14 Optimizing Legume Cropping: the Policy Questions

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Abstract

The cultivation of legumes is low in Europe. Public policy incentives and/or regulations have a role to play in changing this. This chapter examines six such policies. The CAPRI (Common Agricultural Policy Regional Impact) model, a partial equilibrium model for the agricultural sector, is used to simulate the effects of these policies and compare them to what would happen if no policy action were taken. Five of these policy scenarios are aimed at grain legumes (pulses and soybean), and one at forage legumes (in particular, clover). Three of the policies could be incorporated into the Common Agricultural Policy, whereas the other three are more general in nature: related to consumption, international trade and climate-change mitigation. It is the latter two that are likely to have the most significant effect on the cultivation of grain legumes.

Introduction

Preceding chapters in this book describe cropping and forage systems containing legumes which, if realized, would contribute to the sustainable development of European agriculture. The overall costs and benefits of these systems for farm businesses and society have been clarified – weighing the effects on environmental sustainability and social well-being. This chapter addresses the question of how policy can help to promote these systems. It is based on research conducted in the Legume Futures project (Helming *et al*., 2014).

There are two reasons why policy intervention is needed. First, many farmers lack reliable information on the most suitable legume crops and how to integrate them into their farming systems. This is a consequence of the decline in on-farm technical knowledge about legumes as well as the lack of progress through research.

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Second, even though legumes can be a profitable option for farmers, in many situations other crops provide more net revenue. Hence, legumes are used less in farming systems than is desirable from a societal point of view. In the economist's parlance, there are positive economic externalities in growing legumes. This calls for policies to increase the area under legumes.

What, then, can these policies be? It has been famously said that there are three kinds of policy instruments: carrots, sticks and sermons (Bemelmans-Videc *et al.*, 2003). Carrots are incentives (positive or negative) that make the desired decisions more attractive or undesired options less attractive. They narrow the gap between private and social costs and benefits using either subsidies or penalties; we may also say that they are a way to internalize economic externalities. Sticks are regulations that force private decisions more in line with the desired state. Sermons are what Anderson (1977) calls structured options: programmes that individuals can use as they see fit. In our case, a sermon can consist of information provided to land users on how to incorporate legumes into farm practices. Another possibility in the 'sermon' category is the labelling of the products of particular farming systems, such as is currently done for organic production. Many farmers will also respond to the opportunity to produce in a more sustainable way, as long as the cost is not excessive in relation to their (private) benefits.

Farming in Europe is heavily affected by European Union (EU) policies, and the Common Agricultural Policy (CAP) offers plenty of opportunities for influencing farmers' behaviour. This chapter focuses on options that may be envisaged as part of the CAP, although possible policies to be formulated at national or regional level will also be considered. Growing legumes can be influenced also by policies outside the realm of agriculture itself. We first discuss how the CAP has influenced legume growing in Europe until now. From there we consider the formulation of possible policies within and outside the CAP framework which may help to promote the legume-inclusive systems described in this book. These policies have been simulated with the help of the Common Agricultural Policy Regional Impact (CAPRI) model, a partial equilibrium model for the agricultural sector in a European context.

Legumes and the CAP

The area under grain legumes in Europe declined from 5.8 million ha in 1961 to 1.9 million ha in 2011 (Eurostat, 2015). This is not solely due to the CAP, it is also part of a wider process of change: increased consumption of animal products to the detriment of vegetable sources of protein facilitated by the large-scale importation of soy to feed the expanding European livestock herd. However, measures under the CAP have contributed to the decline. Market support for arable crops focused on cereals in the early years of the CAP, leading to an expansion in wheat and barley at the expense of pulses.

Policy makers saw the decline in legumes as problematic: the role of legumes in enhancing soil fertility was well known. Also in the interest of food security (a principal objective of the CAP), there was a case for maintaining protein-rich legume crops. In order to rectify this imbalance, market support for 'protein crops' (pea, faba bean and sweet lupins) was introduced in 1978. This stopped the decline in the countries that were then members of the Common Market (Fig. 14.1). In the late 1980s there was even an increase due to the need for protein-rich animal feed. The 1992 'MacSharry' reform of the CAP, designed mainly to curb excess production, restricted support to cereals and thereby probably helped the relative position of legumes. At the same time, however, the Blair House Agreement put a ceiling on the support for European oilseeds (which includes the legume soybean): a maximum was set on the land area that could receive support, as well as on the amount of oilseed by-products that could be harvested from set-aside land (where non-food crops including legumes could be grown). It is not certain that this agreement actually enforced a decline in legumes, but it did not help their growth potential.

The protein crop premium was finally abolished in 2006, although there was some limited support for these crops under Pillar 1 (production support) until 2012. This support was given only in some countries at their discretion and it was coupled to the cropped area, not to production. The decoupling process was completed in 2012 and this limited area support was discontinued. However, in some countries (e.g. Hungary, Poland, some regions in Spain and Italy) legumes still continued to be subsidized under Pillar 2 (rural development) because of their environmental benefits. This support was also area-based.

