that of the EU12 (new Member States).*

2.2 Species richness

This section reports on the impact of the various CAP measures on biodiversity in agricultural areas. Changes in species richness were modelled using the biodiversity model, based on changes in the pressures of land use, land-use intensity and fragmentation. The indicator was based on coarse, 50 km grid, information on species presence of 145 species (flora and fauna) that depend on agricultural land for their survival. Information regarding the link between pressures and species occurrence, facilitated a downscaling towards a 1 km grid, for species presence maps (see Subsection 1.4.4 for methodological details).

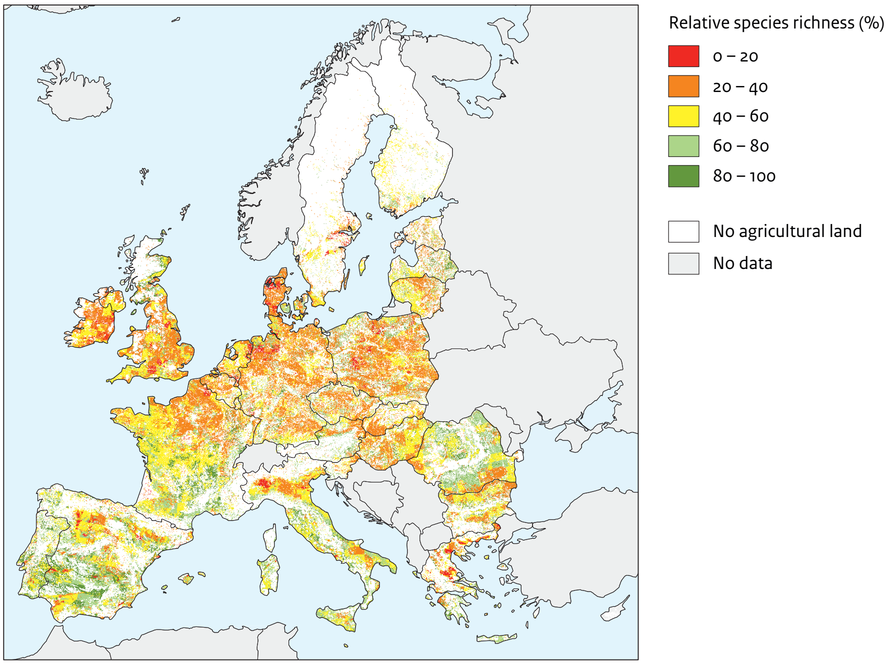
2.2.1 Relative species richness in 2005

Figure 2.3 shows the relative species richness in 2005, which has served as a starting point for our analysis. In 2005, farmland biodiversity was high in Mediterranean regions (Spain, parts of Italy, south-eastern France) and parts of eastern Europe (e.g. Romania, parts of Poland, Bulgaria and the Baltic States). Agricultural intensity (Figure 2.1) was found to be the main pressure determining biodiversity in agro-ecosystems. Figure 2.4 shows a graphic presentation of the averages and ranges of the relative species richness (data taken from Figure 2.3) relative to the land-use types and intensities (data taken from Figure 2.1). The ranges within each type of land use are caused by the spatial variation in potential occurrence of species and their varying reactions to environmental pressures. Extensively managed grasslands had the highest relative species richness, followed by extensively farmed arable lands. Intensively managed grassland had only half the species richness of extensively managed grassland. Moderately and intensively farmed arable land was found to hold about two thirds and one third, respectively, of the biodiversity in extensively farmed arable fields. Striking are the large ranges within each category of arable land, including those with very low species richness.

Explanation of differences

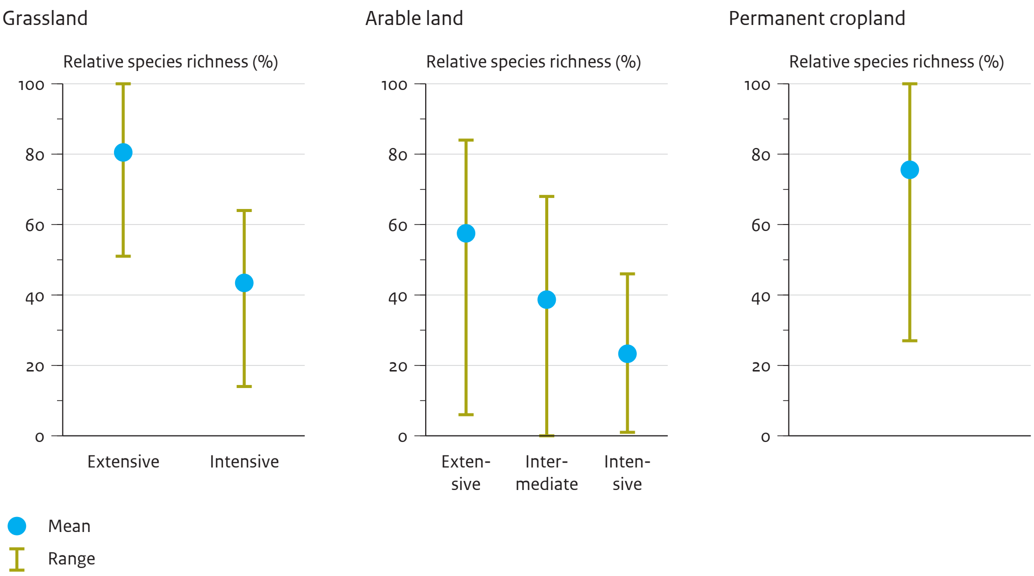
In general, grasslands have a higher biodiversity than arable lands because they suffer fewer disturbances and have a greater habitat diversification. Arable land may be disturbed, for example, by ploughing, planting, harvesting, or the application of pesticides. Grassland may experience trampling by animals and harvesting of grass. However, the pressure of disturbances is less for grassland than for arable land. Grasslands contain more plant species than (mono-cropped) arable fields, thus creating more habitat diversification for animals.

Figure 2.3
Relative species richness in agricultural areas, 2005



Source: PBL

Figure 2.4
Species richness on agricultural land in EU27, 2005



Source: PBL

Table 2.1
Relative species richness, average EU27, 2020

	Baseline Scenario	Moderate shift measures	Greening Scenario
Arable land	39.1	39.7 (+1.4%)	40.3 (+3.1%)
Grassland	66.4	69.3 (+4.4%)	69.0 (+3.9%)
All agricultural land	48.5	49.8 (+2.7%)	50.1 (+3.3%)
... of which High Nature Value farmland	59.1	60.5 (+2.4%)	60.7 (+2.6%)

The *moderate shift measures* is a subset in the Greening Scenario, namely 5% budgetary shift from the first pillar to agri-environmental measures in the second pillar, in the EU15, and 5% shift from the first pillar of the EU15 (old Member States) to that of the EU12 (new Member States)

Following the same line of reasoning intensively managed fields have less biodiversity than those that are extensively managed (both on arable and grassland). Moreover, more nitrogen is applied to intensively managed fields, which often leads to lower species richness, especially for plants.

2.2.2 Average species richness by 2020

EU-wide analysis of the measures
Under the Greening Scenario, the biodiversity indicator has a 3.3% higher value for all agricultural lands (Table 2.1) by 2020, compared with the situation under the Baseline Scenario. Biodiversity gains in grassland areas are greater than increases in biodiversity on arable land. The grassland impact is mainly caused by the agri-environmental measures, as is shown in the column presenting *moderate shift measures* in Table 2.1. Arable lands demonstrate somewhat stronger biodiversity gains under the Greening Scenario, due to the set-aside measure for greening the first pillar, which affects arable land (Table 2.1).

Putting the average result into perspective
The average increase in biodiversity on agricultural land, under the Greening Scenario, is 3.3% (1.6 percentage points) (Table 2.1). For the interpretation of this result, three aspects are of importance:

- Biodiversity trends, putting the biodiversity gains in the context of global and European biodiversity decline. Natural biodiversity is predicted to decline worldwide, from 70% in 2000 to 60% of its natural potential by 2050 (PBL, 2010), with a significant part of this decline attributed to ongoing agricultural expansion and intensification. To date, no data is available on trends in overall change in animal and plant species that are dependent on farmland. Therefore, we used the trend presented in the European Farmland Bird Index (EFBI) – which is well-founded and for which sufficient data were available at the time of publication of this study – as a proxy for the general trend in all farmland-dependent animal and plant species.
  - Historical EFBI trends show a gradual decline. Between the periods of 1991 to 1995 and 2004 to 2008, the EFBI went down by 13% (www.compendiumvoordeleefomgeving.nl). If this decline would also take place in the 2014–2020 period, this would equal a decline of 6.4%. A 3.3% increase under the Greening Scenario (compared with the Baseline Scenario) would mean a (3.3 divided by 6.4 =) 47% reduction in the ongoing loss of farmland biodiversity. However, it should be noted that the EFBI measures the abundance of bird species, whereas the farmland biodiversity indicator used in our study measures species richness of 145 selected animal and plant species. Comparing this indicator against the EFBI data, thus, only gives an indication of the importance of the calculated 3.3% increase, but should not lead to solid conclusions.
  - Some studies report an even more severe decline due to intensive agricultural management. Butler et al. (2010) report that farmland birds have nearly halved since 1980 (see also Vorisek et al., 2010). Butler et al. (2010) predict, under a scenario of continued current land management, that the EFBI will decline from 0.65 in 2005 to 0.50 by 2020. Assuming a linear development this would mean a decline from 0.56 in 2014 (the starting year of the new CAP) to 0.50 by 2020. The starting point of our (aggregated) farmland biodiversity indicator assumes the biodiversity potential for all agricultural areas to be 100%. Table 2.1 shows that the average level of relative species richness is 48.5% of this potential. With the measures in the Greening Scenario a gain of 1.6 percentage points may be achieved. Relative to the potential European decline of 11% (from 0.56 to 0.50), the 3.3% gain in biodiversity (48.5–50.1) would slow down this rate of decline in agricultural areas by about 30% (3.3 divided by 11).

