<u>Working Paper No. 17/09</u>

Amber to Green –
Changing Colour in Agricultural Policy

by

Ivar Gaasland
Klaus Mittenzwei

SNF Project No. 2740
Efficient green support, AREAL-programmet
SNF Project No. 2325
Videreutvikling av Jordmod, MATJORD

The project is financed by the Research Council of Norway

INSTITUTE FOR RESEARCH IN ECONOMICS AND BUSINESS ADMINISTRATION
BERGEN, December 2009
ISSN 1503-2140

© Dette eksemplar er fremstilt etter avtale med KOPINOR, Stenergate 1, 0050 Oslo. Ytterligere eksemplarfremstilling uten avtale og i strid med åndsverkloven er straffbart og kan medføre erstatningsansvar.

Amber to Green –
Changing Colour in Agricultural Policy

7. January 2009

Ivar Gaasland
Institute for Research in Economics and Business Administration,
Bergen, Norway
(E-mail: ivar.gaasland@snf.no)

Klaus Mittenzwei
Norwegian Agricultural Economics Research Institute,
Oslo, Norway

Abstract:
A model of Norwegian agriculture is used to study impacts of and adjustments to a substantial change in agricultural policy involving land subsidies targeted towards amenity benefits and environmental services rather than production. Compared with earlier versions, the model has been improved with more flexible technologies that allow land to replace other factors of production, e.g., making yield a function of fertiliser and introducing cultural landscape technologies completely decoupled from food production (flowery meadows). The shift in policy opens for lower agricultural support and higher economic welfare, while keeping up the level of agricultural land with more variation, less intensity and more grazing animals. The main scenario suggests that the present level of farmland can be maintained with 46 and 59 per cent lower levels of capital and nitrogen fertiliser per unit of land. Agricultural support is nearly halved, while economic surplus increases with NOK 20,000 per ha (≈ €2,500).

1. Introduction

Agricultural policy in most Western countries is still focused on production volumes, as a reverberation of traditional self-sufficiency targets. To provide production incentives, the dominating policy instruments are market price support and production subsidies (OECD 2007). Environmental services and landscape amenities have, until recently, rather been welcoming side-effects of agricultural activity than primary objectives. Thus, the resulting cultural landscape tends to be both costly and inferior compared to a more targeted policy (Brunstad et al. 2005a). Also, agricultural activity brings about negative environmental externalities.

For several reasons, this policy orientation is about to change: First, there has been an increasing acceptance that the role of agricultural policy should be to correct externalities and supply agricultural public goods, and not to support production of food which is a private good (e.g., Blandford and Boisvert 2002).

Next, the view advocated by many high support countries that food and public goods are provided in nearly fixed proportions and that price support therefore is an efficient way to promote cultural landscape, has been convincingly rejected (Peterson et al. 2002). The degree of technological jointness between food production and cultural landscape is complex (Boisvert 2001). Dependent on production systems, the amenity value of the landscape may be positively (e.g., grazing animals) or negatively (e.g., monoculture) correlated to the volume of food production. Cultural landscape can even be decoupled from food production (e.g., flowery meadows).

Finally, according to standards set by the World Trade Organisation (WTO), different kinds of production support, denoted as amber support, are subject to reduction commitments, while so-called green support is accepted. Green support should be payments for incremental costs related to provision of public goods and environmental services, and not linked to production in its self.

Despite some progress, most current agricultural sector models are not well accommodated to this reorientation of policy (Mittenzwei et al. 2007; Britz and Heckelei 2008; Buysse et al. 2007). Models commonly focus on conventional food producing activities, and not on activities targeted on public goods and environmental services. Consequently, current models tend to overstate the technological jointness between food production and the supply of public goods, so that the cost of supplying such goods is overestimated. For example, for given targets on amenity enhancing attributes of the landscape (e.g., varied land use and grazing animals), the lack of technological flexibility implies that the models generate excessive production and use of capital.

The above criticism also applies to the main modelling tool for analysing agricultural policy in Norway (Jordmod). However, the model has recently been improved with more technologies and space for input substitution which makes it more suited for this kind of analysis. Many different activities for supplying coarse fodder (grazing on pastures, grazing on outlying fields and mowing) have been implemented. To represent land use completely decoupled from food production, flowery meadows are included as a separate technology. In all plant productions, yield is made a function of the use of nitrogen (purchased and from own animals). Intensity in milk production is made a function of the amount and mixture of coarse fodder and concentrated feed.