A new phase of the CAP began in 2014. Pillar 1 now consists primarily of direct payments on a per-hectare basis, decoupled from production. However, 30% of these payments are conditional on so-called greening measures by the farmer: (i) crop diversification (for larger arable farms); (ii) maintenance of permanent grassland; and (iii) maintaining so-called ecological focus areas (EFAs) on 5% of farmland, later to be expanded to 7%. Both the crop diversification requirement

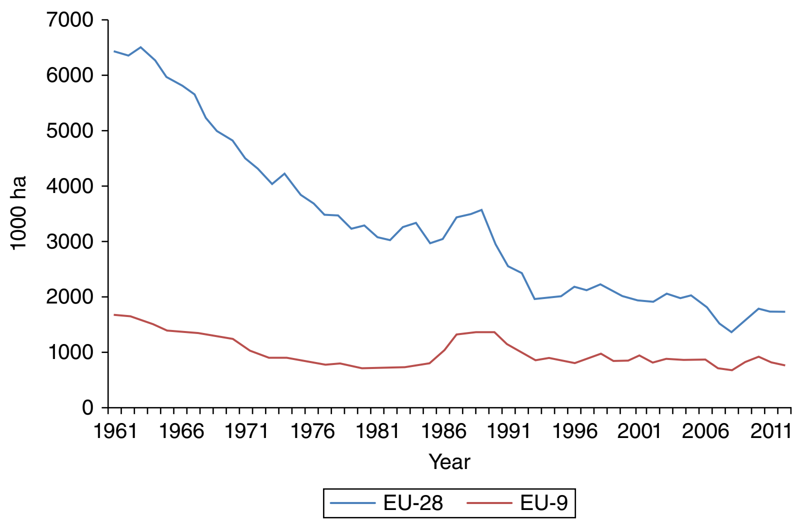

Fig. 14.1. Area under grain legumes in the European Union (EU) (from FAOSTAT, 2015). EU-9: the six founding members of the European Communities plus the three countries that joined in 1973 (the UK, Ireland and Denmark); EU-28: the 28 members of the EU since 2013.

and the EFA may favour legumes. Exactly how EFAs are defined is left to member states, but permitted practices include natural or semi-natural vegetation such as buffer strips next to watercourses or hedgerows, or cultivation with annual rotation without the use of agrochemicals (European Commission, 2013). Growing legumes could fit in this policy, as has happened in, for example, the UK, but this remains controversial in the environmental policy community (Dicks, 2014; Ehlers *et al*., 2014).

In addition to these greening requirements, member states may also still include support for legume cultivation under the agri-environment schemes in Pillar 2, as in the past. These schemes are co-financed by the member states themselves.

Forage legumes may be grown as monocultures or included in a grass sward. No measures have been undertaken under the CAP to promote the growing of forage legumes specifically. Data on the use of forage legumes are patchy, but the general trend of intensification in farming has led to grassland management that favours those species which provide the most productive fodder in terms of energy and respond positively to applied nitrogen. This notably means an increase in grasses at the expense of broadleaved plants which include legumes (Boatman *et al*., 2007).

Policy Scenarios

Judging from the considerable environmental benefits of growing legumes combined with the current negative trend in producing them in Europe, there appears to be a good case for policy intervention. The challenge is to find policies that could bring about the required result without negative side effects. This is where economic modelling can help. Policies can be cast in the form of possible scenarios, each of which is simulated by the model so as to explore its impact on the environment as well as on the economy. The outcomes of these scenarios are compared not with the present situation but with a counterfactual indicating what would happen in the absence of said policy. As part of the Legume Futures project, we modelled different scenarios relating to policies that might be used in future to increase the production of legumes. The impact of these policies is compared with a reference scenario describing the situation in 2020 if no new measures are taken to increase the growing of legumes. The policies are as follows.

1. Hectare premia for grain legumes. Premia existed in the CAP in the recent past. Unlike the policy before the 2003 reform, it would be linked to area rather than production.

2. Legumes included in EFA. Under this policy, legume production would fulfil the EFA obligation under the current CAP. As mentioned above, this would be controversial as the EFA is meant for semi-natural vegetation. However, legumes have ecological benefits and the policy could include restrictions on the use of agrochemicals so as to maximize these benefits.

3. Compulsory forage legumes. A compulsory percentage of clover in grass swards is modelled, but other legumes could be used. The simulated regulation is a requirement to have a proportion of clover of 25% in all grassland.

4. Meat tax. This scenario includes a tax on meat consumption, coupled with a subsidy on vegetable protein (which legumes produce in large quantities). Such a policy would not only address the need to grow more legumes, but also more generally the environmental burden of the rapid increase in livestock production.
5. Carbon taxes in agriculture. Under current policy, farmers are not included in the emission trading scheme, although fertilizer manufacturers are. Under the scenario examined here, all farmers would be taxed for the amount of greenhouse gas (GHG) emissions (not only carbon dioxide (CO_2), but also methane (CH_4) and nitrous oxide (N_2O)). Conversely, the reduction of emissions through carbon storage would be rewarded.
6. Genetically modified (GM) soy imports. Finally, the potential future effects of an existing policy are examined – effects that are not considered in the reference scenario. European livestock production has become heavily dependent on imported soybean as a source of protein. Most of this soybean is GM and subject to a lengthy process of approval. This presents a problem for the future: as more and more GM cultivars are developed, the approval process will lag increasingly behind the commodity markets. Moreover, since there is a zero-tolerance policy in force for the presence of non-approved cultivars in soy shipments, it will become increasingly risky for traders to ship soy to the EU, as the entire shipment may be rejected without compensation if trace quantities of non-approved GM cultivars are found in the load. This can cause disruptions in the soy trade (Nowicki *et al.*, 2010). Under the scenario, the worst case is assumed, where a large proportion of imported soybean cultivars have not been approved and zero tolerance for traces of such cultivars is maintained. The resulting shortage of imported soy would promote the production of soybean and other grain legumes in the EU.

