ENARPRI

Working Paper No. 13
July 2005

Thematic Network on Trade Agreements
and European Agriculture

EVALUATING THE IMPACT OF ALTERNATIVE AGRICULTURAL POLICY SCENARIOS ON MULTIFUNCTIONALITY

A CASE STUDY OF FINLAND

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This series of Working Papers is published by CEPS for ENARPRI (European Network of Agricultural and Rural Policy Research Institutes). Heikki Lehtonen and Jyrki Niemi are with the MTT Agrifood Research Finland, Helsinki. Jussi Lankoski is currently working at the OECD Agriculture Directorate, Paris, France. This paper was first presented at an ENARPRI workshop, 17-18 January 2005, in Brussels, then updated in June 2005. Comments are most welcome to the authors, email heikki.lehtonen@mtt.fi; jussi lankoski@oecd.org, jyrki.niemi@mtt.fi. Unless otherwise indicated, the views expressed are attributable only to the authors in a personal capacity and not to any institution with which they are associated.

ISBN 92-9079-583-2
No. 13/July 2005
Available for free downloading from the CEPS website (http://www.ceps.be)
or the ENARPRI website (http://www.enarpri.org)

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European Network of Agricultural and Rural Policy Research Institutes

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Abstract

This paper provides first results of the sector-model approach to analysing the effects of alternative policy scenarios on the multifunctional role of Finnish agriculture. In terms of environmental non-commodity outputs, this study focuses on nutrient runoffs, landscape diversity and biodiversity. As regards other non-commodity outputs, the paper considers rural socio-economic viability. The results suggest that, on the whole, reform of the common agricultural policy is not likely to result in any drastic decline of agricultural production in Finland. The amount of green fallow will increase considerably when agricultural support payments are decoupled from production, and as a result the remaining cultivated agricultural land will become biologically richer. The agricultural labour force is likely to decrease substantially irrespective of agricultural policy. The study concludes that the credibility of the production economics and biological relationships of the economic model determine the validity of the results of the many indicators examined. Further, the economic logic of microeconomic simulation models provides a consistent assessment of the many aspects of multifunctionality.

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1. Introduction

Evaluating changes in such a broad and often vaguely defined area as multifunctionality is by no means an easy task. It may be that the vagueness of concepts such as 'sustainable development' and 'multifunctionality', which can be understood in many ways depending on the context, is in fact what makes them such popular policy goals. In this paper we try to evaluate the effects of agricultural policies on different dimensions of multifunctionality in a consistent manner. Since we are agricultural economists, our tool is microeconomics-based economic modelling. This approach may be considered biased since certain dimensions of multifunctionality refer to biological and social relationships that may not be sufficiently taken into account in economic models. Nevertheless, we find in economic logic an approach that provides a sufficiently simple way of reasoning that facilitates a consistent analysis. Special emphasis should be given to its different dimensions. For example, biological relationships, physical material flows and social phenomena require special efforts when analysing the impacts of very different agricultural policies on some selected multifunctionality indicators, and we feel that a simple calculation of many indicators on the basis of existing economic models may provide misleading results. A specific research project may be required to clarify and set up the relevant production functions and relationships necessary for a credible assessment of the specific indicators of multifunctionality.

The rest of this paper is organised as follows. In section 2 we clarify the concept of multifunctionality we have in mind, as well as our principal approach and the main challenges in evaluating it. Section 2 presents the agricultural sector model employed by the study as well as the selected multifunctionality indicators used in the calculation. In section 4, alternative agricultural policy scenarios are listed and interpreted. Section 5 lays out the indicator results from the sector model. Finally, the results are evaluated and the applicability of the chosen approach is discussed (section 6).

2. Definition of multifunctionality and our approach to its evaluation

The notion of *multifunctional agriculture* refers to the fact that agricultural production provides not only food and fibre but also different non-market commodities. These non-commodity outputs include the impacts of agriculture on environmental quality, such as rural landscape, biodiversity and water quality. Often this list also includes the socio-economic viability of the countryside, food safety, national food security and animal welfare together with cultural and historical heritage. There is no universally accepted definition of multifunctionality, and the emphasis given to various types of non-commodities differs. OECD (2001) provides a working definition of multifunctionality. This definition gives as the fundamentals of multifunctionality i) the existence of joint production of commodity and non-commodity outputs and ii) the fact that some non-commodity outputs exhibit the characteristics of externalities or public goods (OECD, 2001, p. 13). Both theoretical and applied work has tried to push forward this working definition.

Academic research on multifunctionality has mainly focused on the environmental dimension of multifunctionality. The reason for this is evident: Pareto optimality requires that all positive and negative externalities should be internalised, thus giving a firm theoretical basis to the environmental dimension multifunctionality. Boisvert (2001), Romstad et al. (2000), Guyomard & Levert (2001), Anderson (2002), Paarlberg et al. (2002), Vatn (2002), Peterson et al. (2002), Lankoski & Ollikainen (2003), Guyomard et al. (2004) and Lankoski et al. (2004) focus on the properties and policy design of multifunctional agriculture either in a closed economy or in an international trade framework. All these studies approach multifunctionality with the help of the theory of joint production.

None of the previous papers have focused on the non-public good aspects (such as rural viability or food security) of multifunctional agriculture. The decision of whether aspects other than these public goods should be introduced to the social welfare function of agriculture is a complex question. As OECD (2001) observes and, for instance, Anderson (2002) argues, food security and rural viability cannot entirely be subsumed into the category of public goods. Very recently Ollikainen & Lankoski (2004) have enlarged the conventional public goods and bads framework to include non-public good aspects through rural viability. Following OECD (2001), they express rural viability through the employment effects of agricultural production. They demonstrate that rural viability moderates policy towards public goods (environmental non-commodity outputs) because society trades-off public good aspects for viability aspects.

An important and so far nebulous issue in the literature on multifunctional agriculture is the fact that joint production between commodity and non-commodity outputs naturally differs among alternative production lines. For example, milk production can be considered as a truly multifunctional production activity (both in terms of environmental non-commodity outputs as well as rural viability aspects), which, however, differs much from the multifunctionality associated with crop production. Previous literature has focused on policy packages mainly within crop production (see e.g. Guyomard et al. 2004 and Lankoski et al. 2004), but not in alternative production lines. Hence, an important research question arises: How does multifunctional agricultural policy affect the relative profitability, public goods and viability aspects across alternative production lines within agriculture? The main research question in this paper is how alternative policy scenarios affect the relative profitability of different production lines and how the supply of joint non-commodity outputs change as a result of profitability changes. Moreover, we analyse the merits of environmental cross-compliance schemes to address multifunctionality.