Jordmod is in this paper used to study impacts of and adjustments to a substantial change in agricultural policy from production support to policy instruments that are more targeted on amenity benefits and environmental services. Norway is well suited as an example in this respect. Agricultural support is high[1], and more than half of the support is directly tied to production. In the model simulations, the production support is replaced by land subsidies complying with presumed amenity enhancing attributes of the cultural landscape, and a tax on the use of fertilizer.

2. Model characteristics

Jordmod is a partial equilibrium model of the Norwegian agricultural sector (Mittenzwei and Gaasland 2008). For given input costs and demand functions, market clearing prices and quantities are computed. Prices of goods produced outside the agricultural sector or abroad are taken as given, and domestic and imported products are assumed to be perfect substitutes. As the model assumes full mobility of labor and capital, it must be interpreted as a long run model.

The equilibrium solution is found in an iterative process between a supply module and a market module. The supply module maximizes profit at the farm level for given product prices and subsidy rates, i.e., optimal model farms are constructed for a given set of relative prices. The module includes functions for production technology (e.g., output and input

[1]Relative PSE was 66 per cent in 2004-06, a figure only matched by Iceland and Switzerland.

coefficients per ha or per animal), biological or natural restrictions (e.g., length of grazing season, balance between young and producing animals, respectively, and crop rotation) and cross-compliance restrictions on the farm level (e.g., manure area requirements).

Some production coefficients are constant, i.e., the level of the input (or output) is proportional to the number of hectares or animals at the constructed farm. However, non-linear functions are introduced for three important relations: 1) Crop yields increase at a declining rate with the amount of nitrogen provided on the land. 2) Milk production per dairy cow is a function of the amount and mixture of coarse fodder and concentrated feed. 3) Economics of scale with respect to use of capital and labour per animal or hectare is modelled. These non-linear relations imply that both the scale (number of animals and hectares) and mixture of inputs (use of fertiliser and feeding practice in milk production) are functions of the given relative prices.

In the market module the constructed model farms are integrated into an equilibrium model that includes domestic demand functions (linearly decreasing), given world market prices, subsidies and regulations, trade policies, transportation costs and limitations as to available farmland of different grades. The sum of consumers' and producers' surplus of the agricultural sector is maximized, and the solution is found as the prices and quantities that yield equilibrium in each market. No restrictions must be violated, and no active model farm or processing plant can be run at a loss.

The market clearing prices from the market module is fed back into the supply module which updates the optimal model farms according to the new relative prices. Iterations between the supply module and the marked module continue until equilibrium is reached, in the sense that the equilibrium prices that come out of the market module are equal to the prices that previously have been entered into the supply module.

The model distinguishes between thirty-two production regions, each with varying yields and limited supply of the different grades of land. With few exceptions, the model contains eleven specialised farm types in each region, which are defined by thirty-six production activities (19 for crop production and 17 for animal production). This makes a total of about 350 model farms for which the optimal amount of inputs and outputs can be found in the supply module.

A special feature novel to this analysis is a production technology that supplies culture landscape in the form of flowery meadows completely decoupled from food production. The aim of this technology is to keep the agricultural land open and in good shape, while enhancing amenity values and biodiversity at low costs. The technology involves surface tilled grassland that is cut once a year (late autumn) to keep the land free of scrub and turfs. The cut grass is removed from the field and no fertilizer or pesticides are added. Production factors and costs are derived from the underlying activities (mowing and removing of cut grass), based on NILF (2003).[2] The calculated cost varies between NOK 2100 and NOK 3300 per ha, dependent on production region. In Section 3.2 we discuss to the degree to which this particular technology gives rise to amenity values and biodiversity.

At the farm level the model has 22 outputs (e.g., wheat, potatoes, cow milk and eggs), 12 intermediary products (e.g., different grades of concentrated feed and roughage, and nitrogen and phosphorus from own animals) and 25 other production factors (e.g., different types of capital, energy, seeds and pesticides).

Domestic demand for final products is divided among 5 separate demand regions, which have their own demand functions. Each demand region consists of several production regions. If products are transported from one region to another, transport costs are incurred. For imports and exports transport costs are incurred from the port of entry and to the port of shipment respectively. The model is calibrated, partly by using Positive Mathematical Programming (PMP), to the base year «2003», which is an unweighted average of the years 2002 – 2004.