The first two of these policies are standard components of the CAP. The third one could theoretically be included in the CAP as well. The meat and carbon taxes are not CAP policies, but could be undertaken as general policies to promote a healthier lifestyle (the meat tax) or to mitigate climate change (the carbon tax). The last scenario is a consequence of an existing policy that could lead to stimulating legume production in Europe. Because of the risk of severe disruption of livestock production, it is unlikely that the current policy on importing GM soybean for feed will continue in its present form: the project (Nowicki *et al.*, 2010) in which it was modelled was conducted to apprise the European Commission of the risks involved.

Simulating the Policies: the CAPRI Model

These policies were simulated with the CAPRI model. It is a partial equilibrium model for the agricultural sector and, as the name indicates, it can specify the impact of CAP measures on farmers' behaviour for each region (according to the Nomenclature of Units for Territorial Statistics (NUTS) 2 territorial classification) in EU member states, as well as in some other European countries (Britz *et al.*, 2007).

The model consists of a supply module and a market module (Woltjer *et al.*, 2011). The supply module represents up to ten farm types in each NUTS2 region. The data come from Eurostat's Economic Accounts for Agriculture with 2009 as the base year. The farm models have fixed input–output coefficients for each production activity with respect to land and intermediate inputs, in many cases with a low- and high-yield variant. Fertilizer and feed requirements are taken into account. A land supply module allows for land leaving and entering the agricultural sector and transformation between arable and pasture land, both in response to relative price changes.

The market module is a comparative static global multi-commodity model. It covers 47 primary and secondary agricultural products, and models trade between 60 countries grouped in 28 trade blocks. Among these agricultural products are two legume categories, pulses and soybeans. Apart from marketable agricultural outputs, it contains a specific sub-component that models the feed market. The behavioural equations for supply, feed, processing and human consumption have flexible functional forms. Calibration algorithms make the coefficients in these functions consistent with micro-economic theory.

Labour and capital costs are captured by a non-linear cost function. These cost functions are calibrated so as to mimic the base data and to capture information about supply elasticities. The models allow for much of the detail in CAP regulations. Prices are exogenous in the supply module and provided by the market module. Grass, silage and manure are non-tradable and receive accounting prices based on opportunity costs.

CAPRI uses templates that are filled with different parameter sets for different regions and products. This reduces maintenance cost and makes results comparable across products, activities and regions. The modular set-up allows independent use of the different components.

The CAPRI output includes economic variables such as land areas for different crops, crop and animal production, agricultural prices, farm incomes and budgetary costs, and also environmental variables such as GHG emissions, nitrate and phosphate surpluses, and energy use.

Since CAPRI is a partial equilibrium model, it cannot forecast what happens in other sectors of the economy, outside agriculture. This is another reason why the policy scenarios are structured in such a way that they are neutral in terms of government budget and in taxes and subsidies for farmers. Were this not the case, we would have to take the effect of our policies on other sectors into account, and a general equilibrium model would be needed, which cannot provide the kind of detailed output on agriculture that CAPRI can.

Like most economic models, CAPRI is designed to simulate effects in the short and medium term, so we have modelled 2020 as the target year. This is a limitation, as a significant part of the impact of growing legumes is a long-term process, but we cannot know what trade and prices will do in the longer run.

Another limitation that has some effect on our outcomes is that CAPRI can only simulate the expansion or contraction of existing crops in any particular region, not the introduction of a crop in a region where it was not grown before. The model contains parameters for all crops that are grown in a region, and not for those that might be grown. Finally, it may be noted that Croatia is not included in the simulation, as it was not an EU member state in the base year.

Results

It must be remembered that we cannot pronounce on the probability of any of the scenarios coming to pass. The reference scenario is merely a continuation of recent trends. The GM scenario describes what might happen under certain new circumstances if current policies are not modified. The new circumstances are highly likely, but current policy will probably be modified in response to those circumstances. It is very important also to remember that the scenario changes are in relation to the reference scenario.

Reference scenario

In the reference scenario (i.e. with a continuation of current trends) there will be a further decline in the cultivation of legumes. The area under pulses will decrease by 327,000 ha or 24% over the period 2009–2020. However, cultivation of soybean will increase, by 213,000 ha or 70%, meaning an overall net loss of 114,000 ha for grain legumes or 7% of the grain legume area in 2009. Figures per country are shown in Table 14.1. Large increases in production under the reference scenario are predicted due to an expansion of soybean cultivation in countries where the climate is suitable and where the crop is presently grown only on a small scale.