We examine this problem in a dynamic regional sector model of Finnish agriculture (DREMFIA) (for a thorough description of the model see Lehtonen, 2001). This model is employed to assess the effects of alternative policy scenarios on the multifunctional role of Finnish agriculture. In terms of environmental non-commodity outputs, we focus on nutrient runoffs, landscape diversity and biodiversity. We use regional nutrient surpluses (soil-surface balance method) for nitrogen and phosphorus as a proxy for nutrient runoffs and resulting surface-water quality impairment. Physical input flows are particularly relevant in analysing environmental effects and adjustments to agricultural policies. Evaluation of nutrient balances in very different agricultural scenarios is a challenging task since drastic changes in policies may imply larger changes in the use of fertilisers, manure and feed stuffs, and in the resulting crop and animal yields, than observed in history. First, it is crucial that total *quantities* of inputs, and not only the total *values* of inputs and outputs, are validated to observed aggregate levels in the economic model. Second, not only historical farm-level data on physical inputs and outputs should be used. Experimental and research data may reveal important relationships between physical inputs and outputs. The available relevant crop and animal feeding research results have been used in setting production functions in the model while the level of physical inputs and outputs is validated to observed levels. These two aspects are not always easy to combine. Nevertheless, if the model is also consistent in terms of the physical flows of inputs and products, and in terms of yield responses to large changes in prices and supports, then the indicator changes may be credible as well, up to our current knowledge of the biological production process. The continuous updating of farm-level and biological research information is necessary. The calculation of many agri-environmental indicators should not be done as a careless routine. On the contrary, it requires conscientious assessment: Does the data used in the economic model tell us what will happen in the production process in very different policy scenarios?

Once the crucial relationships of the bio-physical production process have been determined using the best available data and knowledge, the resulting changes in production facilitate a rather straightforward calculation of a number of indicators. For assessing landscape diversity, we employ Shannon's diversity index (SHDI) to assess the richness (number of different land-cover classes, i.e. cultivated crops and bare and green fallow) and evenness (uniformity of distribution between land-use types) of agricultural land use under different policy scenarios. The area under different types of wildlife habitats is used as a proxy for biodiversity.

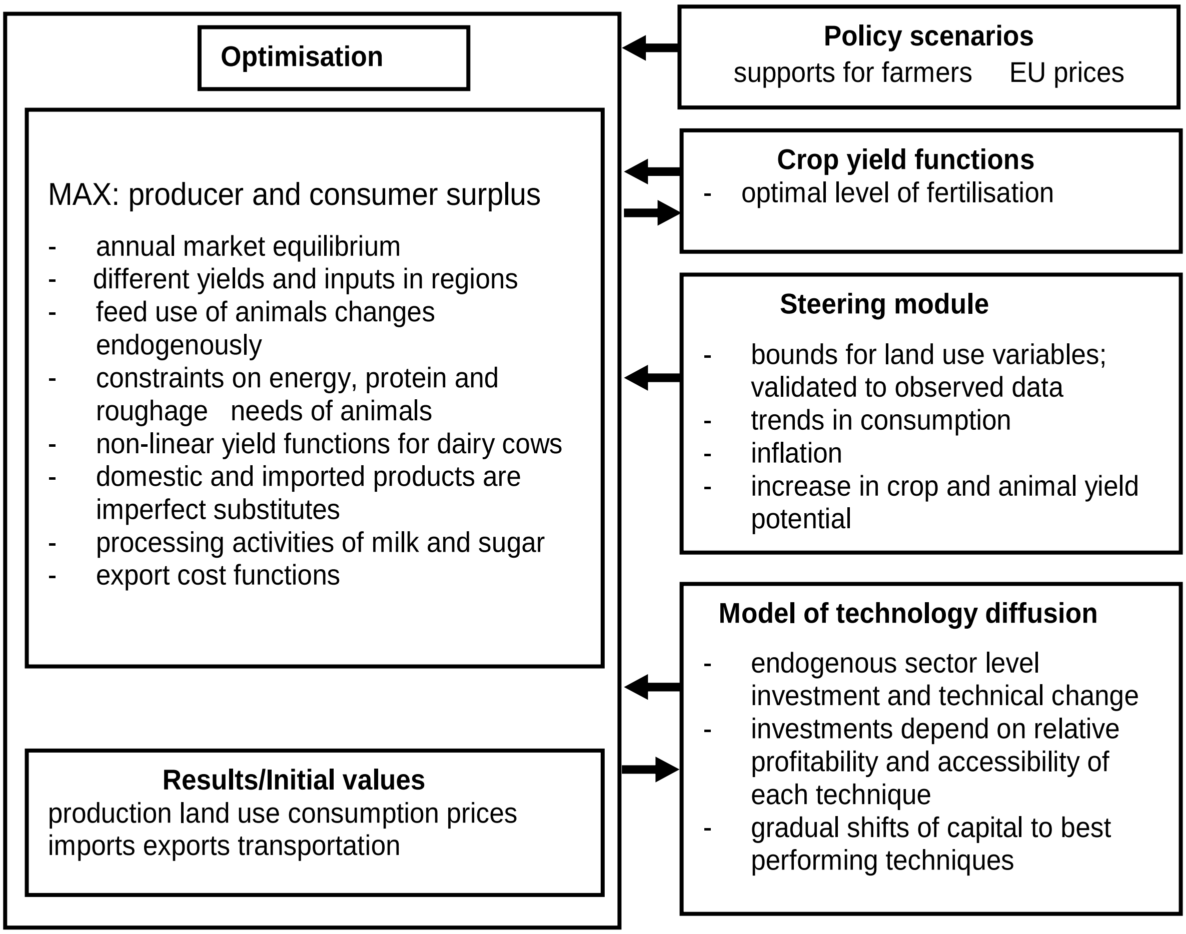
As regards other non-commodity outputs, one of our interests is rural socio-economic viability. In line with Ollikainen & Lankoski (2004), we describe the core economic content of rural viability by employment in agriculture and in the rural sectors serving agriculture. Our approach is to employ an economic sector-level model that does not explicitly consider linkages between agriculture and other sectors of the national economy. Hence the approach cannot provide any final results concerning the employment effects of agricultural policies. The approach taken here does, however, consider in a detailed way the linkages between different production lines in agriculture. Especially the changes in relative profitability in different agricultural activities affect production volumes and land use since land is a restricted limited resource for agricultural activities. Agricultural land and production equipment (buildings and machinery), on the other hand, are of low value in alternative uses in Finland where the countryside is relatively sparsely populated. This makes even a partial equilibrium approach interesting in evaluating the socio-economic effects of agricultural policies.

3. The model and multifunctionality indicators

3.1 The sector model

DREMFIA is a dynamic recursive model and includes 17 production regions. The model provides effects of various agricultural policies on land use, animal production, farm investments and farmers' income. The model consists of two major parts: 1) a technology diffusion model that determines sector-level investments in different production technologies, and 2) an optimisation routine that simulates annual production decisions (within the limits of fixed factors) and price changes, i.e. supply and demand reactions, by maximising producer and consumer surpluses subject to regional product balance and resource (land and capital) constraints (Figure 1).

Figure 1. Basic structure of the DREMFIA mode



In the DREMFIA model, annual land use and production decisions from 1995 to 2020 are simulated by an optimisation model that maximises producer and consumer surplus subject to regional product balance and resource (land) constraints. Final products and intermediate products may be transported between the regions. The optimisation model is a typical spatial price equilibrium model (see for example Cox & Chavas, 2001), except that no explicit supply functions are specified (i.e. supply is a primal specification). Furthermore, foreign trade activities are included in DREMFIA. The Armington assumption (Armington, 1969), which is a common feature in international agricultural trade models but less common in one-country sector models, is used. Imported and domestic products are imperfect substitutes, i.e. endogenous prices of domestic and imported products are dependent. There are 18 different processed milk products and their regional processing activities in the model.