3. Adjustments to green support

3.1 The present amber policy

The green policy, which is formulated in the next section, will be compared to the model's representation of the agricultural policy in the base year 2003. Since the Norwegian production of various agricultural products, as well as agricultural support, has been relatively stable the last decade, the base year 2003 is rather representative for the conventional amber support regime.[3]

The base solution, which is given in column 1 of Table 1, is close to the actual situation in 2003. In spite of climatic disadvantage, production is high and import is low.

[2] The applied method is in the tradition of normative mathematical programming (Buysse et al. 2007).

[3] To bring association as to policy direction, the scenarios are denoted with colors as in the WTO negotiations. However, the policy instruments used in our analysis do not follow any formal WTO definitions of amber and green support.

Norway is self-sufficient in most of the specified products, with the exception of grain. 12 per cent of the milk production is exported in the form of cheese, by means of export subsidies.

The high activity level in Norwegian agriculture is sustained by substantial support. The total support generated by the model is NOK 20.5 billion (1 NOK ≈ 0.125 €), of which NOK 11.0 billion is budget support and NOK 9.5 billion is market price support.[4] Divided on farmland, support is about NOK 24,000 per ha. Market price support and output subsidies constitute 60 per cent of the total support, which illustrates the amber support profile.

[Table 1]

Total land use in agriculture is 0.85 million hectares (outlying fields not included). Nearly 2/3 of this land is covered with grass, while 1/3 is tilled land in grain and potato production. Only 30 per cent of the grassland is taken up by grazing animals, which means that mowing and indoor feeding dominate. Grazing on outlying fields covers about 10 per cent of the total intake of roughage. Roughage in the form of conserved grass is especially common in milk production, while grazing on outlying fields is characteristic for sheep.

Natural conditions for agriculture are best in the most populated areas where the landscape is flat and the temperatures are highest. Grain production is directed to these areas, while milk and meat, intensive in the use of grassland, is reserved for rural areas. As can be seen from Table 2, the ratio between grassland and tilled land is 0.6 in central areas, while it is 4.2 in rural areas. Thus, a side effect of this specialisation policy, from a cultural landscape perspective, is an unbalanced use of land between regions.

[Table 2]

A transition from price support to subsidies related to land use, is expected to reduce the intensity in plant production. The intensity can be measured by the amount of nitrogen (N) fertiliser per ha. Despite high use of fertiliser (about 160 kg N per ha), the yield is low in all plant productions due to the cold climate. On average, e.g., an input of 155 kg N per ha yields about 4600 kg wheat which is only 60 per cent of the level in central Europe.

Compared to countries with milk cows of comparable genetic capacity, e.g., Sweden, milk production per cow is low in Norway (about ¾ of the level in Sweden) and the roughage

[4] To compare, the actual PSE figure reported by OECD for 2003 is NOK 21.7 billion, of which NOK 12.5 billion is budget support and NOK 9.2 billion is market price support.

share of fodder intake is high (68 per cent). The high roughage share follows from the high price on concentrated feed (due to import barriers), combined with subsidies linked to the domestic production of roughage. The low yield per cow is affected by the production quota system and regressive subsidy rates with respect to scale.

3.2 Green support

Assumptions

In the green support case we assume that the role of agricultural policy is to correct for externalities and supply cultural landscape. This involves a substantial change in agricultural policy from price support to payments that are more targeted towards amenity benefits and environmental services. Acknowledging lack of precise information about the willingness to pay for different attributes of the cultural landscape as well as the exact character of the externalities, our approach is to promote farming systems that most likely enhance the amenity value of the landscape and mitigate negative externalities.

The amenity value of the cultural landscape depends on how the land is managed. Studies to measure the economic value of landscapes (e.g., Drake 1992; Schläpfer and Hanley 2003) and the comprehensive work on landscape indicators (e.g., Piorr 2003) suggest that important attributes are biodiversity, variation (e.g., a mixture of tilled land and pastures in a given region), grazing animals and openness (e.g., access to the landscape and open trails). Furthermore, cultural landscape is a spatial public good (Dillman and Bergstrom 1991), i.e., the dispersion of land matters. The amenity value is income elastic and the marginal willingness to pay decreases strongly with rising levels of cultural landscape (e.g., Schläpfer 2007; Lopez et al. 1994). In addition, Kaltenborn and Bjerke (2002) argue that landscape preferences are linked to people's environmental value orientations.

As an approach to move in the right direction, according to these main lines, the current support instruments are replaced by land subsidies targeted towards cultural landscape.[5] The land subsidies are adjusted in order to ensure the current level of farmland in each region (central and rural areas, respectively).[6] Accordingly, we take into consideration that cultural landscape is a spatial public good.