Hectare premium for grain legumes

The rationale behind this policy would be that legumes are often less profitable than other crops, but that they provide environmental benefits. Since these accrue to society at large rather than to the farmer who delivers them, the farmer would tend to produce fewer legume crops than would be in the interest of society. We have defined the premium in such a way that up to 2% of the CAP budget for direct farm payments (Pillar 1) in any one NUTS2 region is allocated to legumes. In order to avoid excessive premia per hectare in regions with very small areas under legumes, the premium cannot be higher than the average direct farm payment per hectare at national level. As the area under legumes increases with the premium, the payment per hectare is reduced so as to avoid overshooting the budget. The resulting annual payments in the scenario range from €70/ha (Latvia) to €425/ha (Greece).

This leads to an increase of the area under grain legumes of 12% in 2020 compared with the reference scenario. This is not very large, but at least it means that there will be a slight increase, as opposed to the decrease projected in the reference scenario. As can be seen in Fig. 14.2, the effect differs between regions, with some regions even experiencing a decrease in the area under legumes. This is probably due to price changes: as more legume products come onto the market, the price will be reduced and this will make cultivation unattractive to some farmers. This is the case in Romania and Bulgaria, where direct farm payments

Table 14.1. Area under grain legumes in 2009 and in 2020 under the reference scenario.

	2009		2020 (reference scenario)		
Country	Thousand ha	As a percentage of arable (%)	Thousand ha	As a percentage of arable (%)	Percentage change in area (%)
Austria	47	3.3	84	5.5	80
Belgium	2	0.2	1	0.1	–68
Bulgaria	8	0.8	45	1.3	474
Cyprus	2	0.9	1	0.8	–19
Czech Rep.	36	0.7	69	2.3	92
Denmark	7	0.3	2	0.1	–75
Estonia	5	0.2	5	0.8	–7
Finland	7	0.3	7	0.3	3
France	263	1.3	221	1.1	–16
Germany	83	0.7	81	0.6	–2
Greece	21	0.6	19	0.6	–8
Hungary	52	4.3	87	1.8	68
Ireland	4	0.4	3	0.3	–11
Italy	210	2.1	92	0.9	–56
Latvia	3	1.6	2	0.2	–39
Lithuania	47	0.3	43	2.1	–10
Malta	< 1	0.2	< 1	0.2	–33
Netherlands	3	0.3	0.5	0.0	–84
Poland	129	8.8	79	0.6	–39
Portugal	15	0.7	4	0.2	–74
Romania	104	14.2	148	1.5	43
Slovakia	20	1.4	24	1.6	18
Slovenia	1	0.6	6	2.7	582
Spain	315	1.8	309	1.8	–2
Sweden	26	1.0	15	0.6	–41
UK	242	4.0	191	3.1	–21
EU-27	1652	1.3	1538	1.2	–7

are lower to begin with, so the premium may not be sufficient to offset the lower price for the produce.

Apart from the increase in area under legumes, the policy will have other effects on land use. First, it becomes more attractive to grow crops rather than to maintain pasture, so some grassland will be converted to arable land: about 42,000 ha compared with the reference scenario. Second, because direct farm payments decline generally where legumes are not grown, some land will be taken out of production. This will occur on 27,000 ha, or 0.015% of the total utilized agricultural area (UAA), mostly in Scotland and north-western Spain.

Economic effects of the legume premium include the following.

- Lower imports of soy and pulses.
- Redistribution of direct farm payments in favour of farmers who grow legumes at the expense of those who do not (including livestock farmers); the total amount per country does not change.

- Although total CAP payments do not change on balance, there is an increase in overall farm income by 0.08% due to slightly higher prices for all crops other than legumes.
- There is on balance a slight advantage to consumers (€36 million/year) due to price effects – although most crops become more expensive, animal products become cheaper.
- On the other hand, there is a cost to taxpayers (€50 million/year), and since consumers are also taxpayers there is no net gain.
- The net effect on the economy is a positive €139 million, or 0.01% of gross domestic product (GDP).

Legumes included in EFAs

If growing legumes fulfils the EFA requirement under the new CAP, the farmer would choose between growing legumes and various types of fallow: (i) simply not using the land; (ii) buffer strips; (iii) hedges; or (iv) some other form of semi-natural vegetation. His or her choice will depend on the costs and revenues of options in different regions. Overall, we forecast an increase in uncultivated land