Table 2.2

Biodiversity impacts of individual policy components under the Greening Scenario, compared to the Baseline Scenario

Measures	Effects on biodiversity
A. A 5% budgetary shift from the first pillar of EU15 (old Member States) to that of EU12 (new Member States)	No effect on biodiversity
B. A 5% budgetary shift from the first pillar to agri-environmental measures in the second pillar, within the EU15	Increase in biodiversity in part of the NUTS2 regions of the EU15. More effects in the intensively farmed areas than in the extensively farmed areas
C. Greening the first pillar via a premium on permanent grassland, with an annual maximum of 100 euros per hectare	Positive effect by an increase in grassland area
D Greening the first pillar via a premium with an annual maximum of 100 euros per hectare of arable land, under the condition of 5% ecological set-aside being implemented on this land	Increase in biodiversity in parts of Europe, mainly in intensively farmed areas
E. First-pillar payments for natural constraints at an annual maximum of 150 euros per hectare; this adds to the current less-favoured area payments in the second pillar	Some positive effects from a slight increase in grassland area

- The agricultural area affected by the policy. Large parts of agricultural land will not be affected by the measures in the Greening Scenario. Thus, the average biodiversity increase would be realised by a relatively high biodiversity increase on a relatively small land area. Under this scenario, 3.5% of total arable land would change from being classified as high or intermediately intensively farmed arable land to extensively farmed arable land. Of the grasslands, an additional 6% would be extensively managed. The size of the area that would be affected by the proposed scenarios is relatively small, and in order to have a large effect on biodiversity EU-wide, such changes should be more significant.
- Budget targeted at biodiversity. In order to assess the results from an efficiency perspective it is important to also place them in the perspective of the budget that is spent on biodiversity. Biodiversity is one of many CAP goals and receives only part of the total budget of over 50 billion euros. Under the Greening Scenario, an additional 1.9 billion euros would be spent on agri-environment schemes in the second pillar, on top of the current 2.86 billion euros. Annually, an additional 22.5 billion euros would be shifted within the first pillar towards more targeted measures (set-aside, permanent grassland and compensation for farmers producing in regions with natural constraints) to serve multiple goals. However, all first-pillar payments still would have income support as their main goal.

2.2.3 Analysis of separate policy components

Figure 2.5 presents the Greening Scenario, and includes the combined results of all measures. Figure 2.6 presents the combined results of a 5% shift in first-pillar budget from EU15 to EU12 and a 5% shift from the first-pillar to agri-environmental measures in the second pillar (i.e. the *moderate shift measures*). Figures 2.5 and 2.6 present the effects for arable land, grassland and total agricultural land. In addition to the effects for arable land and grassland, the figure for total agricultural land also includes permanent cropland and uncultivated arable land (i.e. land, not yet turned into scrubland or forest). Table 2.2 summarises the impacts of separate policy measures, elaborated below.

Five per cent budgetary shift from the first pillar of EU15 towards the first pillar of EU12

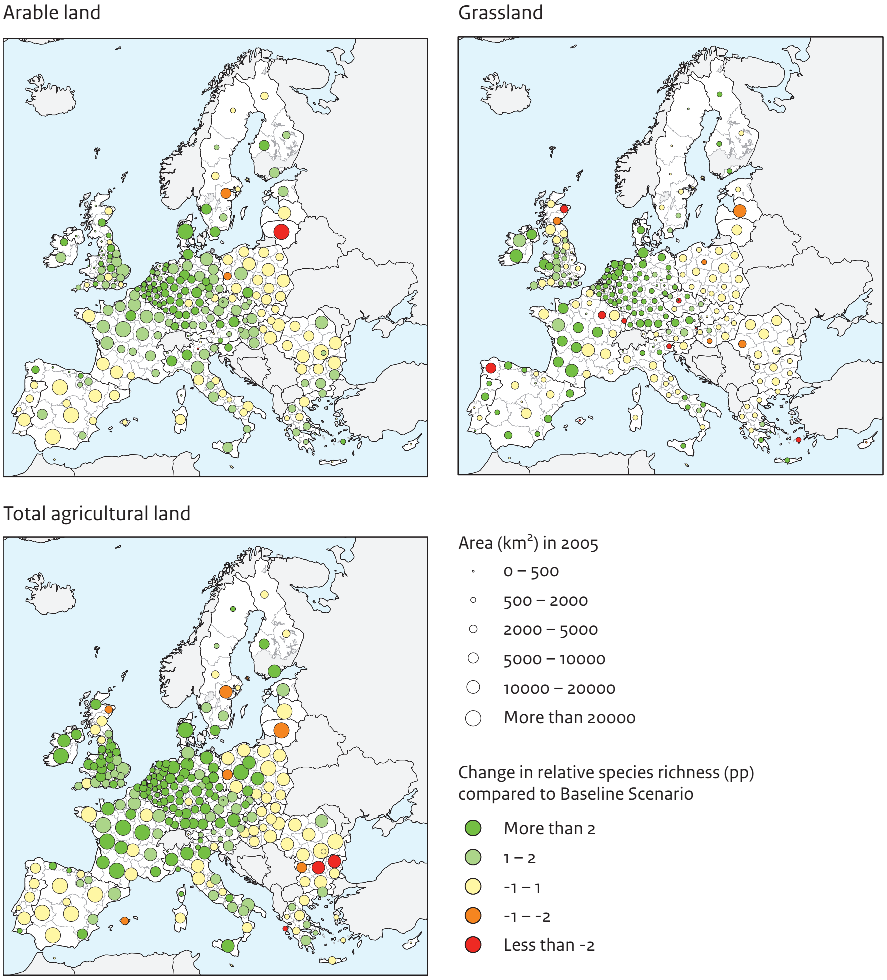
The budgetary shift from EU15 to EU12 will have practically no effect on biodiversity. The production figures in Figure 4.1 show that, effectively, there will be no production effect within the EU27. Helming and Terluin (2011) indicate that the effects on land use also will be very small. As a result, effects of this measure on biodiversity are absent.

Five per cent budgetary shift from the first pillar to agri-environmental measures in the second pillar, within the EU15

The shift from the first pillar to agri-environmental payments in the second pillar, in the EU15, does have an impact on biodiversity. Naturally, in this case, the main impact would be within the EU15. The effects of this measure on arable land would be limited as the division of new agri-environmental payments between farmers with grassland and arable land systems are assumed to remain similar to the current situation, which is dominated by payments for managed grasslands. Consequently, the effect for grasslands would be substantial.

Since measure A (budgetary shift from EU15 to EU12) would not have an effect on biodiversity, the results for

Figure 2.5
Relative species richness on agricultural land, Greening Scenario, 2020