Implicitly, we assume that there exists sufficient willingness to pay to maintain the present level of farmland. However, the composition of the farmland and tilling practice is allowed to change. As described in the previous section, the present land use reflects a strong regional specialisation, and grazing animals are scarce. Cultural landscape technologies completely decoupled from production are also non-existent. To reduce monoculture and to promote regional crop variation, we assume equal shares in each region for tilled land (grain and comparable), grazing pastures, mowed grassland (fodder production) and flowery meadows, respectively.[7] Grazing on outlying fields (highland and wooded pastures) which contributes to keep the outfields open and easy to access is assumed to stay at the present level.

Biodiversity, which is a complex aspect, is hard to handle satisfactory in numerical models like Jordmod. Nevertheless, the following three assumptions will most likely enhance biodiversity: (1) a more varied land use, as assumed above, also involves more variation in available habitats for different species, and should as such promote biodiversity. (2) The flowery meadow technology provides more species than grassland in fodder production. Conventional fodder production normally involves a minimum of two cuttings per season, regular ploughing and specialised forage crops. By allowing wild plants that are cut only once a year (after seed dispersal and the nesting season), more species will be promoted. Also, biodiversity is stimulated by keeping the nutritional content of the soil at a relatively low

---

[5] Since food is a private good, most market price support is eliminated. The present import tariffs in the range of 171 – 429 per cent are reduced by 70 per cent for all products. (To avoid a too strong change in relative prices which tends to give corner solutions in the model, tariffs are not set entirely to zero). Also, free competition in the domestic market is implemented, which, i.e., implies that the Norwegian milk price equalisation scheme is abolished. By law this scheme involves price discrimination and cross-subsidization between different dairy products. Especially, export of cheese and butter are subsidized by revenues from domestically sold drinking milk (Brunstad et al. 2005b). The regulation system at the milk farm level, involving production quotas, is abolished.

[6] This is facilitated in the model by specifying regional minimum restrictions on land use equal to the levels in the base solution. The necessary land subsidies then follow endogenously from the shadow prices of the restrictions. A land subsidy will be generated if the minimum restriction is binding.

[7] In other words, it is assumed that the relative marginal valuations are such that the farmland should be equally distributed between the different land categories which implies ¼ of total regional land use for each of the four land categories. However, since the need for fodder production (mowed grassland) depends on the magnitude of grazing, some degree of freedom is needed. Therefore, we put no separate restriction on grassland in fodder production, but require that the sum of flowery meadows and grassland in fodder production should be (¼+¼) = ½ of total regional land use. The assumption of equal shares will later be discussed and subject to sensitivity analysis.

level.[8] (3) The present practice of small scale farming, which is sustained, implies a scattered dispersion of farm land, which affects the availability of wildlife habitats positively.

Negative externalities, such as emissions of nitrate, ammonia and greenhouse gases, tend to be negatively correlated with landscape amenity values. The reason why is that negative external effects are primarily tied to the degree of capital intensity (inclusive of fertilizer and pesticides). Normally, a switch from output to land subsidies will decrease capital intensity. Thus, land subsidies will not only provide public goods, but also mitigate negative external effects. However, to provide further disincentives for pollution, a high tax on the use of fertilizer (300 per cent of current price) is imposed. As in the base solution, a balanced use of nutrients is promoted by a manure area requirement at the farm level.

Results

The amount of farmland is, as assumed, equal to the level in the amber base solution, both in rural and central areas. The land use has, however, changed significantly. In central areas, the current abundant tilled land is more than halved, and replaced with low-cost flowery meadows and pastures. For acreage involved in meat production (mowed grassland and grazing pastures) a strong shift from mowing and indoor feeding to grazing takes place. In rural areas mowed grassland is replaced with flowery meadows, especially, but tilled land also increase. In both regions more pasturing animals are visible in the landscape even if the number of animals decreases.

Production levels and the intensity in the use of production factors other than land decline. Using an index of production, where the production value of each product is weighted by the product's share of total production value in the base solution (evaluated at world market prices), it can be seen that production decreases with 44 per cent. The decrease in production factor intensity, measured as input per ha, is 39 and 46 per cent for labor and capital, 59 per cent for N-fertilizer and 53 per cent for concentrated feed.