Four main areas are included in the model: southern Finland, central Finland, Ostrobothnia (the western part of Finland) and northern Finland (Figure 2). Production in these areas is further divided into sub-regions on the basis of the support areas. In total, there are 17 different production regions. This allows a regionally disaggregated description of policy measures and production technology. The final and intermediate products move between the main areas at certain transportation costs.

Figure 2. Main regions in the dynamic regional sector model of Finnish agriculture (DREMFIA)

Technical change and investments, which imply the evolution of farm size distribution, are modelled as a process of technology diffusion. Investments are dependent on economic conditions such as interest rates, prices, support, production quotas and other policy measures and regulations imposed on farmers. The model of technology diffusion follows the main lines of Soete & Turner (1984).

Two crucial aspects about diffusion and adaptation behaviour are included: first, the profitability of a new technique; and second, the risk and uncertainty involved in adopting a new technique. The information about and likelihood of adopting a new technique will increase as its use becomes widespread.

To cover the first aspect, the likelihood of adopting a new technique ($f_{\beta\alpha}$) is made proportional to the fractional rate of profit increase in moving from technique α to technique β, i.e. $f_{\beta\alpha}$ is proportional to $(r_\beta - r_\alpha)/r_\alpha$, where r_α is the rate of return for technique α and r_β is the rate of return for technique β. The second aspect is modelled by letting $f_{\beta\alpha}$ be proportional to the ratio of the capital stock in β technique (K_β) to the total capital stock K (in a certain agricultural production line), i.e. K_β/K. The total investments to α technique, after simplification, is:

$$I_\alpha = \sigma(Q_\alpha - wL_\alpha) + \eta(r_\alpha - r)K_\alpha \qquad (1)$$

where σ is the savings rate (proportion of economic surplus re-invested in agriculture), η is the farmers' propensity to invest in alternative techniques, Q_α is the total production-linked revenue for technique α, w is a vector of input prices, L_α is a vector of variable production factors of technique α, and r is the average rate of return on all techniques.

The interpretation of the investment function is as follows. If the value of η was zero, then (1) would show that the investment in α technique would come entirely from the investable surplus generated by α technique. For $\eta \neq 0$, the investment in α technique will be greater or less than the first term on the right-hand side, depending on whether the rate of return on α technique is greater or less than the average rate of return on all techniques (r). This seems reasonable. If a technique is highly profitable, it will tend to attract investments and, conversely, if it is relatively less profitable, investments will decline. If there are no investments in α technique at some time period, the capital stock K_α decreases at the depreciation rate. To summarise, the investment function (1) is an attempt to model the behaviour of farmers whose motivation to invest is greater profitability, but who, nevertheless, will not adopt the most profitable technique immediately because of uncertainty and other retardation factors.

The investment function (1) shows that the investment level is strongly dependent on capital already invested in each technique. This assumption is consistent with the conclusions of Rantamäki-Lahtinen et al. (2002) and Heikkilä et al. (2004), i.e. farm investments are strongly correlated with earlier investments, but poorly correlated with many other factors, such as liquidity or financial costs. Other common features, except for the level of previous investments of investing farms, were hard to find. Hence, the assumption made on cumulative gains from earlier investments seems to be supported by the findings of Rantamäki-Lahtinen et al. (2002) and Heikkilä et al. (2004). The investment function allows regional re-location and concentration of production and technical change at the same time.

Three dairy techniques (representing α techniques) and corresponding farm size classes have been included in the DREMFIA model: farms with 1-19 cows (labour-intensive production), farms with 20-49 cows (semi-labour intensive production), and farms with 50 cows or more (capital-intensive production). The parameter σ has been fixed to 1.07, which means that the initial value 0.85 (i.e. farmers re-invest 85% of the economic surplus on fixed factors back into agriculture) has been scaled up by 26%, which is the average rate of investment support for dairy farms in Finland. The value of η (fixed to 0.77) is then used as a calibration parameter, which results in investments that facilitate the *ex post* development of dairy farm structure and milk production volume. The chosen combination of the parameters σ and η (1.07:0.77) is unique in the sense that it calibrates the farm size distribution to the observed farm size structure in 2002 (Farm Register, 2002). Choosing larger σ and smaller η exaggerates the investments on small farms, and choosing smaller σ and larger η exaggerates the investments on large farms. Choosing smaller values for both σ and η results in investment and production levels that are too low, and choosing larger values for both σ and η results in overestimated investment and production levels, compared with the *ex post* period.

Use of variable inputs, such as fertilisers and feed stuffs, is dependent on agricultural product prices and fertiliser prices through production functions. The nutrients from animal manure are explicitly taken into account in the economic model. The feeding of animals may change provided that nutrition requirements, such as energy, protein, phosphorous and roughage needs, are fulfilled. In the feasible range of inputs per animal, production functions can be used to model the dependency between the average milk yield of dairy cows and the amount of concentrates and other grain-based feed stuffs. Since in historical farm-level data there are relatively less low or high levels of concentrates, the dataset is enriched by experimental data. A number of trials have been undertaken by agro-biological research on the yield-response effects of significant changes in animal feeding and crop fertilisation (Sairanen et al., 1999, 2003; Bäckman et al., 1997). In the case of dairy cows and field crops, the uniform pattern of the results of many similar trials facilitates the inclusion of the data material in the estimation of the production functions. Hence, the production functions in the model include not only the observed historical variation in the use of inputs but also responses to large changes in the use of inputs rarely observed in actual farms. This means that if agricultural policies imply significant changes in feed or fertiliser use, for example through relative input and output prices or restrictions on land use, the most relevant biological relationships are taken into account in calculating the economically rational production adjustment. The new farm-level data on animal feeding, however, is richer (there is more variation) than the earlier one as farmers have gradually increased the use of feed concentrates (Pro Agria, 2005), so we believe that the role of experimental data decreases over time.

Milk quotas, which constrain milk production at farm and country level, are traded within three separate areas in the model. Within each quota-trade area, the sum of quotas purchased must equal the sum of quotas sold. The price of the quota is the weighted sum of the shadow values of an explicit quota constraint in each sub-region. Milk quota trade has an important role in facilitating improvements in production efficiency. The observed milk quota prices have served a valuable reference point in the model validation.

The overall model replicates very closely the *ex post* production development in 1995-2003. Official agricultural production and price statistics[1] have been used as the basis in validation. Calibrating the unobserved parameters of the investment model (discussed above) is a significant part of the overall validation of the model. Price changes in 1995-2003 have been validated through calibrating the unobserved parameters in the Armington system and in export-cost specification (see Lehtonen, 2001, for details). The total value of each single input, calculated from input specifications of many production activities in the model, has been checked and validated using cross-sectional statistical data (Statistics Finland, 1995 and 2003). Furthermore, total *quantities* of inputs and not only the total *values* of inputs and outputs are validated to observed aggregate levels. Hence, the validation of the model is also consistent in terms of the physical flows of inputs, such as fertilisers and feed stuffs. Physical input flows are particularly relevant in analysing environmental effects and adjustments to large changes in agricultural policy. In the validation process, two individual years were excluded due to very unusual weather conditions and subsequent crop failures.