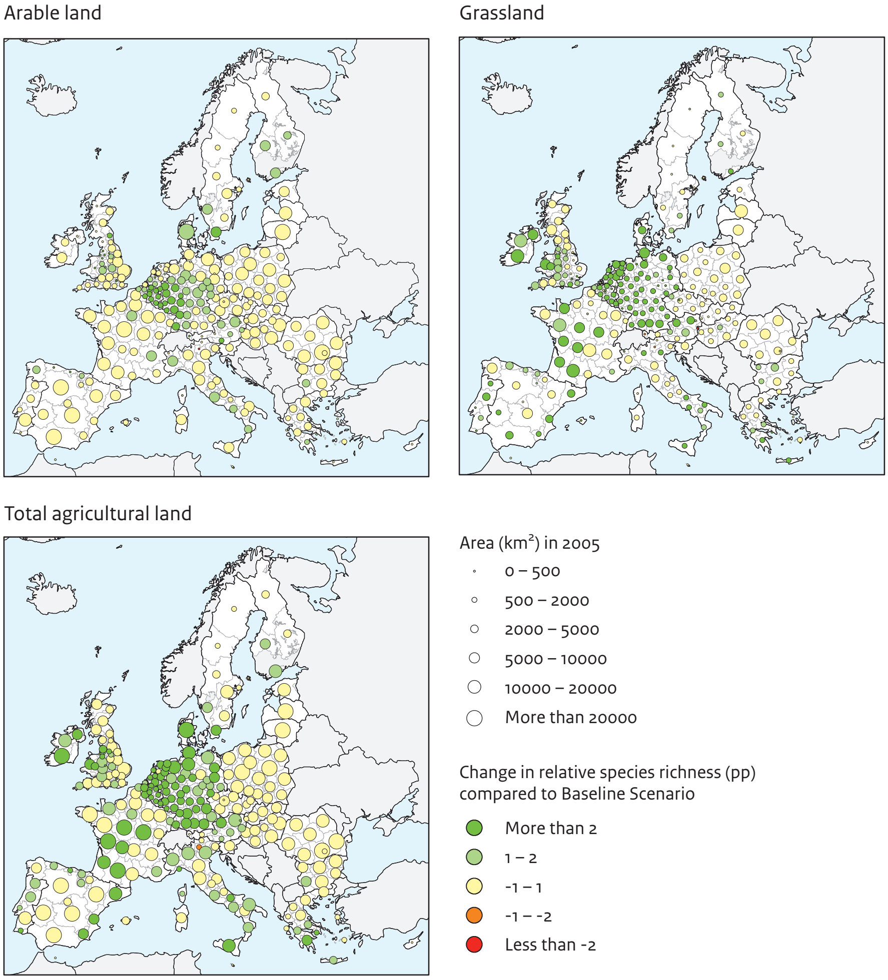


Source: PBL

grassland in Figure 2.6 can be fully attributed to measure B (5% budgetary shift from the first pillar to agri-environmental measures in the second pillar, in EU15). Figure 2.6 shows that, in the EU15, an average increase in species richness of more than two percentage points is reached in 17% and 47% of the NUTS-2 regions for arable lands and grasslands, respectively. In 22% of arable lands and 18% of grasslands in NUTS-2 regions in the EU15, the average species richness would be one to two percentage points higher. The additional area of extensively managed arable land and grassland within the EU27 would be 3.5% and 6%, respectively, compared to the original areas of arable land and grassland (Figure 2.2). This study has not determined if the agri-environmental measures actually would work, as this would depend on their practical implementation (see Section 2.3).

Greening the first pillar via a premium on permanent grassland
The impacts of the premium on permanent grassland cannot straightforwardly be derived from Figure 2.5 or 2.6. However, grass production figures in Section 4.1 do show a difference between the Baseline Scenario and the Greening Scenario for the permanent grassland measure, resulting from changes in the grassland area (and therefore in biodiversity). The positive effect of the premium for permanent grassland, however, would largely be counteracted by pressure from arable land, since arable land also would receive a premium – conditional on 5% set-aside – which increases the incentive to convert grassland into arable land. Thus, the net effect on grassland would be small.
In the modelling, the proportion of permanent grassland relative to total grassland was kept equal to that of the current situation. Premiums were allocated according to

Figure 2.6
Relative species richness on agricultural land, Moderate shift measures, 2020



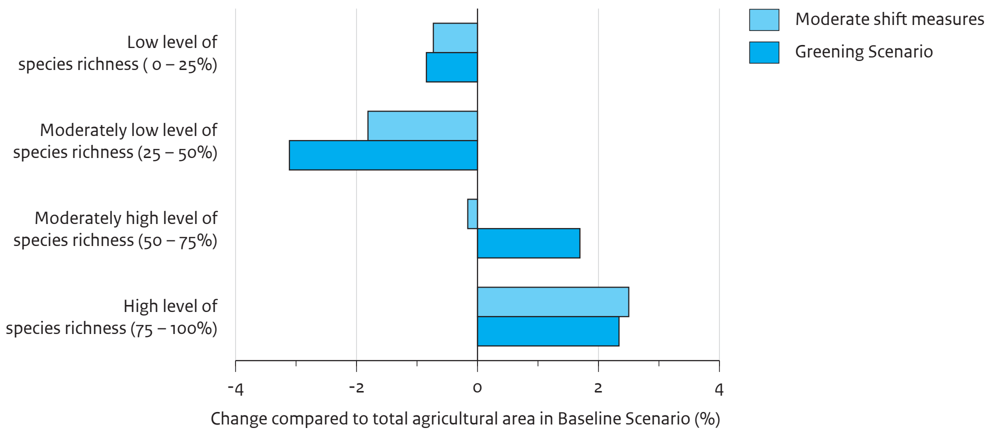
Source: PBL

the current proportion of permanent grassland in each NUTS-2 region. In real-world policy implementation, however, the measure would be farm specific (and not region specific) and proportions may vary. This is actually the purpose of the measure. According to our modelling exercise, the measure would result in more grassland. However, in actual practice, the quality of the grassland also would improve, as permanent grassland has a higher biodiversity value than temporary grassland (see also Section 2.3).

Greening the first pillar conditional on a 5% ecological set-aside on arable land

The upper left picture of Figure 2.5 shows the effect on arable land resulting from the measure of 5% ecological set-aside, and, for some regions in the EU15, from agri-environmental measures (Figure 2.6). Positive effects for biodiversity are mainly observed in intensively farmed areas and hardly in extensively farmed regions (e.g. those in Spain, Poland, Baltic States, Romania), although in the scenario the measure of 5% ecological set-aside was applied in the EU27 as a whole. The reasons for the differences in effects between intensively and extensively farmed areas are twofold. Firstly, because the implementation of 5% ecological set-aside was modelled as making 5% of all arable area extensively farmed, this would not lead to extra extensification in the current extensively farmed areas (although the land management would shift from extensive cropping to no cropping at all). Secondly, in moderately and extensively farmed areas, the ecological set-aside may lead to increased pressure to produce more food on the remaining 95% of the arable land, in order to make up for production losses. This would lead to some conversion of grassland into arable land and

Figure 2.7
Changes in agricultural area per relative species richness level, 2020
Compared to Baseline Scenario in EU27



Source: PBL

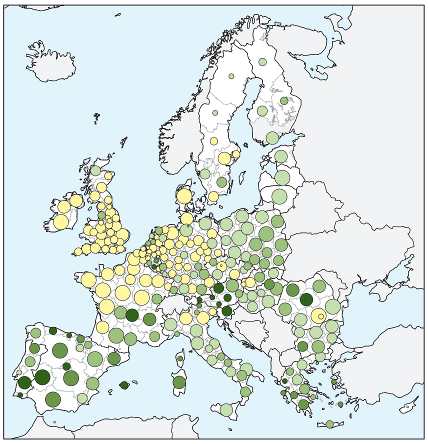
decreased animal fodder production on arable land, thus inducing intensification of grassland production.

First-pillar payments for natural constraints
The shift from a general, regional flat-rate payment towards a specific payment for farmers in areas with natural constraints would mainly benefit grassland farms. So, compared to the situation under the Baseline Scenario, relatively extensively managed grasslands would be kept in production at the expense of arable land. Generally, grassland has higher biodiversity than arable land, so the effect on biodiversity would be positive. Total acreage of grassland in the EU27 would increase by about 1%, while the acreage of arable land would decrease by about 0.8%. However, Figure 4.1 shows that the effects of payment for natural constraints would be small compared to those for agri-environmental measures and the permanent grassland premium.

2.2.4 Changes in agricultural area per level of species richness
Figure 2.7 provides more detail on the increase in species richness. Areas with low (relative) species richness (indicator value 0%–25%), which are mainly intensively farmed arable lands (Figure 2.4), only slightly would be affected by the policy measures of the reformed CAP. The areas with moderately low levels of species richness (25%–50%), which are mainly intensively managed grasslands and moderately intensively farmed arable lands, demonstrate a relatively large decline. These lands would be affected by the new policies and become more extensively managed. The lands with a moderately high species richness classification (50%–75%) show an increase in area under the Greening Scenario – although when *moderate shift measures* are applied this is turned into a slight decrease. The area increase may be explained by the fact that this category mainly consists of extensively farmed arable areas, which would expand by the measure of ecological set-aside. The category with the highest species richness classification (75%–100%) shows a clear increase in area, due to an increase in extensively managed grasslands, as a result of the agri-environmental measures (shift in budget from the first pillar in the EU15 to the second pillar).
Although the total area with low species richness would decrease only slightly, this does not mean that these areas would not benefit from the measures. Intensive and extensive farming practices, in actual practice, occur in mixed forms, at regional or even at farm level. Each individual farm would have its own set-aside, achieving biodiversity impacts at farm level. Also in the intensively farmed arable fields this results in set-aside on field edges with high species richness (category 50%–75%). Although the net area of intensively farmed arable land would be nearly the same, the changes in structure could be an improvement for species richness.

2.2.5 High Nature Value farmland
Certain agricultural areas in Europe are considered more important, with respect to biodiversity conservation, than others. These areas are often referred to as High Nature Value (HNV) farmlands. In this study we used a selection of CORINE land-use classes, NATURA 2000, Important Bird Areas, and Primary Butterfly Areas. The

Figure 2.8
High Nature Value farmlands in agricultural land, 2005



Area agricultural land (km²)
- 0 – 500
- 500 – 2000
- 2000 – 5000
- 5000 – 10000
- 10000 – 20000
- More than 20000

Agricultural land identified as HNV (%)
- 0 – 10
- 10 – 20
- 20 – 30
- 30 – 40
- More than 40

Source: PBL

map with High Nature Value farmlands presents the percentage of the area in a cell that is possibly an area of High Nature Value. Figure 2.8 shows the distribution of High Nature Value farmlands in agricultural areas across NUTS-2 areas.