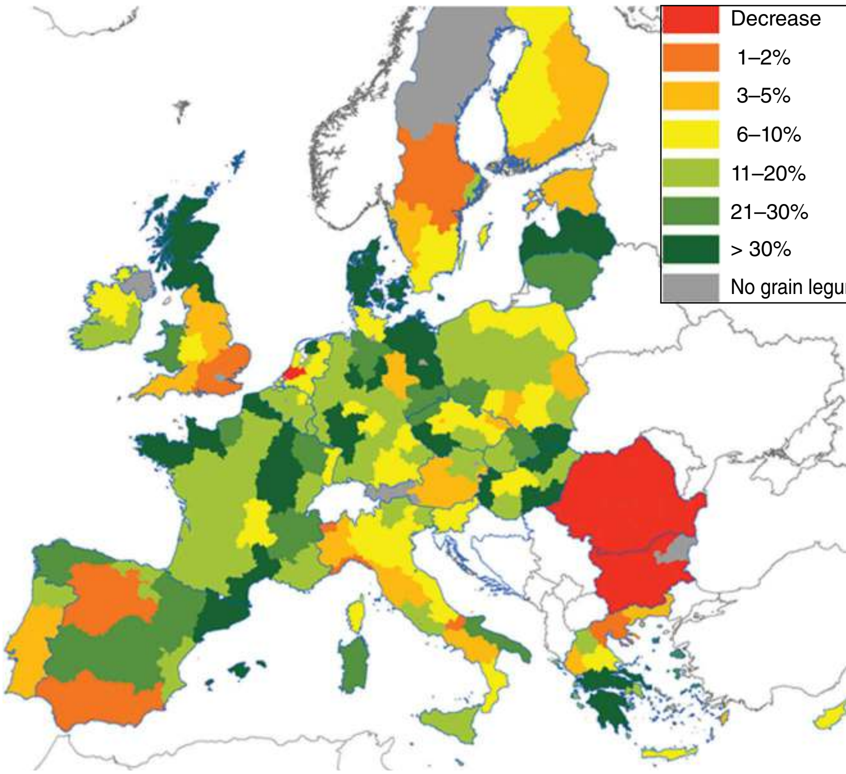

Fig. 14.2. Change in cultivation of grain legumes under hectare premium scenario.

of almost 3 million ha while legumes increase by no more than 50,000 ha relative to the reference scenario. Once again, the effect differs strongly by region, with many regions showing an even stronger decrease compared with the reference scenario, with significant increases elsewhere. Moreover, the geographical pattern of increase and decrease of legumes differs from that under the hectare premium scenario.

These results seem counter-intuitive: the policy implicitly subsidizes legumes, so how can this lead to a decline in some regions (although not a decline in the EU as a whole)? To understand this, we must consider that the costs and revenues of growing legumes in comparison with leaving the land fallow are different in each region. Moreover, the overall increase in legume cultivation (albeit slight) causes a decrease in price. In regions where the profitability of legumes is marginal, this price change may tip the balance and cause a decrease in their cultivation. In such regions, the area under legumes will be small, meaning that a decrease of a few hundred hectares may constitute a decrease of over 10%. The hectare premium, on the other hand, may be sufficient to persuade these farmers to increase the area under legumes. It is precisely such counter-intuitive results that make a model such as CAPRI a useful tool for predicting the impact of agricultural policies.

The environmental and welfare effects of the policy will be similar to those of the hectare premium scenario, but even smaller – in line with the limited effect on land use.

Compulsory forage legumes

It is estimated that grassland in the EU contains only 5% clover on average, but the percentage varies widely per country. An increased share of clover will reduce the dry matter yield of the grassland where it is already heavily fertilized, but it is more difficult to say what happens to nutritional value (energy and protein). The data coverage on this point is limited, and the outcome varies per country for those countries where data are available. Hence, only the impact on dry-matter yields could be modelled in CAPRI.

From the point of view of a farmer who uses synthetic nitrogen fertilizer, increasing the proportion of clover means that additional feed needs to be purchased in order to have the same total quantity of stockfeed (in terms of dry matter) for the same number of animals. The farmer saves money on the fertilizer he or she does not need to use, but this saving is less than the extra feed cost. The net increase in cost is on average 2.5%. The resulting lower profitability of livestock will lead to a slight decrease in the livestock herd. As with other policies, the effect will not be the same throughout Europe, and under some conditions a grass–clover mix can be more profitable than pure grass, such as when the ratio of fertilizer price to milk price reaches a tipping point (Humphreys *et al.*, 2012; see Chapter 9, this volume).

Compared with the alternative of fertilized pure-grass swards, grass–clover mixtures produce lower emissions of N_2O and ammonia (NH_3), as well as leading to a decrease in CO_2 emissions from the manufacture of nitrogen fertilizer (see Table 14.2). Methane emissions also decrease, due to the reduction in livestock herd.

Table 14.2. Environmental impact of the forage legumes scenario.

Type of impact	Difference with reference scenario (%)
Ammonia emissions	–0.7
Methane emissions	–1.4
Global warming potential	–2.1
N input with mineral fertilizers	–15.0
N input with manure (excretion)	–1.2
N input with crop residues	–3.3
Biological nitrogen fixation	130.8
Atmospheric N deposition	0.0
N export with crop products	–2.5
N surplus total	–4.6

Meat tax

The meat tax policy is implemented in such a way that 2.5% of meat consumption is substituted by vegetable proteins, in particular, pulses. This is done by first taxing the margin between producer price and consumer price of meat products, such that consumption will decrease by the target 2.5%. Next, a subsidy is applied to the same margin in pulses, until their consumption rises by an amount equivalent to 2% of meat consumption (pulses contain more protein than meat, so the protein content of food remains the same). These changes are iterated until the increase in protein consumption from pulses is equal to the decrease in meat protein for the EU as a whole. The result is achieved by taxing meat production by an average 7% of the margin between producer and consumer price, and by subsidizing the same margin in the pulse price by, on average, 50%.