Substitution, as a response to the change in relative prices, explains the shift towards more land intensive production techniques. At the farm level, the use of fertilizer has declined so that more land is required for given levels of crops. For example, the use of N per ha in wheat and grass production has decreased by 39 per cent and 24 per cent, respectively, while the corresponding decrease in yields are 8 per cent and 4 per cent. Our results are comparable to

[8] A high level of nutrition tends to reduce the number of plant species since the most competitive plants (fast-growing) thrives on the expense of other (Sommersel and Alm 1996).

other Norwegian studies. Vatn et al. (1999) report a reduction in N-fertilizer in grains and grass in the range of 10 per cent and 27 per cent, respectively, assuming a 100 per cent N-tax. In their model, the larger reduction in grass is induced by substitution with clover, a feature that is not handled in Jordmod. Vedeld (1998) concludes with a 10 per cent reduction in nitrogen use in response to a 100 per cent N-tax. Christoffersen et al. (1992) report a 30 per cent reduction in nitrogen use as a result of a 170 per cent N-tax.

Furthermore, subsidies dedicated to grazing give incentives to fully utilize the grazing season. Since more grazing lowers the need for winter fodder, the mowed acreage is reduced. Substitution from mowing to grazing increases land intensity since fields used for grazing in general are less productive than mowed fields.

Since different sectors are more or less land intensive, substitution at the sector level also takes place. The shift from production support to land subsidies favors sectors that can maintain the different types of land at the lowest level of subsidy. Flowery meadows represent the most extreme degree of substitution. This technology requires a subsidy per ha that is around NOK 2,500 which is only 10 per cent of the average support in the base solution at about NOK 24,000 per ha.

Milk farms and self-recruiting beef production represent the most economical way to keep infield grazing land at a level nearly twice as high as in the base solution. The yield in milk production has increased due to absence of regulations and lower price on feed. Self-recruiting beef production is land intensive, and both production and use of inputs other than land is relatively low. Nevertheless, land use that involves grazing animals accompanied with indoor feeding in the wintertime bears a high price tag. Table 3 shows that the subsidy per ha is more than 4 times higher than for flowery meadows.

[Table 3]

Less tilled acreage (2/3 of the present level) means lower grain production, in particular food grain. Production of potatoes which is close to competitive at world market prices is more or less unchanged. The required subsidy per ha of tilled land is about the same as for grassland. (see Table 3).

The extent of grazing on outlying fields is at the present level. As shown in Table 1, the total area of highland and wooded pastures used for grazing is more than 5 times higher than total infield farmland. However, each hectare only provides about 30 feed units. Sheep are the only animals utilizing this acreage in the model, and receives for this a subsidy of about NOK

300 per ha. The sheep farms obtain relatively more of the fodder from this activity (compared to the base solution), which explains why the required area of outlying fields can be upheld with less sheepmeat production.

The shift in policy opens for a substantial reduction in agricultural support. Total support is reduced with 47 per cent compared to the base solution. Most of the remaining support is targeted land subsidies (NOK 9.5 billion), complemented with some market price support (NOK 1.8 billion), and deducted for NOK 0.3 billion in tax income on fertilizer. Mainly due to lower domestic prices and less net budget support, economic welfare, defined as the sum of producers' and consumers' surplus deducted for net budget support, increases by NOK 17.3 billion.

If we exclude the flowery meadow technology from the simulation, it can be revealed how much of the gain that owes to this particular technology.[9] Table 4 shows that NOK 2.5 billion of the NOK 9.5 billion reduction in support, i.e., 26 per cent, can be attributed to the flowery meadow technology. With regard to economic welfare, the additional gain from the introduction of this technology is NOK 2.4 billion.

[Table 4]

Willingness to pay - sensitivity

The main purpose of this paper has been to investigate gains from a substantial change in agricultural policy from production support to payments targeted towards cultural landscape and environmental services, when taking into account important substitution possibilities at the production side. On the demand side we have, as a simplification and in lack of reliable willingness to pay estimates for the Norwegian cultural landscape, assumed that the total willingness to pay is sufficient to keep up the present level of farmland and that the relative marginal valuations are such that the farmland is equally distributed between the different land categories.