In general, the areas of High Nature Value have a relative species richness indicator value of over 10 percentage points higher than average (Table 2.1). Under the Greening Scenario the situation in areas of High Nature Value will improve, but the average increase in species richness in all areas together would be higher – implying that measures would be more effective in increasing species richness outside High Nature Value areas. This difference in effectiveness could also be seen in a comparison between the locations with high and low impact on species richness under the Greening Scenario (Figure 2.5) and those of the HNV areas (Figure 2.8): for most High Nature Value areas the smallest impact on species richness is shown. In general, the effects of the Greening Scenario in areas with a high present level of biodiversity seem to be limited. Rewarding farmers in biodiversity-rich areas will not change land-use practices from those in the Baseline Scenario. However, the measures taken under the Greening Scenario may have an impact later on. For example, a region with currently 30% of its farmland being biodiversity-rich, of which one third (10 percentage points) is being protected by CAP measures, could still decline severely, down to as little as 15% by 2020. CAP measures would have no effect within this time span, but may have an effect at a later time, if the decline were to continue.

2.3 Discussion of model results, on the basis of the literature

Apart from the modelling exercise described above, our study also involved a survey of available literature on the effectiveness of agri-environment schemes (AES). The literature was reviewed in order to evaluate the effects of measures included in our modelling analysis, as well as options for improvements. In addition, this section also presents a discussion on measures and pressures (e.g. land abandonment and landscape heterogeneity), not accounted for in our modelling exercise. This section was written around a number of fundamental questions that presented themselves following our modelling exercise, namely:
- Does the literature agree with our analysis of the modelled measures?
- How could the effectiveness of these measures be improved?
- Which other measures could effectively target biodiversity?
- Is it possible to target other environmental goals through biodiversity measures?
- What are the scale and the effect of additional pressures on agricultural biodiversity?

2.3.1 Modelled measures that benefit biodiversity in agricultural areas

Agri-environmental measures

Agri-environment schemes (AES) underline the values of agricultural areas in the EU, also regarding biodiversity, and are unrelated to production. These schemes aim to conserve these values by counteracting the economic incentives that may lead to intensification. Our modelling results demonstrate that increasing the AES funds (5% shift from the first pillar to AES in the second pillar, in the EU15) would benefit biodiversity, in particular, via extensification of grassland. However, other recent evaluations demonstrate mixed results of AES from an ecological perspective (e.g. Kleijn et al., 2006; Whittingham, 2007). As 2.86 billion euros (EC, 2010) of CAP money is being spent on AES, annually, from a total budget of 54 billion euros, there is a strong urge for making measures more (cost) effective. Measures should be sufficiently targeted, with multi-annual contracts implemented where they would be most effective for biodiversity, and with sufficient level of farmer participation. In this way, the CAP could profoundly contribute to the COP10 biodiversity targets to halt biodiversity loss by 2020 and ensure the sustainable management of agricultural areas (CBD, 2010).

Ecological set-aside

The literature (e.g. Kleijn and Baldi, 2005; Van Buskirk and Willi, 2004) agrees with our model findings by demonstrating the generally positive effect of ecological set-aside on agricultural biodiversity. These effects could even be profound when management, often identified as the most influential factor for longer time spans (e.g. (Clevering et al., 2005), is improved through the efficient use of green infrastructure and source populations in hot spots (see Subsection 2.3.4). In addition, biodiversity-rich habitats for relatively rare species could be created (Haveman et al., 2005). It should be noted that any set-aside should not necessarily be left fallow; extensively managed low-input croplands also contribute to biodiversity while limiting production losses. With regard to the measures (Subsection 2.3.3) aimed at increasing biodiversity by improving landscape heterogeneity through green infrastructure, set-aside on strips of land could reduce the external effects of agricultural practices. This could improve the ecological quality of the surrounding landscape. Similarly, when positioned around water bodies, set-aside could contribute to water quality by serving as buffer zones. Finally, although bound to very specific conditions (Van Rijn and Wäckers, 2007), set-aside could provide valuable habitats for pest control species, thereby optimising the provision of this ecosystem service as well as reducing the demand for pesticides.

Permanent pasture

Our modelling results demonstrate that the most significant improvements are to be expected in intensively managed agricultural regions. However, it must be noted that these changes have been described in relative terms and often only concern a small number of species (Overmars et al., 2011). Nevertheless, extensively used grasslands are very important from a biodiversity perspective, and not specifically targeting and preserving these species-rich source areas could threaten their ecological value, in the long term (e.g. Birdlife, 2011; King, 2010). This was found to be particularly relevant in the modelled intensification of such areas following the set-aside measure. CAP support for low-intensity grassland farming – including semi-natural grasslands, which were not included in the EU agricultural survey – seems appropriate here. The effectiveness of such a measure, as well as other proposed greening options for the first pillar, will be improved when tied to the more stringent objectives that are characteristic for the current set-up of the second pillar. Furthermore, closer integration of various policy components should counteract undesired incentives in the current situation. Examples are the removal of landscape elements in order to 'avoid the encroachment of unwanted vegetation', in line with the GAEC protocol on the removal of trees and shrubs from wooded grassland in order for farmers to become eligible for direct payments.

Natural constraints

The impacts of payments for natural constraints on farmland biodiversity would be small, according to the model calculations. However, the indicator refers to the average quality of the agricultural land, and not to the amount of agricultural land. In this study, the total amount of agricultural area remains more or less the same under the Greening Scenario (Section 2.1), although certain regions may experience land shifting away from agricultural production. This regional detail was not captured adequately in our modelling. Therefore, the following subsection contains an elaboration on land abandonment, on the basis of literature.

2.3.2 Land abandonment

Uncertainties about the scale of land abandonment

There is a large degree of uncertainty involved in estimating recent abandonment as well as predicting future trends within the EU. Time series are rare and often include the 1990–2000 time frame – a period that is unrepresentative for the average situation, due to the large degree of socio-economic change in eastern Europe following the collapse of the Warsaw Pact (EEA, 2006). Modelled estimates, which are linked to a set of possible future socio-economic developments, show variable outcomes. For instance, the EURURALIS 2.0 results (Verburg et al., 2009) demonstrate a bandwidth from 2.2% to 6.7% of abandonment of the total land area by 2030, depending on the applied socio-economic scenario. Land abandonment is highly difficult to predict and depends on a large number of uncertain and complex interactions between changing economical, social and environmental factors, resulting in economic marginalisation. And although marginal land that is at risk of abandonment is mostly found in extensively managed less-favoured areas, the earlier stated factors could also render highly productive areas marginal (Strijker, 2005). In addition, a future CAP with a stronger greening component could provide a stronger incentive to keep marginal lands in production, as well as take up agri-environment schemes (AES) in extensively managed marginal areas, often species-rich HNV farmland, thereby potentially offering a viable economic alternative and preventing land abandonment.

Impacts of land abandonment on biodiversity
Notwithstanding the uncertainties about the scale and effect of land abandonment, negative effects on biodiversity have been demonstrated and appear to be particularly significant for semi-natural grasslands, which are only partly included in the agricultural land count. Often, these ecosystems have been subjected to extensive agricultural management for centuries; they harbour a set of well-adapted species that depend on these agricultural practices. Land abandonment in formerly arable lands could benefit biodiversity through improvements in soil and water quality, as management-related disturbances and the application of external inputs cease (Expertisecentrum LNV, 2004). The effects of abandonment differ over time and can roughly be divided into three stages. The first stage is characterised by the accumulation of litter. The second by the gradual invasion of tall herbs and woody scrubs, heralding the start of structural change of the grassland habitat and leading to a loss of agricultural biodiversity. The third and final stage involves the development of woodland and the gradual closure of a forest canopy, leading to the demise of most remaining grassland pockets. In addition, the effects of abandonment also differ in pace and mainly depend on climatic variables. The pace of structural change is markedly slower in Mediterranean, steppe and mountainous habitats. It should be stressed that land abandonment does not necessarily lead to a decrease in species richness, but could also result in a transition towards equal levels or even richer natural biodiversity. When awarding priority to restoration of abandoned land, the degree of abandonment should be a decisive criterion, as both structurally intact areas and the presence of seed banks greatly facilitate recovery. The number of similar habitats with source populations could also influence the rate and degree of success. As demonstrated before, the degree of abandonment is characterised by the increase in total biomass due to the invasion of tall herbs and woody plants (Grime, 1979). Consequently, the total amount of biomass, which can be determined with remote sensing techniques, could serve as a tool to prioritise specific areas.

2.3.3 Other measures that could benefit biodiversity in agricultural areas

Scale dependency of measures and heterogeneity
Our biodiversity analysis focused on the effects of measures implemented at field level on land-use change with a relatively coarse (1 x 1 km) resolution. However, in assessing biodiversity, multiple spatial levels play a role, for example, those of farm, field and landscape. All levels should be assessed in order to increase the effectiveness of biodiversity measures. Scale-specific variables have a strong influence on the response of species to agri-environment schemes (AES), as landscape heterogeneity is a strong driver of biodiversity change (Simpson, 1949); according to some studies, the effect is even stronger than from the use of fertilisers or pesticides (Freemark and Kirk, 2001). Consequently, results on one level cannot directly infer developments on other levels. The underlying hypothesis states that increasing the heterogeneity of a specific landscape will promote the availability of habitats for more species (Söderström and Pärt, 1999). This applies not only to uncropped areas, but also to those croplands that involve measures such as crop rotation and the application of cover crops. Additionally, species richness of specific taxa is often related to total species richness (Duelli and Obrist, 1998). Consequently, the creation of a plethora of habitats at multiple scales could overcome the obstacles posed by species specific responses to heterogeneity and implicitly call for more generalist measures. Measures targeted at one species could even provoke a negative response in others by depriving them of resources (Olson and Wäckers, 2007). It is important to note that heterogeneity not only concerns spatial, but also temporal variation, the latter being determined by harvesting regimes and acts as a buffer for the former (Benton et al., 2003).