The long- and medium-term changes in aggregate amounts and regional location of production are consistent in the economic sense since the model is built to reach a steady-state equilibrium in a 10-15 year period given no further policy changes. There is a built-in gradual adjustment in the model as fixed production factors and animal biology make immediate adjustments costly. Non-linear production functions in the model are concave, i.e. the marginal productivity is decreasing with output. The steady-state equilibria found at the whole country level are also owing to limited domestic consumption of food stuffs and expensive exports because of low EU price level compared with the production and transportation costs. Another reason for steady states in 10-15 year period is the Armington assumption and the assumption that consumers have some preference as to domestic products, i.e. scarcity of domestic food stuffs slightly increases producer prices, even though this increase is relatively low (only 1-10% on producer price level) in the model, when validated to the observed price development. A more detailed presentation of the model and its parameters can be found in Lehtonen (2001; partly updated in 2004).

3.2 Multifunctionality indicators

The available indicators derived from the DREMFIA model output are listed in Table 1. Not all the indicators are listed in this paper, however. Most of the indicators presented in this paper, such as production volumes, hectares of crops, nutrient balances and incomes, as well as direct agricultural employment, are calculated directly using the DREMFIA sector model. Indirect agricultural employment was calculated using regional input-output tables that take into account both upstream and downstream indirect employment (Knuuttila, 2004).

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[1] See http://matilda.mmm.fi.

Table 1. The applied indicators, derived from DREMFIA model, in the agricultural policy scenario analysis

Applied indicator	Measured quantity	Indicator reflecting	Strategic goal of indicator
Total number of animal units up to 2020	Animal units	The scale and long-term economic viability of aggregate animal production	To conclude the relative economic viability of animal production in different policy scenarios
Number of bovine animal units	Animal units	The scale and long-term economic viability of dairy and beef production	To conclude the relative economic viability of dairy and beef production in different policy scenarios
Number of pig animal units	Animal units	The scale and long-term economic viability of pig production	To conclude the relative economic viability of pig production in different policy scenarios
Number of poultry animal units	Animal units	The scale and long-term economic viability of poultry production	To conclude the relative economic viability of poultry production in different policy scenarios
Total cultivated area (excluding set-aside) up to 2020	Hectares	Incentives for active crop production	Changes in incentives for active crop production
Set-aside area	Hectares	Incentives for fulfilling cross-compliance criteria and minimising costs	Changes in incentives in fulfilling cross-compliance criteria and minimising costs in different policy scenarios
Unused area	Hectares	Share of abandoned agricultural land owing to unprofitable production	Changes in the share of abandoned land owing to unprofitable production
Grass area	Hectares	The scale of grass feed production; incentives for grass feed use and bovine animal production	Changes in the scale and incentives for grass feed production in different agricultural policy scenarios
Grain area	Hectares	The scale and incentives for grain production	Changes in the scale and incentives for grain production in different policy scenarios
Nitrogen balance on cultivated area[1]	kg/ha	Nitrogen-leaching potential from cultivated land	Changes in the nitrogen-leaching potential in different policy scenarios
Phosphorous balance on cultivated area[1]	kg/ha	Phosphorous-leaching potential from cultivated land	Changes in phosphorous-leaching potential in different policy scenarios

Table 1. Cont'd.

Habitat index	(scale of 0-100)	Value of agricultural land for certain indicator species	To ascertain the biodiversity effects of agricultural policies
Agricultural income	€ million	The level of economic activities in agriculture	Changes in the level of economic activity in different policy scenarios
Profitability coefficient[2]		Profitability of agricultural production	Changes in profitability of agricultural production in different policy scenarios
Labour hours in agriculture; indirect effects on employment	million hours or 1000 employees	Social sustainability of farmers, the working conditions of agricultural labour	Changes in the number of people employed in agriculture and related professions in different policy scenarios
Agricultural income per hour of labour	€/hour	Economic and social welfare of farmers	Changes in the economic and social viability of agriculture in different policy scenarios

1 The soil surface nitrogen and phosphorus balances are calculated as the difference between the total quantity of nitrogen or phosphorus inputs entering the soil and the quantity of nitrogen or phosphorus outputs leaving the soil annually, based on the nitrogen or phosphorus cycle.

2 The profitability coefficient is a ratio obtained when the agricultural surplus is divided by the sum of the entrepreneur family's salary requirement and the interest requirement on the capital invested.

Source: Authors' data.

Shannon's diversity index (*SHDI*) was applied in the land-cover diversity calculations (McGarigal & Marks, 1995). The index is based on information theory (Shannon, 1948) and it is frequently used in diversity quantifications (Di Falco & Perrings, 2003; Hietala-Koivu et al., 2004). The values of *SHDI* were calculated according to the formula:

$$SHDI = -\sum_{i=1}^{m} \left(P_i \times \ln P_i\right), \qquad (2)$$

where m is the number of land-cover classes, P_i measures the proportion of area covered by land-cover type i and ln denotes natural logarithm. *SHDI* is equal to zero when the agricultural area contains only one land-cover class (i.e. no diversity). The value of Shannon's diversity index increases as the number of different land-cover classes increases and/or the proportional distribution of the area among land-cover classes becomes more equitable. Hence, for a given number of land-cover classes, *SHDI* reaches its maximum when the proportions of land-cover classes are uniform, i.e. $P_1 = P_2 = \ldots = P_m = 1/m$ (McGarigal & Marks, 1995).

In addition to diversity in agricultural land use, we also discuss the potential biodiversity effects of policy scenarios. According to Duelli (1997), biodiversity evaluation at the regional level can be based on landscape parameters. Even though landscape diversity indicators give an overview of biological diversity, there are no general models that relate overall species diversity to landscape diversity (Jeanneret et al., 2003). The relationship thus depends strongly on the organism examined.

The aggregate soil surface balances (surplus/deficit) for nitrogen and phosphorus per cultivated area, excluding set-aside, were calculated by adding the nutrient content of fertilisers, organic manure and nitrogen deposits, and by subtracting the nutrient content of the harvest and losses to the atmosphere. The calculated net nutrient surplus (kg/ha) provides an indicator of the production intensity and of the potential nutrient losses and environmental damage to surface and ground waters.

The amount of pesticide application area was also reported. Chemical pesticides enhance agricultural productivity but also pose potential risks to human health and the environment. They may, for example, cause contamination of surface water.