If our solution should happen to be optimal, the results say that when all land types are available in equal amounts, the marginal willingness to pay (MWP) for grassland is only

[9] In this simulation agricultural land is equally divided between tilled land, grazing pastures and mowed grassland, while flowery meadows are excluded.

slightly higher than for tilled land (3-19 per cent) while flowery meadows have a significantly lower valuation (75 per cent lower).[10]

A study by Drake (1992) can be used to assess the reasonability of this assumption. The study provides estimates of amenity benefits in Sweden which is Norway's closest neighboring state. The marginal rate of substitution between grazing and tilled land was estimated to 2.15. Assuming a Constant Elasticity of Substitution (CES) production function for landscape, the marginal rate of substitution can be expressed as[11]:

$$\frac{\alpha}{(1-\alpha)}\left(\frac{G_S}{T_S}\right)^{-1/\sigma} = 2.15,$$

where α is the distribution parameter attributed to grassland G in the CES function, T denotes tilled land, and σ is the constant substitution elasticity between G and T. The subscript refers to Sweden. Using the Swedish ratio $G_S/T_S = 0.26$ and the conjecture $\sigma = 2$, we find $\alpha = 0.52$.

Assuming these parameters to be valid for Norway, equal shares between grassland and tilled land implies:

$$\frac{\alpha}{(1-\alpha)}\left(\frac{G_S}{T_S}\right)^{-1/\sigma} = \frac{0.52}{(1-0.5)}\left(\frac{1}{1}\right)^{-1/2} = 1.09.$$

We see that the results deduced from Drake also indicate that grazing land is only slightly more appreciated than tilled land when both types are available in equal amounts. The Drake study involved no flowery meadows, but it is reasonable to believe that the relative valuation between flowery meadows versus tilled land and grassland should be closer to 1 than the model results indicate.

The comparison to the Drake study suggests that the optimal solution should include close to equal shares of tilled land and grassland while it is reasonable to believe that flowery

[10] This follows from Table 3. An optimal solution implies: $MWP_j = SUBSIDY_j \ \forall j \in$ {tilled, grassland, flowery meadows}. Therefore, if the subsidy differs between land types, the MWPs also have to differ.

[11] See Brunstad et al. (1999). They assume that the willingness to pay (WTP) for cultural landscape is a function of total land use (L): $WTP = B L^{\varepsilon}$, where B is a parameter and $\varepsilon < 1$ implies that MWP is a decreasing function of L. The CES production function for landscape in the WTP function has the form: $L = \beta\left[\alpha G^{\frac{\sigma-1}{\sigma}} + (1-\alpha)T^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$. The marginal rate of substitution between grazing and tilled land then follows as: $\frac{\partial WTP}{\partial G} / \frac{\partial WTP}{\partial T} = \frac{\alpha}{1-\alpha}\left(\frac{G}{T}\right)^{\frac{-1}{\sigma}}$.

meadows should have a higher share.[12] Table 5 provides results under different assumptions with respect to the composition of farmland. The second row assumes equally distributed shares as in the previously described solution. In the third row, the share of land maintained as flowery meadow is allowed to increase to 0.4 while tilled land, grazing pastures and mowed land are reduced to 0.2. The last row assumes, as an extreme, that the different land types are perfect substitutes.

[Table 5]

Not surprisingly, the results show clearly that production levels, as well as the intensity in production, declines in lines with assumptions that involve higher valuation of flowery meadows compared to grassland and tilled land, while economic welfare increases substantially. In the case of perfect substitution, 70 per cent of the farmland is flowery meadows. 1/4 is grassland in milk and sheepmeat production, while only 3 per cent is tilled land.

The assumption that the total willingness to pay is sufficient to keep up the present level of farmland is questionable. Based on the Drake study and under different assumptions with respect to parameters that decides how strongly the MWP decreases with rising levels of landscape and the elasticity of substitution between grazing and tilled land, Brunstad et al. (1999) find that the willingness to pay hardly can defend more than 2/3 of the present acreage. If we repeat the initial simulation (equal shares) but confine the level of farmland to 2/3 of the current level, agricultural support decreases further from NOK 10.8 billion to NOK 8.2 billion, which is 40 per cent of the present agricultural support.

4. Concluding remarks

The clear message from the model analysis is that a transition from the present amber to a more green agricultural policy not only opens for lower agricultural support and higher economic welfare, but tends to enhance cultural landscape and environmental values. While

[12] The marginal cost in the provision of flowery meadows is substantially lower than for grassland and tilled land. Therefore, if we assume that the relative MWP between flowery meadows and grassland (and tilled land) available in equal amounts is closer to 1, an optimal solution requires a higher share of flowery meadows.

keeping up the level of agricultural land with more variation, less intensity and more grazing animals, the consumers get access to cheaper food and save tax expenses.

In our main scenario, the present level of farmland is maintained with 46 and 59 per cent lower levels of capital and N-fertiliser per unit of land and only 56 per cent of production. Agricultural support is nearly halved, while economic surplus increases with NOK 17.3 billion. We argue that the implicit valuation of cultural landscape as well as the relative valuation of grassland compared to low-cost flowery meadows is too high in the simulation, which suggest that the potential gains could be even higher.