Green infrastructure
As stated before, most current agri-environment schemes (AES) are focused on field level, and our modelling exercise also evaluated the effect of measures on this scale. However, measures aimed at landscape level seem to be particularly beneficial to biodiversity through the expansion of home ranges by means of migration routes through (semi-natural) habitats. As a result, source populations, for example, in High Nature Value (HNV) farmland may be tapped and disperse into more isolated patches of agricultural land included in an agri-environment scheme. Consequently, the favourable conditions created by these schemes could be optimally used as species-rich areas that form ecological steppingstones (Sutherland, 2004). Species would be able

TWO

to recolonise agricultural land much faster following disturbances inherent to agricultural practices, due to connections with regional species pools, increasing the resilience of the system. Specific measures to increase landscape heterogeneity could involve the creation of semi-natural habitats, such as hedgerows or woodlands. Such keystone structures (Tews et al., 2004) could benefit multiple species (groups) and can be identified by correlating landscape variables with biodiversity patterns. Such rather generalist measures are relatively easy to implement, have relatively small effects on the productivity of agricultural land (Tscharntke et al., 2005) and could increase the effectiveness of agri-environment schemes. Furthermore, these measures could be tailored to specific areas and could also benefit appearance, identity and recreational potential by restoring original landscape characteristics. In addition, these measures on landscape level could also improve ecosystem functioning, reflected by an improvement in the provision of ecosystem and/or environmental services (Bengtsson et al., 2003). Subsection 2.3.5 presents the potential of these and other benefits.

Restrictions and limitations regarding the relation between biodiversity and heterogeneity

Naturally, there are limits and restrictions to the positive impact of increasing landscape heterogeneity on biodiversity. First of all, the relation between heterogeneity and biodiversity is not necessarily correlated between species groups (Billeter et al., 2008). The generalist measures, suggested earlier, will not suffice for some, often extremely specialised species. Consequently, these species may still require very specific measures (Jeanneret et al., 2003) and are therefore unlikely to expand their territory into adjacent areas. Moreover, the relation between heterogeneity and biodiversity is by no means linear or predictable, as underlined by a number of studies (e.g. Roschewitz et al., 2005) and appears to level off when a certain level of biodiversity is reached. One of the explanations would be that, at that point, most species would be either present and/or able to migrate into an area.

Crop rotation and green cover

Both crop rotation and green cover were excluded from our biodiversity analysis, because of limitations of the applied set of model instruments. These measures, however, could benefit biodiversity in agricultural areas, in a number of ways. Planting multiple crops increases field heterogeneity and, therefore, biodiversity (e.g. Benton et al., 2003) as described earlier in this subsection. In addition, wider crop rotations could improve the degree of pest control (e.g. Gabriel et al., 2010). Furthermore, the presence of multiple crops could counteract the current trend of regional specialisation, potentially improving food security by limiting the scale and risk of disease outbreaks as described in Subsection 2.3.5. Green cover or cover crops influence a comprehensive set of agro-ecosystem processes (Altieri, 1999), such as fixation of nitrogen and the addition of organic material, greatly facilitating soil biota diversity. Also, seed-producing cover crops could increase food availability for birds in winter.

Payments to small farms

Extra payments to small farms were also excluded from the calculation. These payments may have an indirect, positive effect on biodiversity. For example, small farms normally have smaller land parcels and thus more field edges, which are relatively species-rich. The opposite, however, is not necessarily true: large farms with high levels of biodiversity do exist and do participate in agri-environment schemes.

2.3.4 Evaluation of agri-environment schemes

Thorough evaluation of agri-environment schemes is lacking

As already stated in the introduction to this section, there is a strong urge for a more cost-effective approach to agri-environment schemes (AES) and cross-compliance measures, as current schemes generally have not been successful from an ecological perspective. Our review of available literature identified both the lack of evaluation and clear, realistic targets for farmers to be major obstacles to future improvements. Currently, success often seems to be defined by the number of participants or euros spent on schemes, instead of by meeting targets. Evaluations, generally, are hampered by a number of factors, most importantly by a lack of a standardised approach or protocol for monitoring, something that hinders the comparison of results (e.g. Kleijn and Sutherland, 2003). Furthermore, multiple biodiversity indicators are used, relatively short time horizons do not account for lagged responses and may induct stochasticity, differences in extraneous conditions, such as soil or hydrology, are not always considered, and information regarding the baseline situation at the start of schemes is often lacking. Moreover, some reviews demonstrated that evaluation results were often not underpinned by robust statistics (e.g. Kleijn and Sutherland, 2003). Available literature presented a number of interesting solutions to overcoming the earlier described challenges. Simoncini (2009), for instance, proposed setting an Environmental Minimum Requirement (EMR) that describes the minimum requirement for an agricultural ecosystem to be still able to deliver environmental services, such as biodiversity. In order to explain differences between the EMR and actual state of a system, dominant pressures need to be identified. Such an analysis was also applied in our biodiversity analysis (Section 2.2) and facilitated the implementation of targeted measures that address the most dominant pressures and, therefore, would be more likely to succeed in achieving policy targets. The concept of setting minimal requirements for the provision of ecosystem services, such as biodiversity, could be integrated into the GAEC (Good Agricultural and Environmental Conditions) framework as a compulsory standard.

Resilient ecosystems and functional diversity

Considering biodiversity as one of many environmental goals, as well as focusing on relatively generalist measures targeted at multiple species, requires a species-based biodiversity indicator, for a number of reasons. First of all, as already explicated, responses to measures are not always correlated between different taxa (Billeter et al., 2008), making it hard to find a representative indicator for multiple localities. Second, the use of one or a small set of species as an indicator could result in measures that provoke negative responses in others (e.g. Olson and Wäckers, 2007; Tews et al., 2004). Finally, in order to secure the efficient provision of ecosystem services, it is important to consider the various niches that species occupy and the different traits that they possess. When it comes to resilient ecosystems and functional diversity, all species matter. A species that might seem redundant now, might become an *insurance species* (Batary et al., 2010) when others in the same niche, providing the same ecosystem service, decline due to disturbances. Subsection 2.3.5 further elaborates on this theme.

2.3.5 Synergies between biodiversity objectives and other goals

Multiple goals lead to efficient use of rural development budget of the CAP

CAP reforms (EC, 2010) foresee an increased emphasis on the provision of environmental services in the rural development budget. These include, for instance, food protection through pest control, carbon sequestration in soil and biomass, planting of cover crops to manage soil quality, as well as water management by helophyte filters. These services often make significant contribution, as is expressed in research results indicating that soil organisms mineralise 50% of nitrogen (Robertson and Swinton, 2005) in intensified agricultural areas. As briefly discussed in earlier sections, agri-environment schemes could also contribute to the provision of environmental services, as these services also benefit from extensive, low-input agricultural practice. By looking for synergies with other environmental goals, the estimated 20% to 33% of total CAP budget required to meet biodiversity targets (ENCA, 2010) could be spent more efficiently and be mobilised more easily.

Synergies between biodiversity and ecosystem services through functional diversity

As stated earlier, measures aimed at raising biodiversity levels by increasing landscape heterogeneity, also benefit ecosystem functioning, and thus the provision of other environmental services. As these measures are rather generalist and target all species, they could increase the number of species providing a specific environmental service, ergo increase functional diversity, contributing to the higher ecological insurance value (Batary et al., 2010) of agricultural ecosystems. Higher functional diversity will increase the probability of a specific ecosystem service being continued after disturbances to the ecosystem. Furthermore, a greater number of species associated with a specific function could increase its effectiveness and impact through complementarity. Although not all species are associated with the provision of environmental services at a given time, apparently 'redundant' species could become insurance species for the future, due to the consequence of major perturbations such as climate change. Tscharntke et al. (2005) indicate that between 30% and 50% of these species are rare and therefore vulnerable. Consequently, the preservation of (functional) diversity in agricultural ecosystems is vital to both ecological and economic sustainability.

Synergies between biodiversity measures and the viability of rural areas

Apart from environmental services, the proposed biodiversity measures could also contribute to the survival of vital rural areas, as well as to food security and quality. In this respect, 'realistic' pricing of agricultural products, accounting for the costs of negative environmental effects associated with intensive agricultural practices, is an option. Farmers, however, should also be rewarded for providing non-food commodities such as environmental or recreational services to society, instead of being compensated for the loss of yield or revenue. The net worth of such commodities may sometimes exceed that of agricultural output, as demonstrated by the impact of the foot-and-mouth epidemic of 2001 in England (e.g. Sharpley et al., 2001). Consequently, CAP payments should not only be based on historical land use, but also on the potential and actual provision of non-food commodities by agricultural ecosystems. The integrated countryside concept (e.g. Whittingham, 2007) provides an interesting model, integrating agricultural extensification, the provision of environmental services and the secure supply of qualitative food. Local markets could be created for extensively produced food, as farmers are no longer able to compete on the global market. Food security could be benefited through earlier posed measures, such as multi-cropping as well as shorter transportation links, thus containing the risk of large-scale spread of disease. In addition, transportation costs and carbon emissions could also be substantially reduced (Stephens et al., 2003), mitigating the effects of climate change. The integrated countryside concept is an interesting example that illustrates how extensification associated with biodiversity measures could benefit the socio-economic context of the European countryside. However, there obviously is a limit to the substitutability between food production and other goals in agricultural landscapes as global demand is expected to double before 2050 (e.g. Green et al., 2005).