The habitat index was calculated on the basis of a large-scale dataset of empirical observations concerning butterfly numbers on lands of different crops (Kuussaari & Heliölä, 2004). The butterfly was selected as an indicator species by environmental scientists. It was observed that green set-aside was a more valuable habitat for butterflies by six times than grain fields, whereas field edges provided more valuable habitats by more than seven times and natural meadows provided more valuable habitats for butterflies than grain fields by more than ten times. These relative weights were used directly when calculating a habitat index as a linear vector, divided by overall hectares of agricultural lands. Hence, the resulting index represents an average biodiversity value of all agricultural land, in comparison with natural meadows. In 1995-2004 the calculated habitat index was valued between 20 and 25. The index would be 100 if all agricultural lands were changed to natural meadows.

4. Alternative agricultural policy scenarios

Based on the current multilateral trade negotiations and the most recent indications of negotiation positions from various WTO members, there are a number of interesting policy scenarios that could be analysed. In response to the WTO's framework agreement approved in Geneva on July 2004 and the possible conclusion of the Doha round, the following scenarios are formulated below.

4.1 The baseline scenario (BASE)

The baseline scenario (BASE) corresponds to the continuation of the Agenda 2000 agricultural policy (agreed in Berlin in 1999) over the medium term. The purpose of the baseline is not as a forecast of the future but to establish a yardstick against which policy simulations can be judged. The baseline simulation is a view of the world where policies remain unchanged. The impact of EU enlargement has not been incorporated into the baseline. It is important, however, to remember that the baseline scenario includes the reductions in intervention support prices and future increases in quotas in the dairy sector that were already politically agreed in Berlin 1999. Therefore, it is assumed that the producer price of milk would fall by 12% in the EU and in Finland until 2008 from the average producer price of 1999-2001.

4.2 Common agricultural policy reform scenario (REF)

The on-going common agricultural policy (CAP) reform scenario (hereafter 'REF' scenario) follows the CAP reform agreement made in June 2003, according to which most direct CAP subsidies will be decoupled from production and paid in a single, lump-sum farm payment based on 2000-02 historical production levels (European Commission, 2003). On options given for the EU member states, the Finnish government has decided that the implementation of the reform will start in 2006. From there on, all CAP arable-area payments will be decoupled from production and a regionalised flat-rate payment will be paid for all farms and all crops (including set-aside, but excluding some permanent crops). Also, decoupled CAP animal support, based on 2000-02 production, will be paid for individual farms. However, 69% of bull premia and 100% of suckler cow premia will remain coupled to production, i.e. paid per animal. The sum of coupled bull and suckler cow premia will not exceed 75% of the bull premia paid in the reference period 2000-02. Overall, 85% of CAP support will be de-coupled. The farm-specific payments of decoupled animal support will later be included in the flat-rate payment. The timetable of the shift of farm-specific top-ups into the flat rate is still open (MAF, 2005).

Receiving decoupled CAP support will not require any agricultural commodity production. Yet farmland has to be kept in good agricultural and environmental condition and this means in practice that land has to be either cultivated or kept as set-aside land. In the REF scenario, no change in the EU level of cereal prices is assumed. The reform of the milk sector will be more radical than the one agreed in Berlin in 1999. The intervention price for butter is reduced 25% (-7% in 2004, 2005, 2006, and -4% in 2007), which is 10% more than that agreed in Agenda 2000. For skimmed milk powder (SMP), prices will be cut by 15% as agreed in Agenda 2000 (but in steps of 5% over three years from 2004-06). In 2007, it is assumed that the overall decrease in the average producer price of milk at the EU level will be 16% down from the 2003 price level, i.e. 4 percentage points more relative to the baseline. The price cuts will be compensated by a direct payment of €35.50 per tonne of milk quota. This payment becomes fully decoupled in 2007. Furthermore, 5% of all direct EU payments will be cut (modulated) from 2007.

As regards multifunctionality issues and indicators, the question here is to evaluate to what extent the 2003 CAP reform, notably the decoupling of agricultural income-support direct aids (with the possibility for each member state to maintain part of these direct aids as coupled support) is likely to have positive or negative impacts on multifunctionality indicators.

4.3 Environmental cross-compliance (ECC)

The environmental cross-compliance (ECC) scenario is identical to the REF scenario, except that one assumes that each member state chooses the full decoupling option and that field edges have to be expanded by 300%, i.e. from 0.5 to 2 metres wide. The idea of this scenario is to test the field edges' contribution to the habitat index and the possible effects on production.

4.4 Attack on domestic support scenario (RED)

The attack on domestic support (RED) scenario assumes, in addition to scenario ECC, that the EU (and Finland) is forced to agree a 20% cut in existing decoupled payments by 2013. By comparing the RED and ECC scenarios, one should be able to say something on the 'relative' efficiency of decoupling as regards multifunctionality.

5. Indicator results from the model

5.1 Continuation of Agenda 2000

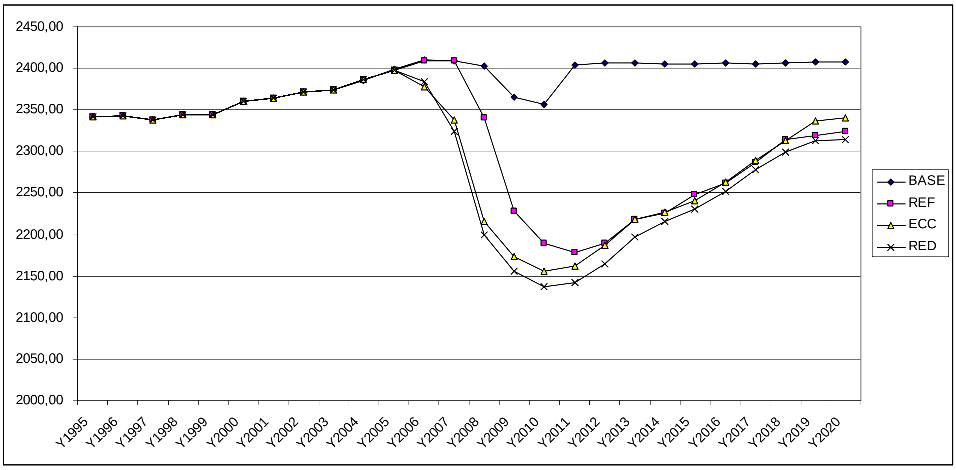
The baseline run of the agricultural sector model indicated (with certain exceptions) that if the Agenda 2000 policy continued, there would be no substantial changes in production volumes. For example, dairy production would remain almost unchanged in all regions. But the total amount of cultivated area, including fallow and cultivated grassland, would decrease significantly. The most important change therefore concerns the amount of marginal farming land taken out of production, the area of which would increase up to 10-15% of all agricultural land. Such a change results mainly from investments in larger dairy facilities, which in turn lead to a regional concentration of agricultural commodity production within each individual region studied. Consequently, the demand for feed (grain and grass) decreases in many areas. This weakens endogenous market prices and the profitability of grain production. Because pork and poultry production also continue to become concentrated into large production units, some agricultural land is left idle in relatively less favourable agricultural areas. The relative increase in the uncultivated land area will be largest in northern Finland, but the absolute changes are largest in southern and central Finland. Soil quality is highly heterogeneous even in southern

Finland. This heterogeneity is partly taken into account since there are 18 production regions in the DREMFIA model. Nevertheless, soil quality is considered homogenous in each region.