Policy instruments that are targeted towards amenity benefits and environmental services, and not at food production, are a prerequisite for these gains. A flexible production technology that allows substitution is, however, also required. In the model simulation, substitution takes place both at farm and sector level. Land replaces other factors of production, like capital and fertilizer that do not necessarily enhance the value of the cultural landscape. As a side effect production declines and more food is imported, which weakens the trade distorting effect of the Norwegian agricultural policy.

Further work in this area should involve better estimates on the willingness to pay for different attributes of the northern cultural landscape, considering specific characteristics of the region in question related to culture, income and production conditions. On the supply side further improvements should include more farm technologies directly targeted on cultural landscape, rather than on food production alone, e.g., specialized grazing animals adapted to the cold Norwegian climate.

References

Blandford, D. and R. Boisvert. 2002. Multifunctional Agriculture and Domestic/International Policy Choice. Estey Centre Journal of International Law and Trade Policy 3: 106-18.

Boisvert, R.N. 2001. A note on the concept of jointness in production. Multifunctionality: Towards an Analytical Framework, Annex 1. Paris: OECD.

Britz, W. and T. Heckelei. 2008. Recent Development in EU Policies - Challenges for Partial Equilibrium Models , invited paper presented at the 107th EAAE Seminar "Modeling of Agricultural and Rural Development Policies". Sevilla, Spain, January 29th -February 1st, 2008

Brunstad, R.J., I. Gaasland and E. Vårdal. 1999. Agricultural production and the optimal level of landscape preservation. Land Economics 75: 538–546.

Brunstad, R.J., I. Gaasland and E. Vårdal. 2005a. Multifunctionality of agriculture: An inquiry into the complementarity between landscape preservation and food security. European Review of Agricultural Economics 32:469–488.

Brunstad, R.J., I. Gaasland and E. Vårdal. 2005b. Efficiency losses in milk marketing boards - the importance of exports. *Nordic Journal of Political Economy* 31:77-98.

Buysse, J., G. Van Huylenbroeck and L. Lauwers. 2007. Normative, positive and econometric mathematical programming as tools for incorporation of multifunctionality in agricultural policy modelling. Agriculture, Ecosystems & Environment 120(1): 70-81.

Dillman B.L. and J.C. Bergstrom. 1991. Measuring environmental amenity benefits of agricultural land. In: N. Hanley, Editor, Farming and Countryside, CAB International, Wallingford, UK.

Drake, L. 1992. The non-market value of Swedish agricultural landscape. European Review of Agricultural Economics 19: 351–364.

Kaltenborn, B.P. and T. Bjerke. 2002. Associations between environmental value orientations and landscape preferences. Landscape and Urban Planning 59: 1–11

Lopez, R.A., F.A. Shah and M.A. Altobello. 1994. Amenity benefits and the optimal allocation of land. Land Economics 70: 53–62.

Mittenzwei, K. and I. Gaasland. 2008. Dokumentasjon av JORDMOD- modellbeskrivelse og analyse. NILF-rapport no. 3, Norwegian Agricultural Economics Research Institute, Oslo.

Mittenzwei, K., W. Fjellstad, W. Dramstad, O. Flaten, A.K. Gjertsen, M. Loureiro and S.S. Prestegard. 2007. Opportunities and limitations in assessing the multifunctionality of agriculture within the CAPRI model. Ecological Indicators 7(4): 827-838.

OECD. 2007. Agricultural policies, markets and trade in OECD countries. Monitoring and evaluation 2003. Paris: Organisation for Economic Co-operation and Development.

Peterson, J.M., R.N. Boisvert and H. de Gorter. 2002. Environmental policies for a multifunctional agricultural sector in open economies. European Review of Agricultural Economics 29: 423–443.

Piorr, H.P. 2003. Environmental policy, agri-environmental indicators and landscape indicators. Agriculture, Ecosystems & Environment 98(1): 17-33.

Schläpfer F. and N. Hanley. 2003. Do Local Landscape Patterns Affect the Demand for Landscape Amenities Protection? Journal of Agricultural Economics 54(1): 21-34

Schläpfer, F. 2007. Demand for public landscape management services: Collective choice-based evidence from Swiss cantons. Land Use Policy 24(2): 425-433

Sommersel G-A. and T. Alm. 1996. Slått – eller ljåens landskap. Ottar nr. 209: 6-9.