THREE

Impacts on greenhouse gas emissions

The EU has agreed on a reduction in total greenhouse gas emissions of at least 20% by 2020, compared to 1990 emission levels. This reduction is to be partially achieved through the EU Emission Trading System. For sectors not included in this system, such as agriculture, national emission targets have been set. CAP measures could help Member States to achieve their national targets, thus contributing to the overall EU target. This chapter depicts the results from the Greening Scenario regarding carbon dioxide emissions from agricultural soils under the influence of land-use changes (Section 3.1) and from changes in agricultural activities, such as animal husbandry and fertilisation (Section 3.2).

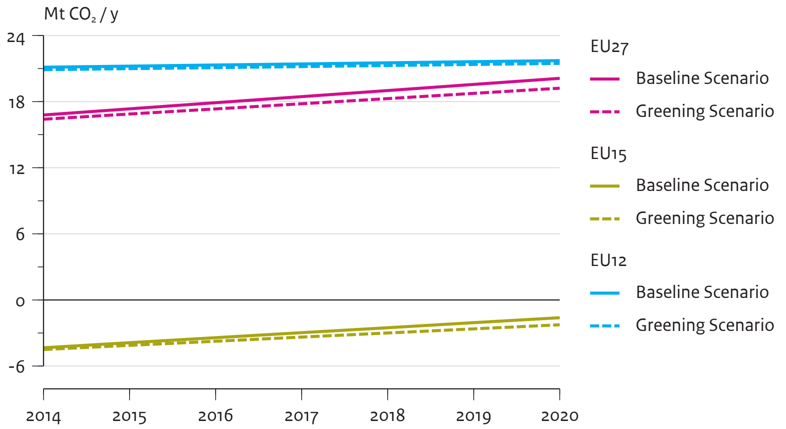
3.1 Carbon dioxide emissions from agricultural soils

Figure 3.1 shows the projected emission of carbon dioxide from agricultural lands (arable land, grassland, permanent cropland), under the Baseline Scenario and the Greening Scenario, between 2014 and 2020. On average, EU agricultural soils emit carbon. However, within the EU15 carbon is sequestered from agricultural land, while from the EU12 there is a net emission of carbon. This is because arable lands dominate agriculture in the new Member States, while in the old Member States there is relatively more grassland. Grasslands have a large input of organic matter in the soil and the level of disturbance from soil cultivation is much lower, resulting mostly in net carbon uptake.

Under the Baseline Scenario, arable land area will increase and permanent croplands and grasslands will decrease. These changes are driven by a larger, global demand for food, which influences food and feed production. As arable lands generally emit carbon while grasslands and permanent croplands sequester carbon, the land-use changes in this scenario would lead to an increase in emissions from the EU as a whole. The trends of increasing carbon emissions and decreasing sequestration are shown for both old and new Member States.

Under the Greening Scenario, the decrease in grassland area in the 2014–2020 period will be slightly smaller than under the Baseline Scenario (2.5% versus 3.1%), and the increase in arable land area slightly larger. The change in carbon flux, over time, would consequently be smaller under the Greening Scenario. For 2020, the difference with the Baseline Scenario is 3%. Under the Greening Scenario, an additional amount of 0.5 to 1.0 Mt CO_2/yr would be sequestered. As the measures in this scenario hardly would affect the areas of grassland and arable land, but mainly would influence land-use intensities, the impact on the carbon budget would be small. However, a decrease in land-use intensities may indirectly have a twofold effect on the carbon budget. A decrease in the level of disturbance would cause less carbon loss, and lower fertiliser inputs may cause a decrease in carbon

Figure 3.1
CO_2 emissions from agricultural soils



Source: PBL

sequestration (but also higher emissions of N_2O, see Section 3.2). The effects of land-use intensity currently are not included in the carbon budget model.

3.2 Emissions from agricultural practices

Emission sources and measures
Emissions of greenhouse gases from on-farm activities originate from various sources. Carbon dioxide emissions come from the use of fossil energy, such as tractor fuel and heating (stables, greenhouses). Net emissions could be lowered by an increase in efficiency and the use of renewable energy. Methane is emitted by ruminants, as a result of enteric fermentation (digestion of feed and fodder). Methane and nitrous oxide are released also from stored manure. Nitrous oxide emissions are largely linked to the application of inorganic fertiliser and manures. Emissions of methane and nitrous oxide from the agricultural sector in the EU27, amount 187 Mt CO_2 equivalents and 256 Mt CO_2 equivalents, respectively (EEA, 2009). Methane and nitrous oxide are process emissions, strongly linked to the size of the agricultural production. In contrast to CO_2 from fossil fuels, these emissions cannot be reduced to zero. However, some reduction is possible through manure management, more timely and efficient use of fertilisers, the modification of feeding strategies, and changes to the management of water, nutrients and tillage. Currently, stimulation of climate mitigation measures by the CAP is limited to cross compliance, by introducing compliance with the Nitrates Directive as a statutory management requirement (legislative act). Limits to the amounts of animal manure and fertiliser applied to land not only would prevent increases in nitrate leaching, but also as a side-effect limit the emission of nitrous oxide. Other farm measures to reduce greenhouse gas emissions would mainly be taken on a voluntary basis.

Emission reduction under the Greening Scenario
The scenario calculations show a small decline in N_2O and CH_4 emissions. CO_2 emissions were not included as the proposed CAP measures not specifically target at reducing fossil energy use. The results shown in Table 3.1 are related to difference in emissions from the extensification of farming under the Greening Scenario, compared with those in the Baseline Scenario. Emission reductions are linked with a decrease of number of animals and animal production (e.g. -0.2% milk and -0.5% beef) and to a large extent to the reduction of mineral fertiliser use with 4.5% in the Greening Scenario. The sharp decrease is explained by the ecological set-aside obligation on arable land.

Putting results into perspective
Currently, EU agriculture contributes about 11% to EU greenhouse emissions, mainly linked with livestock production. According to calculations made with the Miterra model, the total in greenhouse gas emissions attributed to European agriculture, in 2005, was 616 Mt CO_2 equivalents (Lesschen et al., 2009; Oenema et al., 2007; Velthof et al., 2009). In 2007, the total of greenhouse gas emissions in the EU27 amounted to 5,360

Table 3.1

Changes in CH_4 and N_2O emissions from agricultural practices, in the Greening Scenario, compared with those in the Baseline Scenario, expressed in percentages

	EU27	EU15	EU12
CH_4	-0.9	-1.0	-0.5
N_2O	-2.0	-2.2	-1.3
Total CO_2 equivalents	-1.6	-1.7	-1.1

Source: LEI

Mt CO_2 equivalents, including emissions from international aviation and shipping, but excluding net CO_2 removals from land use, land-use change and forestry (EEA, 2009). Roughly speaking, the Greening Scenario would reduce emissions by (-1.1%*616 =) 7 Mt CO_2 equivalents, which equals 0.1% of total EU emissions. It should be noted that this slight decrease would be combined with a slight increase in imports, which in turn would lead to increased production and greenhouse gas emissions elsewhere. This effect was not calculated in this study, but the net result probably would show that global emission changes will be close to zero.

Added value of CAP options

More marked emission reductions would be possible with the use of more technology (while maintaining production levels), such as manure management, more timely and efficient use of fertilisers, and the modification of livestock feeding strategies. The way forward is to improve farm management, using nutrient, soil and overall farm environment management plans. Furthermore, efficiency may be improved by imposing strict policy standards on manure and fertiliser use, such as those in the Nitrates Directive and Water Framework Directive. Finally, changes in consumer behaviour towards less consumption of animal products would be helpful, as livestock products contribute substantially to greenhouse gas emissions. Thus, voluntary measures, regulations and consumption changes form the backbone of a greenhouse policy for the agricultural sector. How much CAP options, specifically targeted at stimulating these voluntary measures, would contribute to combatting greenhouse gas emissions from agriculture, is uncertain.

Impacts on production, prices and income

The Greening Scenario would not only have impacts on biodiversity (Chapter 2) and greenhouse gases (Chapter 3), but also would affect socio-economic parameters and food production within the EU. This chapter presents results from the calculations with the CAPRI model (Subsection 1.4.1). Section 4.1 first provides the implications of greening the CAP with regard to food production. Section 4.2 shows the socio-economic impacts on prices and farm incomes and in developing countries. More information on socio-economic impacts is available from the study by Helming and Terluin (2011).