Since this is not a specifically agricultural policy but a general one (it could be implemented either at European or at national level, although only the European option is considered here), its effect on land use is indirect. The direct effect is on prices: consumer prices for pulses go down while the price paid to producers goes up, and the reverse happens for meat products (Table 14.3). CAPRI projects a decrease of meat consumption by 1.1 million t or 2.5%, whereas human consumption of pulses goes up by 865,000 t or 72%. However, not all of this change in consumption means a parallel change in production: net exports of meat increase and so do net imports of pulses; moreover, less pulse produce is used for animal feed. On balance, production of meat decreases by 1.5% and domestic production of pulses increases by 2.9%.

The area under pulses increases proportionally to the increase in production, but the production of soybeans does not increase, because the decrease in meat consumption reduces demand for soy. Hence, the increase in area under legumes as a whole for the EU-27 is only 25,000 ha. This represents a 1.7% increase as a percentage of the arable area – lower even than the previous policy scenario. The spatial pattern is similar to that of the EFA scenario: decreases mostly in the Netherlands, Ireland, Sweden, Finland, southern Greece and the Italian islands; increases in Denmark, Brittany and the Baltic states.

Table 14.3. Price effects of the meat tax scenario.

	Reference scenario (2020)		Change under meat tax scenario			
			Absolute difference with reference		Percentage difference with reference	
Product	Producer price (€/t)	Consumer price (€/t)	Producer price (€/t)	Consumer price (€/t)	Producer price (%)	Consumer price (%)
Pulses	278	2518	14	–855	4.9	–34.0
Beef	3408	6798	–84	159	–2.5	2.3
Pork meat	1592	4436	–55	157	–3.4	3.5
Sheep and goat meat	5388	5747	–51	138	–0.9	2.4
Poultry meat	1578	4668	–16	94	–1.0	2.0

Total GHG emissions from agriculture decline by 0.4%, not so much due to the increase in legumes but more to a decline in livestock production, which in turn means less land needed for feed. Ammonia emissions are reduced by 0.6% for the same reason.

Farmers' income declines under this scenario, particularly in areas with few legumes but much livestock, which is the case over much of north-west Europe. This might lead to further farm consolidation, although that phenomenon is not modelled in CAPRI. The increase in farming scale is primarily driven by technology, but smaller farmers are forced out more quickly where margins are squeezed.

Carbon tax for agriculture

The carbon tax scenario is not modelled as an overall tax on GHG emissions, but only on emissions from the agricultural sector. CAPRI is not suited to simulating the effect of taxes on all sectors. In the particular version of the scenario discussed in this chapter, a price for emission rights of €72/t of CO_2 equivalent is used. This price is based on the Stern Review of 2006, corrected for inflation, and is the price that would be necessary to keep climate change at an acceptable level. It is much higher than recent prices on the emissions market. The policy means that farmers are taxed for all GHG emissions (including nitrous oxide from nitrogen fertilizer use), and conversely rewarded for diminishing these emissions (including the storage of carbon in the soil).

Under these conditions, the cultivation of legumes would increase by 62%, to 3.5 million ha in 2020. This increase would take place in almost all parts of Europe (Fig. 14.3). In many regions, notably in parts of Spain, France, Romania, Germany and Scotland, the area under grain legumes would more than double.

There are numerous other effects. Most importantly, livestock farming would become less profitable, and beef cattle in particular would decrease. The total utilized agricultural area would decrease by 1.6%, mostly because of a decrease in intensive grassland. The area under fallow would increase significantly, as this would avoid GHG emissions. The same explains a shift from intensive to extensive grassland (which would be richer in clover): the latter attracts less carbon tax, and the lower land price (another result of this policy) would make extensive land use more interesting to the farmer.

The increases in area under legumes and fallow land, along with the shift from intensive to extensive grassland, all produce positive and fairly significant environmental effects (Table 14.4). The actual impact is even larger, as not all