Christoffersen, K., Rysstad, S. and J. Simonsen. 1992. Avgift på nitrogen. pp 179-208. In: Simonsen and Vatn (eds). Landbruk i endring fra opptrapping til omstilling. Universitetsforlaget. Oslo.

Vatn, A. Bakken, L. Botterweg, P. and E. Romstad. 1999. ECECMOD: an interdisciplinary modelling system for analyzing nutrient and soil losses from agriculture. Ecological Economics 30(2): 189-206

Vedeld, P.O. 1998. Farmers and Fertilizers – A Study of Adaptation and Response to Price Change among Norwegian Farmers. Dissertation no. 1998:3 Department of Economics and Social Sciences. Agricultural University of Norway. Ås.

Table 1. Amber versus green policy; main indicators

	Amber policy (base solution - 2003)	Green policy
(column no.)	(1)	(2)
Production (mill. kg/liter)		
Cow milk	1534	1039
Goat milk	19	8
Beef- and vealmeat	81	47
Sheepmeat	27	20
Pigmeat	111	0
Poultrymeat	51	0
Eggs	53	56
Food grains	240	46
Coarse grains	936	545
Potatoes	290	295
Index of production	*1*	*0.56*
Land use (1000 ha)		
Grassland, infield	531	461
Grazing pastures	161	213
Mowed grassland	370	248
Tilled land	322	213
Food grains	52	11
Coarse grains	249	186
Potatoes, oilseed rape, peas	21	16
Flowery meadows	0	176
Total (infield)	853	853
Outlying fields, grazing (highland; wooded pastures)	6300	6300
Intensity		
Main inputs		
Capital (NOK pr ha)	50,050	27,124
Labor (hours pr ha)	12.17	7,5
Feed, purchased (feed units pr ha)	1868	876
Nitrogen (kg pr ha)		
Wheat	155	95
Grassland, ploughed	192	146
All infield land types, average	162	67
Yield (kg pr ha)		
Wheat	4620	4230
Grassland, ploughed	4090	3926
Dairy farms		
Milk per cow (liter per year)	5900	7407
Fodder per cow (feed units per year)	4852	6178
% roughage	68	65
Agricultural support (billion NOK)	20.5	11.0
+ Market price support	9.5	1.8
+ Output subsidies	2.8	0
+ Land subsidies	3.1	9.5
+ Other input subsidies	5.1	0
- Tax on fertilizer	0	0.3
Total support NOK pr ha	23,850	12,890
Economic Surplus (billion NOK)	19.2	36.5
Economic surplus NOK pr ha	22,415	42,760

Table 2. Composition of land use in central and rural areas

	Amber policy (base solution - 2003)	**Green policy**
Central areas		
Farmland (1000 ha)	332	332
..share:		
Tilled land	(0.63)	(0.25)
Grazing pastures	(0.13)	(0.25)
Mowed grassland	(0.24)	(0.26)
Flowery meadows	(-)	(0.24)
Outlying fields (1000 ha)	2385	2385
Rural areas		
Farmland (1000 ha)	521	521
..share:		
Tilled land	(0.21)	(0.25)
Grazing pastures	(0.23)	(0.25)
Mowed grassland	(0.56)	(0.31)
Flowery meadows	(0.00)	(0.19)
Outlying fields (1000 ha)	3915	3915

Table 3. Green policy – subsidy rates

	Subsidy (NOK pr ha)	Total subsidy (million NOK)
Central areas		
Tilled land	10,015	830
Grassland	11,893	1,993
Flowery meadows	3,300	261
Outlying fields	291	618
Rural areas		
Tilled land	10,282	1,340
Grassland	10,581	3,103
Flowery meadows	2,430	235
Outlying fields	259	1014

Table 4. Green policy – the importance of flowery meadows (NOK billion)

		Green policy	
	Amber policy	Exclusive of flowery meadow technology	Inclusive of flowery meadow technology
Total support	20.5	13.5	11.0
Economic welfare	19.2	34.1	36.5

Table 5. Sensitivity with respect to composition of farmland

	Production (base=100)	Ec. welfare (NOK pr ha)	Support (NOK pr ha)	Capital (NOK pr ha)	Labor (hours pr ha)	Nitrogen (kg pr ha)
Base solution	100	22,415	23,850	50,050	12.17	162
Equal shares	56	42,760	12,941	27,124	7.5	67
More flowery meadows	50	44,530	11,636	23,465	6.9	56
Perfect substitution	35	47,757	8,431	14,856	5.5	29