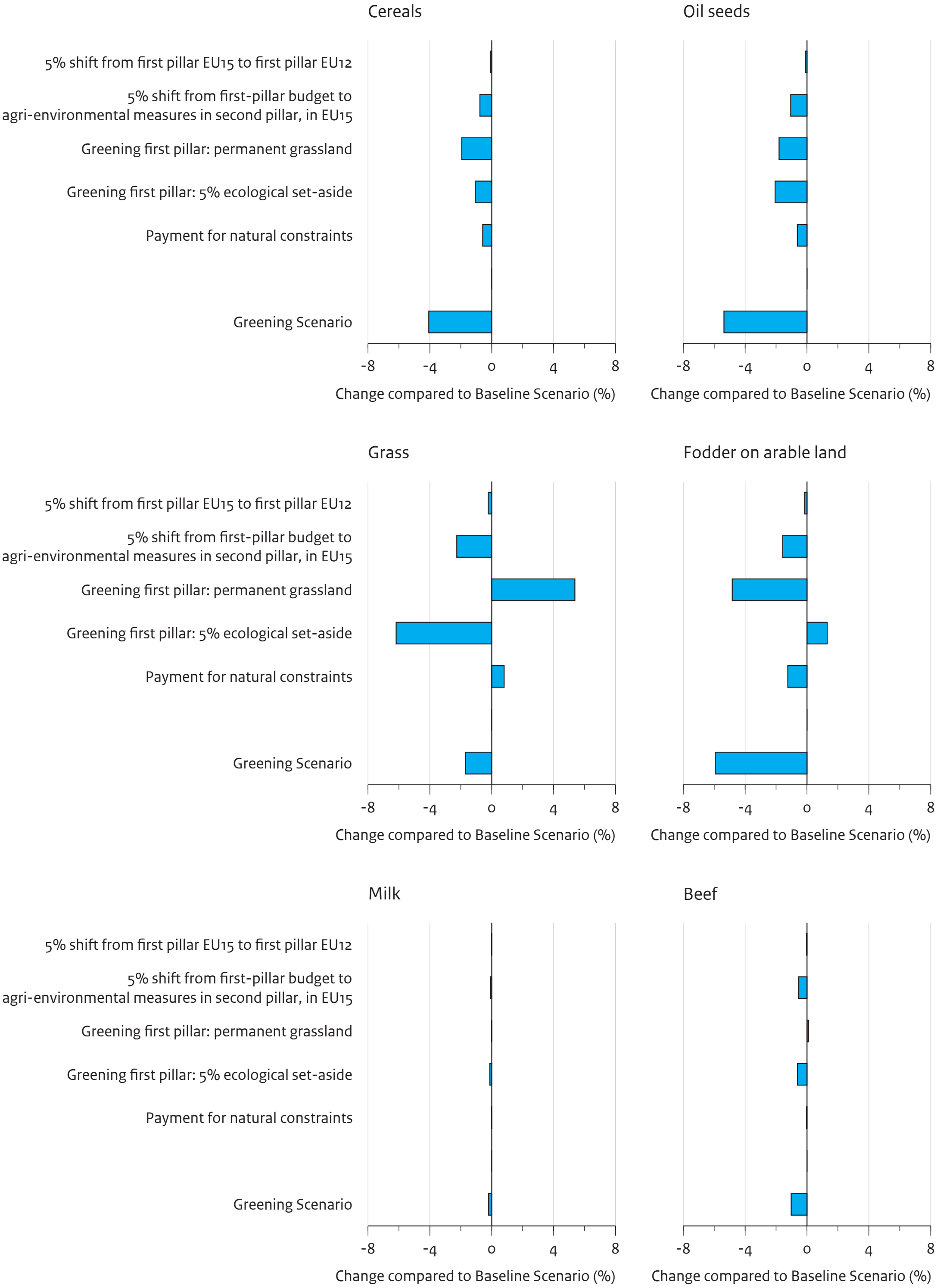
4.1 Agricultural production

4.1.1 Impacts on production from the policy components

Impacts on production range from -0.2% for milk to -5% for oil seeds. We unravelled the impacts of the Greening Scenario on production, by calculating the impacts of the individual components. These impacts (Figure 4.1) can be explained as follows:

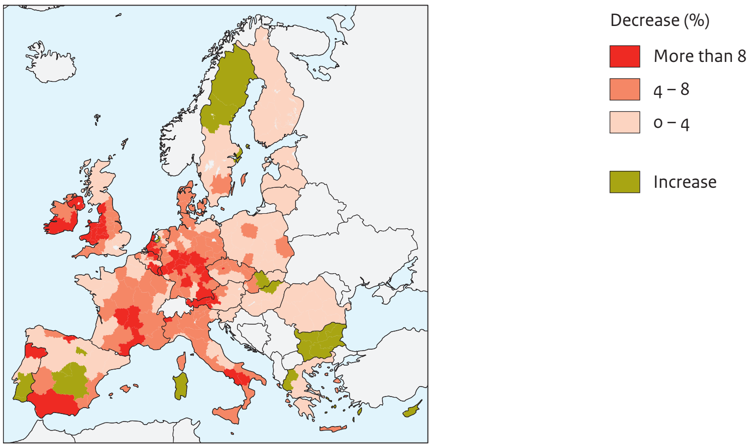
- A transfer of 5% of the first-pillar budget from the old Member States (EU15) to the new Member States (EU12) would not have significant impact on agricultural production, because farm payments are decoupled from production.
- A 5% shift of the first-pillar budget in the EU15 towards payments for agri-environmental measures in the second pillar, would lead to an expansion of agricultural land under agri-environment schemes. As these schemes mostly concern grasslands, the main effect would be a 3% reduction in grass production in the EU15 (Helming and Terluin, 2011), because of extensification of grass production (see also Section 4.1). Impacts would be somewhat counteracted by more intensive use of other agricultural lands and production increases within the EU12.
- Greening of the first pillar by awarding premiums for permanent grassland would create a significant increase in the acreage of grassland, at the expense of croplands (including those used in fodder production). Grass and beef production would go up, while the production of cereals, oil seeds and fodder on arable land would go down.
- The impact of an arable premium conditional on 5% ecological set-aside would have the opposite effect: grass production would strongly decrease, which a predominant effect on beef production. As in this measure 5% of the arable land is left fallow, also the production of arable products would decrease. However, arable production would go down by less than 5%, as arable land use increases at the expense of grassland area.
- The payment for natural constraints may be considered a shift from (part of the) first-pillar budget towards specific first-pillar payments to farmers in less favoured areas (areas that – in this study – are used as a proxy for areas with natural constraints). These payments would mainly be received by grassland farmers (extensive animal husbandry), leading to a slight shift from arable and fallow land to extensively managed grassland.

Figure 4.1
Effects on agricultural production, compared to Baseline Scenario in EU27, 2020



Source: LEI

Figure 4.2
Changes in cereal production EU27, Greening Scenario, 2020



Source: LEI and PBL

4.1.2 Balance between arable land and grassland production

The impact of the Greening Scenario is complex because of contradictory impacts from the single components. On balance, reductions in arable production would be more severe (about -4% in cereal) than in grass (-2%). Grass production would have a slight comparative advantage over arable production, compared with the Baseline Scenario. It would be easier for farmers to qualify for first-pillar greening payments for grassland than to obtain first-pillar premium payments for arable land, because of the precondition of a 5% ecological set-aside that is related to the latter. Furthermore, payments for agri-environment schemes and natural constraints mainly would be awarded to grassland farmers.