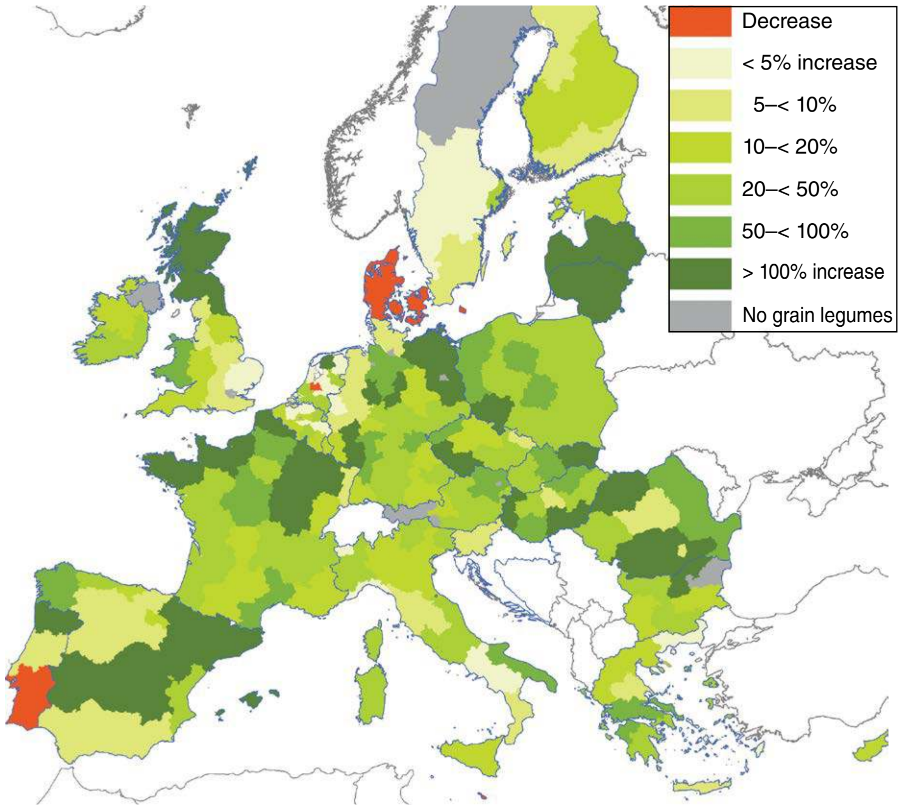

Fig. 14.3. Change in cultivation of legumes under carbon tax for agriculture scenario.

Table 14.4. Environmental impact of carbon tax scenario.

Type of impact	Reference (1000 t)	Carbon tax (% change)
N input from mineral fertilizer	10,690	–4.4
N input from manure	9,086	–3.6
Nitrous oxide emissions	743	–3.4
Methane emissions	7,899	–3.6
Total GHG emissions from agriculture (CO_{2e})	396,156	–3.6
Ammonia emissions	2,412	–3.3

CO_{2e}, Carbon dioxide equivalent; GHG, greenhouse gas.

effects are included in CAPRI: although the concept of the carbon tax means that the increased storage of carbon in the soil under legumes is credited to the farmer, this effect is not measured by CAPRI and thus cannot be quantified.

The net effect on average farm income would be very small, as the revenue from the tax is returned to the farming sector in the form of rewards for mitigating GHG emissions. Since some farmers will be more successful at changing their practices than others, some will benefit while others will lose out.

GM soybean imports

Nowicki *et al.* (2010) modelled several possible scenarios in CAPRI, of which the more serious one assumes that many new GM cultivars not approved for food and feed in the EU are introduced in all major soy-exporting countries. Under policies currently in force, this scenario is deemed plausible, although in recent years the industry has been responding to the demand for non-GM soy and the premium for those cultivars has reportedly come down. The scenario would lead to a cessation of soy imports from the major suppliers: the USA, Argentina and Brazil, as well as from Paraguay (a minor source). In all of these countries, the different cultivars of soy are grown in close proximity, such that the risk of traces of unapproved soy in batches of approved soy is high. Only Canada and some parts of Brazil, where GM and non-GM production areas are geographically separated, would continue to supply soybean to the EU.

The effects would be multiple and complex, but one of them would certainly be an increase in the production of soybeans as well as other legumes in Europe. Nowicki *et al.* (2010) showed that the total area under grain legumes would increase by 1 million ha, half in the form of soybeans and half in peas and faba beans, which would serve as substitutes for soybeans. This represents an increase of 67% over the reference scenario and would nullify the decline in legume area over the last 25 years or so. Production would increase even more, as the higher prices (the instrument through which farmers would be motivated to grow legumes) are also an incentive to seek increased yields. The land used for legumes would come at the expense of other arable crops, an effect made even larger because maize (of which the EU imports some 50–60 million t/year) would also be affected by the trade disruption, necessitating increased domestic production of maize for stockfeed. Even some land now under vegetables or permanent crops would be converted to growing maize and legumes.

The economic effect would be a loss to the livestock sector, against which arable farmers would gain. On balance, the agricultural sector would neither lose nor gain, although there would be a redistribution of income among different groups of farmers. Consumers would be affected by higher prices of animal products, to the tune of €10.5 billion/year across the EU.

Nowicki *et al.* (2010) do not specify the environmental impact of this scenario, but we estimate that it would be similar to the impact of the carbon tax scenario.

Discussion and Conclusions

The scenario outcomes must be seen not in comparison with today's situation, but in relation to the reference scenario. Policies prevailing in 2013 are likely to lead to further decline in legume cultivation. The question that the policy scenarios are designed to answer is whether they are able to reverse this trend.

Our analysis indicates that measures which can be included in the CAP with relative ease are unlikely to reverse the trend of declining legume cultivation in Europe. Only much bolder policies, such as an ambitious climate change strategy, could achieve that. How plausible are such scenarios, and to what extent may we trust their results?

Accepting legume cultivation as a way to fulfil the EFA obligation is the least controversial policy, since use of nitrogen-fixing crops (i.e. legumes) has been formally accepted as a permissible land use in EFAs in 2013, although member states may implement this possibility as they see fit. In the Netherlands, for instance, only perennial legumes (i.e. forage crops such as clover or lucerne (alfalfa)) are allowed. Hence, our modelling of this scenario may be regarded as a forecast of the impact of an existing policy – albeit one that is not included in the reference scenario, as it was not yet known at the time that the reference scenario was built. Yet, even this policy is not without controversy: some in the environmental policy community see it as less beneficial for the environment than the alternatives such as semi-natural vegetation. As we saw in the previous section, farmers, too, might find the option less attractive than fallow. That is why we predict its effect to be very small.