5.2 Agenda 2000 vs. the on-going reform of the CAP

In the baseline scenario, milk production remains relatively stable in all regions since milk payments compensating the price reductions of butter and skimmed milk powder are tied to milk quotas. In the CAP reform scenario, the linkage between milk payments and milk quotas is removed. According to the model results, CAP reform is not likely to result in any drastic decline of agricultural production in Finland, on the aggregate. Milk production may reduce substantially, however, in northern Finland, where dairy products dominate. Some decline of production may also take place in central Finland but the decline of production in these areas will be partly compensated by an increase in production in the Ostrobothnia region, which may benefit from the decreasing values of milk quotas under CAP reform. Hence, some milk quotas from central Finland shift to Ostrobothnia. Since milk quotas cannot be sold from southern Finland to Ostrobothnia (the movement of milk quotas has been restricted in three major quota-trading areas, where the number of sold quotas must equal to the number of purchased quotas), the decreased value of milk quotas in southern Finland will facilitate a recovery of milk production from 2010. In northern Finland, which constitutes a third of the quota-trade area, however, not even the reduced milk quota values are sufficient to lead to later recovery in the milk production volume (Figure 3).

Figure 3. Total milk production volume (million litres) in Finland.



Notes: Abbreviations – BASE = Agenda 2000; REF = Luxembourg 2003 reform with national adaptations; ECC = environmental cross-compliance; RED = reduction of CAP payments by 20% until 2013.

This difference results from cuts in the milk price and decoupled CAP payments, which considerably reduce incentives to invest in milk production in the REF scenario. Since many farms are small and production costs are high, most dairy farmers who exit milk production make only the minimum effort to receive the CAP payments, i.e. they leave their land as set-aside. The reduction in overall production volume, on the other hand, provides opportunities for expanding dairy farms (Table 2).

A decreasing number of dairy cows and the partial or full de-coupling of CAP headage payments will gradually result in decreasing beef production and grass area in all parts of Finland. The effects of CAP reform on pork and poultry production will be minor, however.

Table 2. Percentage changes in milk production by 2015 in different scenarios compared with the baseline

	REF			**ECC**			**RED**		
	2010	2015	2020	2010	2015	2020	2010	2015	2020
Southern Finland	-11.1	-9.3	-0.9%	-14.8	-9.2	+1.0%	-14.4	-8.5	+0.5
Ostrobothnia	-4.0	+3.4	+3.7	-2.2	+3.6	+4.9	-3.3	+3.3	+6.1
Central Finland	-5.9	-11.3	-8.9	-9.1	-13.4	-11.8	-9.3	-14.7	-11.7
Northern Finland	-7.4	-18.6	-22.2	-6.5	-16.5	-17.5	-9.1	-20.5	-25,0
Whole country	-7.1	-6.6	-3.4	-8.5	-6.9	-2.8	-9.3	-7.3	-3.9

Notes: Abbreviations – BASE = Agenda 2000; REF = Luxembourg 2003 reform with national adaptations; ECC = environmental cross-compliance; RED = reduction of CAP payments by 20% until 2013.
Source: Authors' calculations.

When comparing the agricultural land-use predictions of the on-going CAP reform scenario to the corresponding results of the extended Agenda 2000 scenario, we found that the REF scenario resulted in an almost four-times larger green fallow area than the BASE scenario. Correspondingly, the areas devoted to barley, oats and grass will be significantly smaller under the REF scenario (Table 3). Only the most feasible areas of earlier grasslands will be used for grain production. In relative terms, the difference in the green set-aside area between the two scenarios was largest in northern and central Finland. In both regions, the green set-aside area will increase significantly as a result of the REF scenario.

Table 3. Percentage changes in land use (1000 ha) by 2015 in different scenarios compared with the baseline scenario

	Cereals area			**Grass area**			**Green set-aside**		
	REF	ECC	RED	REF	ECC	RED	REF	ECC	RED
Southern Finland	-12.8	-13.1	-11.9	-20.4	-23.2	-20.1	+350	+231	+341
Ostrobothnia	-23.2	-25.6	-23.9	-5.2	-2.7	-0.0	+156	+78.7	+143
Central Finland	-45.5	-48.3	-46.8	-11.2	-12.8	-12.6	+440	+357	+450
Northern Finland	+150	+191	+166	-9.7	-13.3	-13.1	+1073	+705	+1089
Whole country	-19.2	-20.2	-18.9	-11.8	-12.3	-11.1	+305	+206	+299

Notes: Abbreviations – BASE = Agenda 2000; REF = Luxembourg 2003 reform with national adaptations; ECC = environmental cross-compliance; RED = reduction of CAP payments by 20% until 2013.

Source: Authors' calculations.

Compared with the baseline scenario, the decoupling of CAP support from production (in the REF scenario, 85% of CAP supports are de-coupled, and in the ECC and RED scenarios 100% of CAP supports are de-coupled) slightly decreases the area under cereal production in southern Finland. The changes in the dairy sector are clearly seen in the proportion of grassland area, which will be approximately 20% smaller in 2015 as a result of the REF scenario. Instead, the fallow area may be over three times larger than that under Agenda 2000. These changes in grassland and fallow areas are also significant in absolute terms, since over a half of the total agricultural area is located in southern Finland.

Ostrobothnia is the second largest agricultural area. If CAP supports are decoupled from production, the area under cereals in 2015 will be over 20% smaller than as a result of the baseline scenario. Fallow area, in turn, will be almost 2.5 times bigger. If CAP support is disconnected from production, the cereals area will decrease (relatively) the most in central Finland. In 2015 it will be close to 50% smaller than as a result of Agenda 2000 policy. The grassland area in turn will be over 10% smaller, but the fallow area may be almost 10 times larger.

The share of agricultural land under grain was about 9% and the share of set-aside was around 4% in northern Finland in 2003. In the BASE scenario, the share of grain reduces further to 3% by 2015. As opposed to the other regions, the on-going CAP reform will not decrease the cereals area of northern Finland. Instead the grain area remains close to the 2003 level, i.e. grasslands, but not grain areas, are converted to set-aside areas. When many northern dairy farmers exit unprofitable dairy production, this not only adds set-aside areas, but may also lead to an increase in grain areas on those former grasslands where the costs of feed-grain cultivation can be covered. The greatest increase is, however, in the fallow area, which will be over 10 times larger as a result of the REF scenario. The area under grass, which already covers close to 90% of agricultural land in northern Finland, will be approximately 10% smaller compared with the baseline scenario. While dairy production reduces by 15-20%, this means that production becomes relatively more extensive.

The decreasing cereals area also means a decreasing area under pesticide application. Everywhere except in northern Finland, the chemical pesticide application area is smaller under CAP reform scenarios than as a result of the baseline scenario, since cereal areas will decrease if direct aid payments are decoupled from production. If we examine the land-use results at the whole country level, the pesticide application areas will be largest as a result of the baseline scenario and smallest as a result of the RED scenario. This will benefit farmland birds for example, since the reduced use of pesticides may increase the amount of insect prey.