4.1.3 Regional differences

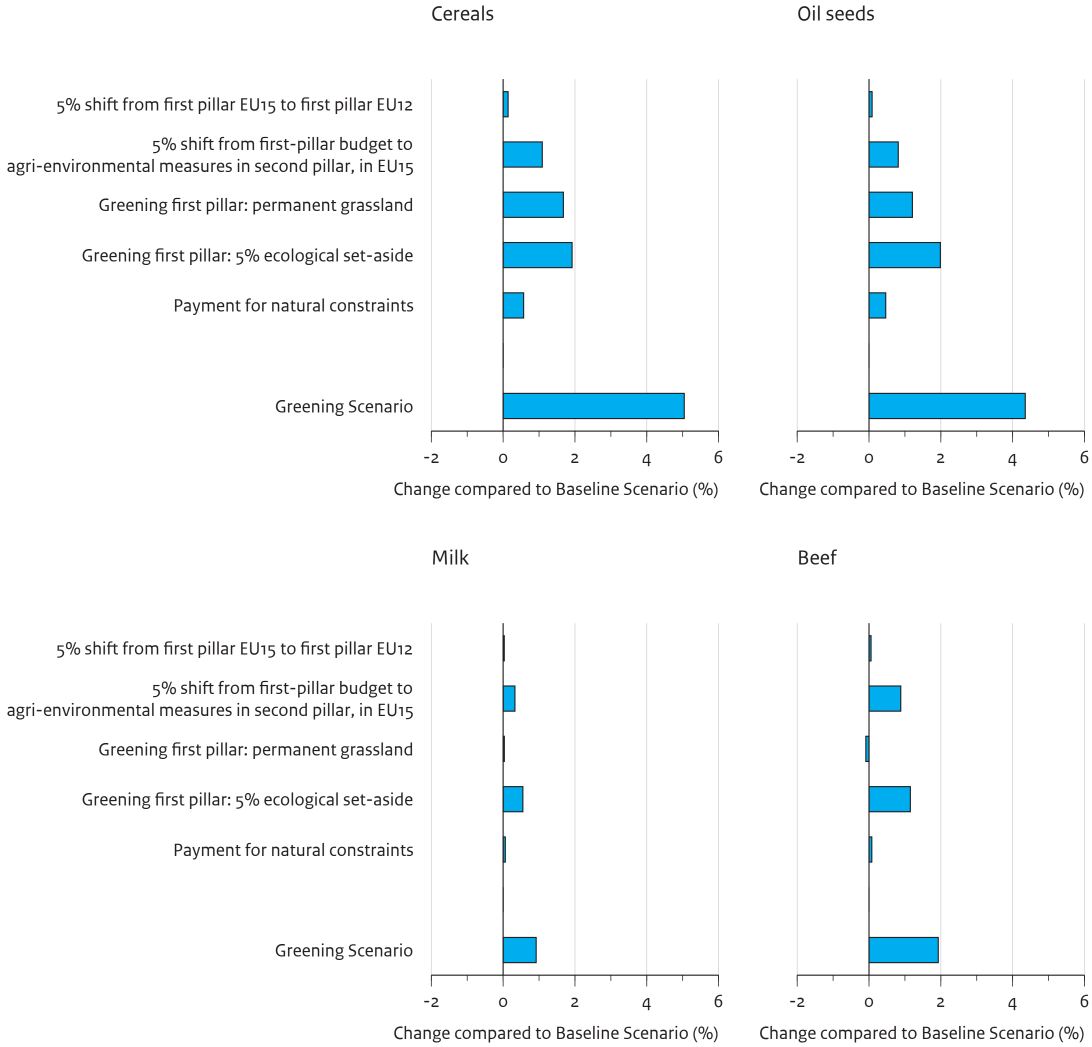
Cereal production in the EU27 would decline by 4%, which would be a direct consequence of the 5% ecological set-aside under the Greening Scenario. Regional impacts would be significant, as is shown in Figure 4.2. The image is rather scattered, as in each region the equilibrium between the various payments (see above) would be different. Generally speaking, cereal production in the EU15 would decrease more than in the EU12. Differences mainly would be driven by the 5% shift of the EU15 first-pillar budget to agri-environmental measures in the second pillar; for the EU12 no shift was included in the scenarios. Furthermore, expansion (compared with the situation in the Baseline Scenario) of ecological set-aside and grassland in the EU12 partly would use land currently fallow, and therefore would not occur at the expense of arable production.

4.2 Farm incomes

4.2.1 Producer prices

Lower production, in principle, would lead to lower farm income. However, this would be counteracted by price increases. Price increases, under the Greening Scenario, would range from 1% (milk) to 5% (cereals). Figure 4.3 shows that the most important price increasing factors would be the greening first-pillar payments. Premiums for permanent grassland as well as ecological set-aside on arable land would lead to lower arable production (Section 4.1). This, in turn, would lead to higher prices of cereals, oil seeds and other arable products, although the effect would be partly counteracted by intensification of grassland production, to compensate for less fodder production on arable land, and decreased exports and/or increased imports (Table 2.2). Greening payments also would reduce the supply of arable crops for the production of pig and chicken feed. As a result, prices of pork and poultry meat would increase by about 2%, according to the CAPRI calculations.

Figure 4.3
Changes in producer prices of agricultural products, compared to Baseline Scenario in EU27, 2020



Source: LEI

4.2.2 Farm incomes

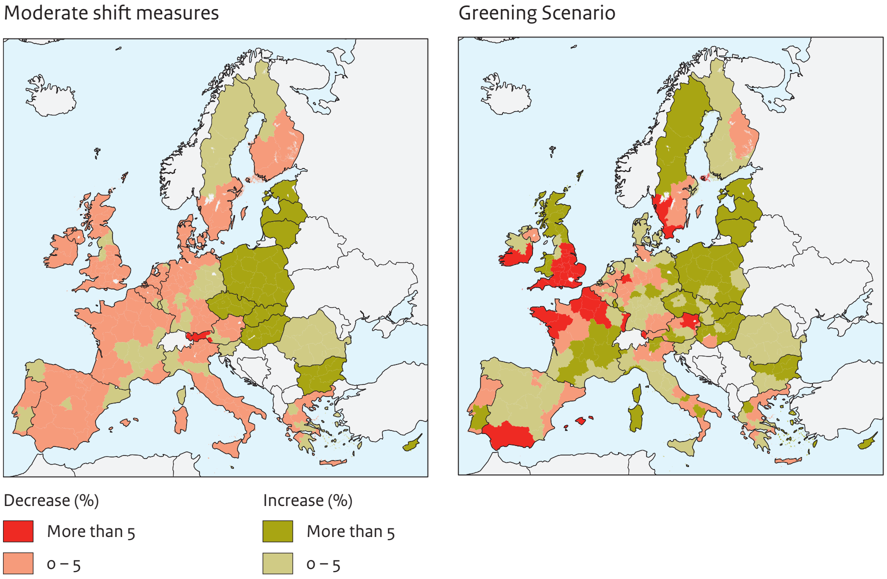
Average impact

Average impacts on agricultural incomes would be remarkably limited. Reductions in yields as a consequence of greening measures would lead to lower incomes, but the subsequent increase in prices would more than counteract this effect. On average, a small 2% increase is shown. However, this result should be viewed with caution, as interaction with world markets could diminish EU price increases further than was assumed in the CAPRI model calculations. Moreover, costs associated with the management of ecological set-aside were not included in the calculation.

Regional impacts

Most pronounced regional differences in impacts concern divisions of income between the old and new Member States (Figure 4.4). Because a 5% shift in first-pillar budget from EU15 to EU12 is assumed in both scenarios (to contribute to the policy goal of a better 'territorial balance'), old Member States lose, while new Member States gain. On average, the EU15 would lose 0.7% income in case of a moderate shift and would equal the income level of the Baseline Scenario under full implementation of the Greening Scenario. The EU12, however, would experience farm income gains under the *moderate shift measures* and the Greening Scenario, of 6.6% and 6.5%, respectively. However, variations are large,

Figure 4.4
Changes agricultural income EU27, 2020



Source: LEI and PBL

caused by shifts within Member States (Figure 4.4). The Member State budgets would partly be shifted from intensive production regions to those with extensive farming. The latter regions would profit more from agri-environmental payments, permanent grassland premiums and payments for natural constraints, for example, in south-eastern France and Scotland.

The *moderate shift measures* are a subset in the Greening Scenario, and involve a 5% budgetary shift from the first pillar to agri-environmental measures in the second pillar, in the EU15, and a 5% shift from the first pillar of the EU15 (old Member States) to that of the EU12 (new Member States)

4.2.3 Consequences for developing countries

Prices

Global producer and consumer prices are only slightly affected by the CAP scenarios, as are imports and exports. Under the Greening Scenario, production decreases would occur for most products (Figure 4.1). Producer price increases would range from about 1% for milk, to 2% for meat and 5% for cereals (Figure 4.3). These are EU prices, which would globally translate to price increases of 0.25%, 0.4% and 1.5% respectively. Effects on consumer prices would vary between world regions, but in all cases would be limited. On average, the change in global consumer prices would be small – the largest change being an increase of 0.4% for oil seeds.

Table 4.1
Agricultural EU imports and exports, shares of EU production

	import,% of EU27 production		export,% of EU27 production	
	Baseline Scenario	Greening Scenario	Baseline Scenario	Greening Scenario
Cereals	3.4	3.9	13.5	12.5
Oil seeds	79.2	87.4	18.7	18.8
Dairy products	1.8	1.8	4.6	4.6
Beef	10.8	11.2	7.3	6.9
Pork	2.3	2.3	11.4	11.1
Poultry meat	2.3	2.4	16.2	15.6

Source: LEI

EU imports and exports
Under the Greening Scenario, imports would increase and exports would decrease, albeit by small percentages (Table 4.1). Most pronounced changes concern cereals and oil seeds. Oil seed imports would increase from 79% to 87%, expressed as their share in the EU27 production, although must be noted that the EU production of oil seeds is only small. Cereal imports would increase from 3.4% to 3.9% and exports would decrease from 13.5% to 12.5%. Increased imports from cereals, however, would not benefit developing countries, as cereals mainly originate from agricultural producers in temperate zones.

Land use and biodiversity
Impacts on land use and biodiversity outside the EU were not quantified within the framework of this study. Production changes within the EU would probably lead to changes in agricultural production outside the EU, and thus to additional pressure on biodiversity. A lowering of the EU production would increase prices and create additional food imports into the EU or reduce exports from the EU. Outside the EU, this may lead to intensification of agricultural production or to increased land conversion, from nature to arable land. Also, changes in EU farming practices could alter emissions from agriculture, thus leading to other impacts on climate change and subsequently on biodiversity.

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Agriculture not only produces food, but also provides a habitat for various wild animal and plant species. However, intensification of farming practices endangers this habitat. Greening of the Common Agricultural Policy (CAP) offers opportunities to reduce the ongoing loss of biodiversity in agricultural areas.

This report analyses the potential impacts of options for greening the CAP as proposed by the European Commission in late 2010. For this analysis, the PBL used a species richness indicator that was developed for EU farmlands. Trade-offs between biodiversity and agricultural production are presented and suggestions are made for increasing the efficiency of using the EU budget for greening the CAP.

Keywords:
agriculture, farmland biodiversity, greenhouse gases, Common Agricultural Policy

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