The premium per hectare for growing grain legumes is the most straightforward of our scenarios, and one that has been effective in the past. However, it goes against the trend of CAP reforms over the last 15 years, which will make it less attractive to policy-makers. To make the scenario a little more realistic, we have made the premium independent of production quantity and also set it up in such a way that the premia would be limited in terms of the amounts paid per hectare and as a percentage of total CAP payments under Pillar 1 (direct farm payments). Such a modest policy produces modest results, but a greater impact on legume production than the EFA measure, and is probably more acceptable from an environmental perspective. We predict that the declining trend of legume cultivation would be reversed into a modest upward one.

The forage legume scenario was chosen to provide a focus on this important crop group. As expected, the environmental impact is favourable, not only because of the direct effect of forage legumes on reducing fertilizer needs and nitrous oxide emissions, but also because the livestock herd is reduced, leading to reduced methane emissions. The policy comes at a cost to grassland farmers, who might of course be compensated for this if the environmental benefits are deemed sufficiently high.

Promoting a change in consumption patterns by taxing meat and subsidizing vegetable protein is attractive in that it directly addresses consumption patterns to protect the environment. It is unlikely to come to pass as a European policy, although it might be considered by individual member states; in our scenario we have considered only the situation where such a policy would be implemented in all member states. One might have expected that if the demand for meat decreased then farmers would respond by changing their production in the desired direction. CAPRI forecasts a different outcome because trade is affected more than production. Less meat would be imported and more exported, and the opposite would apply to protein crops. The overall effect on the area dedicated to legumes would be minimal: whereas production of pulses would increase, soybean production would not. Meanwhile, the direct economic cost to both farmers and consumers would be high. We have not included a calculation of the health benefit of the change in consumption patterns, because doing so would require: (i) an estimate of the healthy life years (HLY) gained by the change; and (ii) an estimate of the monetary value of an HLY. There exists a body of literature for the latter (see, for instance, Schoeni *et al.*, 2011), but the former is highly controversial and the subject of a debate beset by ideological differences.

The carbon tax would have a large effect. The carbon tax scenario would fit into a more ambitious climate-change mitigation policy than currently pursued in the EU. Its cost in direct welfare terms would be quite substantial both to farmers and to consumers, but in the long term the benefits might well outweigh them (Kuhlman and Linderhof, 2014).

The GM scenario too would have a very significant impact, both on the livestock sector in general and on the cultivation of legumes. However, it is precisely this impact which may provoke policy makers to push for a modification of current policy on GM. The rationale behind the study from which our findings are drawn was to warn of the possible consequences of that policy.

Turning to the question of the reliability of our results rather than the plausibility of the scenario assumptions, naturally this is affected by the assumptions and limitations of the CAPRI model. For one thing, as the model does not contain parameters and data for the cultivation of crops not grown in a particular region, it cannot simulate introductions, only expansions or contractions. As the various maps show, there are only a few regions in Europe where no legumes are grown (or more correctly, where existing data do not show them). CAPRI models two types of grain legumes, soybeans and pulses, and whereas pulses are widespread, soybeans are grown only in a limited number of regions. Undoubtedly, measures to promote legumes would cause them to be grown in some regions where they are not presently grown but could be. This problem may well lead to an underestimation of the effect of all legume-promoting policies.

Compulsory forage legumes present another difficulty: CAPRI does not contain forage crops other than silage maize, although it does have data on clover in grassland. The model is also limited in that it only simulates the effect of clover on biomass quantity, not on its quality; in other words, the higher protein content of a grass–clover mix is not taken into account. Also in this case, the model yields a conservative estimate of the benefits of legumes. Moreover, a policy on forage legumes might well stimulate innovations in pasture management, such that the extra cost to farmers would be minimized or even reversed.

Financial incentives are only one way of influencing farmers' behaviour. Progress in research on legumes, and the application of this knowledge to local conditions, may well make them more attractive than they are today. Policies promoting not only such research but also cooperation between researchers and farmers will reduce the profitability gap between legumes and alternative crops. Such policies, which we might term 'sermons' as opposed to 'carrots' (financial incentives such as the legume premium, the EFA policy, the meat tax and the carbon tax) and 'sticks' (regulations such as the compulsory clover-in-grassland policy), would be a departure from the focus on increasing the yield of crops such as wheat or potatoes. The effect of research and extension may be less predictable, but not necessarily smaller than the effects we are able to simulate by modelling.

Nevertheless there is undoubtedly a role for carrots and sticks as well as sermons. Concluding from our research, the most promising way to promote grain legumes would be through a policy taxing GHG emissions at a fairly high rate; that policy would not be restricted to the agricultural sector and would produce a much wider impact than analysed here. An additional policy would be needed to promote forage legumes in grassland; we have shown only one example of such a policy, but inventive policy makers may well come up with better ones. Our modelling exercise did not discuss management practices such as rotation patterns with legumes. CAPRI is not equipped to deal with them, but legume-friendly policies may well consider such aspects.

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