The REF scenario will result in lower nitrogen and phosphorus surpluses only temporarily in all regions. Regional concentration of dairy and beef production is stronger in the REF scenario compared with the BASE scenario. This, in turn, will drive up the nutrient balances again. The same kind of development takes place in the REF scenario. Significant regional concentration of dairy production and larger farms imply more intensive grassland management, despite lower milk prices due to CAP reform. For this reason, nutrient balance increases even in central Finland where dairy production volume decreases slightly. The high increases of average nutrient balances in central Finland are partly the result of a drastically diminishing grain area and more intensive dairy production. In central Finland there will be some scarcity of land available for large dairy farms, which will drive up the nutrient balances. The nitrogen and phosphorous balances remain below the baseline scenario levels in southern Finland and also in northern Finland, where the overall milk production volume will decrease considerably, and there is less pressure for intensive dairy production (Table 4).

Table 4. Percentage changes in the aggregate nitrogen and phosphorus balance (kg/ha) by 2015 in different scenarios compared with the baseline

	Aggregate nitrogen balance			**Aggregate phosphorus balance**		
	REF	ECC	RED	REF	ECC	RED
Southern Finland	-17.8	-18.2	-18.5	-2.2	-3.5	-2.3
Ostrobothnia	-7.2	-2.5	-0.0	+5.8	+11.2	+8.1
Central Finland	+10.1	+10.2	+11.1	+19.7	+20.1	+18.7
Northern Finland	-0.1	-6.0	-1.8	-6.9	-7.5	-6.5

Notes: Abbreviations – BASE = Agenda 2000; REF = Luxembourg 2003 reform with national adaptations; ECC = environmental cross-compliance; RED = Reduction of CAP payments by 20% until 2013.

Source: Authors' calculations.

The above-mentioned changes in land allocation lead to a slightly more uneven aggregate land-cover class distribution in southern and central Finland and in Ostrobothnia (see Shannon's diversity index in Table 5). Instead, in northern Finland, the value of SHDI will slightly increase in CAP reform scenarios along with the higher cereals area and uncultivated agricultural area. Increased uncultivated area results in increased Shannon index values in the CAP support-reduction (RED) scenario. Expanded field edges in the ECC scenario provide a further increase of diversity in land use. On the other hand, a reduction of CAP supports does not lead to a decrease in the Shannon index compared with the REF scenario.

Table 5. Percentage changes in Shannon's diversity index and habitat index by 2015 in different scenarios compared with the baseline

	Shannon's diversity index			**Habitat index**		
	REF	ECC	RED	REF	ECC	RED
Southern Finland	-13.7	-6.0	-8.8	+53.7	+30.8	+52.2
Ostrobothnia	-5.6	-2.1	-4.4	+30.0	+12.4	+29.6
Central Finland	-17.7	-7.5	-17.7	+69.5	+52.2	+70.3
Northern Finland	+20.0	+36.4	+24.4	+46.6	+27.2	+43.3

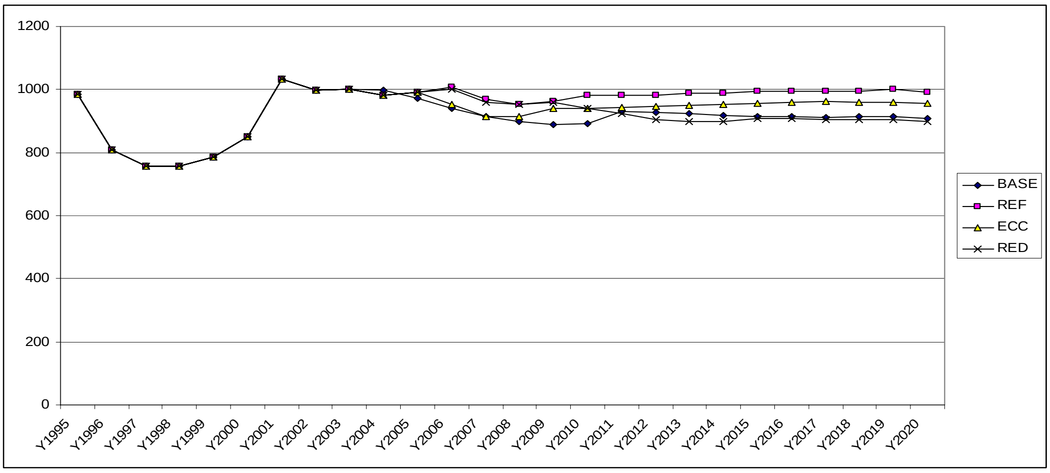
Notes: Abbreviations - BASE = Agenda 2000; REF = Luxembourg 2003 reform with national adaptations; ECC = environmental cross-compliance; RED = Reduction of CAP payments by 20% until 2013.

Source: Authors' calculations.

In order to evaluate changes in biodiversity, a habitat index has been calculated. While the baseline scenario shows gradually decreasing levels of the habitat index on agricultural lands (grass area decreases), the rapid expansion of green set-aside in all other scenarios results in a significant increase in the habitat index. This is because green set-aside is considered almost a more valuable living environment than grain crops by five times for certain indicator species (in this case, butterflies). Nevertheless, if large areas are idled and gradually converted to forest, this will decrease the biodiversity value of agricultural lands. The actual effect on biodiversity in the overall ecosystem (comprising agricultural land, forests, ponds, lakes, etc.) where farmlands are idled, however, is uncertain. Hence the habitat index calculated only shows the value of different uses of agricultural land.

According to the model results, agricultural income, as well as agricultural income per labour hour, is higher in CAP reform scenarios. In the case of partial or full de-coupling, a farmer may reduce relatively less-profitable activities without losing all support. This is a commonly perceived effect of CAP reform and one motivation of it. Yet according to the model results, aggregate agricultural income will decrease in northern Finland due to diminishing dairy production. This is understandable since in the north there are few alternatives to dairy and beef (Figure 4 and Table 6).

Figure 4. Agricultural income (€1000) in Finland



Notes: Abbreviations - BASE = Agenda 2000; REF = Luxembourg 2003 reform with national adaptations; ECC = environmental cross-compliance; RED = reduction of CAP payments by 20% until 2013.

Source: Authors' calculations.

Table 6. Percentage changes in total agricultural income and income per hour of labour by 2015 in different scenarios compared with the baseline

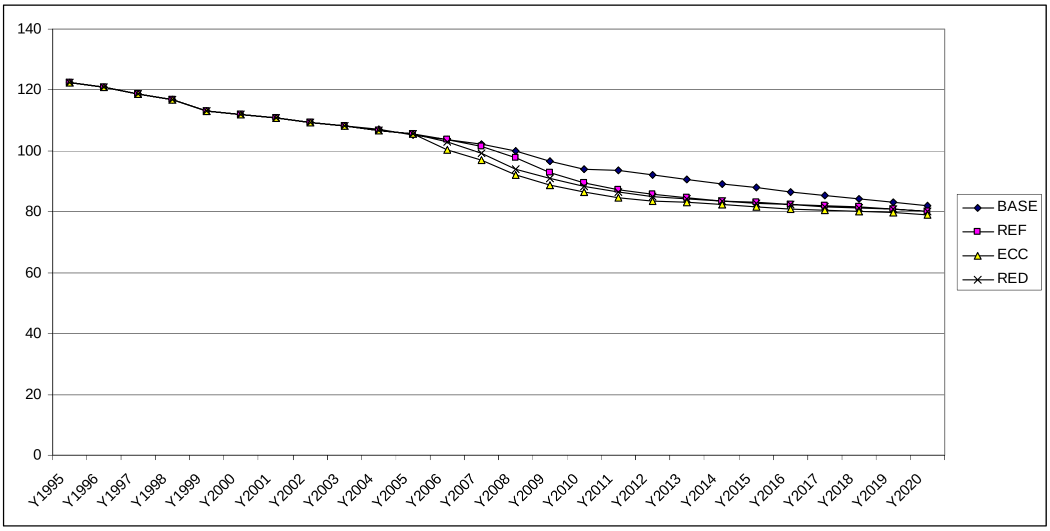
	Agricultural income (€ million)			**Agricultural income per hour (€/hour)**		
	REF	ECC	RED	REF	ECC	RED
Southern Finland	+12.6	+7.9	+2.1	+16.8	+14.5	+5.4
Ostrobothnia	+6.9	+3.0	-2.1	+10.4	+7.0	+0.6
Central Finland	+5.3	+2.7	-4.6	+17.4	+18.2	+9.5
Northern Finland	-3.1	-6.4	-6.6	+13.4	+11.8	+10.7
Whole country	+8.5	+4.5	-0.1	+14.9	+12.3	+4.9

Notes: Abbreviations – BASE = Agenda 2000; REF = Luxembourg 2003 reform with national adaptations; ECC = environmental cross compliance; RED = reduction of CAP payments by 20% until 2013.

Source: Authors' calculations.

In any scenario, including the BASE scenario, agricultural employment will decline in all parts of Finland. This is because farm size has been relatively low in Finland for historical reasons, and despite the relatively rapid decline of cattle farms in the last 10 years there is still a substantial scope for farm-size growth. In the future, the decline in agricultural employment is likely to be relatively largest in northern Finland and smallest in southern Finland and Ostrobothnia (Figure 5 and Table 7).

Figure 5. Direct and indirect labour in agriculture (per 1000 employees) in Finland in the BASE scenario



Source: Authors' calculations.

Table 7. Percentage changes in the direct and indirect labour of agriculture (1000 employees) in different scenarios compared with the baseline

	REF			**ECC**			**RED**		
	2010	2015	2020	2010	2015	2020	2010	2015	2020
Southern Finland	-3.5	-3.6	+3.8	-9.6	-5.7	+1.7	-5.1	-3.1	+4.5
Ostrobothnia	-7.2	-3.1	-3.0	-6.4	-3.7	-2.8	-6.5	-2.7	-1.1
Central Finland	-3.5	-10.3	-8.4	-8.0	-13.1	-11.5	-7.2	-12.9	-12.2
Northern Finland	-3.1	-14.6	-20.1	-5.5	-14.7	-17.2	-5.7	-15.6	-21.1
Whole country	-4.6	-5.6	-2.4	-8.1	-7.3	-3.7	-6.0	-5.9	-2.4

Notes: Abbreviations – BASE = Agenda 2000; REF = Luxembourg 2003 reform with national adaptations; ECC = environmental cross-compliance; RED = reduction of CAP payments by 20% until 2013.

Source: Authors' calculations.

The food industry in Finland has experienced major structural changes as well in the last 10 years. These changes are still going on. Hence it is assumed in this study that indirect employment in agriculture is considered to remain fixed for the agricultural labour force. For example, transportation of inputs and outputs will employ less labour as the number of farms decrease. Overall, the efficiency of labour will increase significantly and in the same magnitude in agriculture and in upstream and downstream industries. This means that the average reduction in agricultural employment (-18% in the baseline and -23% in the CAP reform scenarios until 2015) is accompanied by the same change in indirect employment. This assumption will be relaxed as soon as new input-output data in each of the 20 provinces is obtained.

6. Discussion and conclusions

The aim of this study has been to predict and compare the multifunctionality effects of alternative agricultural policy reforms in Finland. Since the multifunctional value of agriculture lies in the joint production process of agricultural and public goods and various externalities, the impact on production, biological and employment factors of different agricultural policies were analysed. The research method applied was agricultural sector modelling, which takes into account changes in profitability between different agricultural production lines and the resulting changes in land use and production intensity. Since the model does not explicitly consider the links between agriculture and the national economy, the effects on direct and indirect employment in agriculture are considered external to the model.

CAP reform, possibly through partial or full-decoupling of CAP payments, is not likely to result in any drastic decline of agricultural production in Finland, on the whole. Yet according to the economic analysis made, milk production may reduce substantially in northern Finland where dairy farming is the dominant line of production. Some decline of production may also take place in central Finland, but the decline of production in these areas will be partly compensated by an increase in production in the Ostrobothnia region, which may benefit from the decreasing values of milk quotas in CAP reform.

A decreasing number of dairy cows and the partial or full de-coupling of CAP headage payments will gradually result in decreasing beef production and grasslands area in all parts of Finland. Furthermore, the enlarging size and regional concentration of dairy production is likely to keep up the nutrient balances on agricultural land despite decreasing milk prices, which, *ceteris paribus*, would reduce the intensity of milk production. The scarcity of land in the relatively most-competitive areas may even increase the phosphorous balance – which is a risk in terms of nutrient runoffs and water quality.

In any scenario (also in the baseline scenario) agricultural employment will decline significantly in all parts of Finland. It is notable that the agricultural labour force is likely to decrease substantially irrespective of agricultural policy. According to our results, only a significant reduction in agricultural supports would speed up the decline in agricultural labour in southern Finland and Ostrobothnia. This is because overall animal production will in any scenario stay at the present level or gradually increase in these relatively more competitive regions. But in northern Finland, CAP reform will reduce agricultural employment (and related indirect employment) significantly because of the substantial reduction of milk production, which is the dominant line of production in this part of the country. Interestingly, in the ECC scenario the reduction of agricultural employment is less than under the REF scenario. In addition to restrictions in milk-quota trading among the regions, this result is partly owing to enlarged field edges, which slow down the concentration of production in other areas and also the outflow of milk quotas from northern Finland to some parts of central Finland. Hence the enlarged field edges slightly mitigate the decrease in dairy production and employment in northern Finland. From a multifunctionality viewpoint, this is an interesting result as environmental cross-compliance may also enhance socio-economic viability as measured by agricultural labour.

On the effects of policies on agricultural land use, the main finding was that the amount of fallow land (especially green fallow) will increase considerably if agricultural support payments are decoupled from production. Although the expenses of establishing green fallows are higher than for bare fallows, maintenance costs of green fallows are less. Based on the farm-level production cost calculations of the Union of Rural Advisory Centres (MKL, 1995), green fallows more profitable than bare fallows in a five-year period, and thus the predicted increase in the area of green fallows is justified. Nevertheless, there is a substantial uncertainty about the number of green fallow areas in the future, since at the farm level the choice of set-aside management also depends on the opportunity cost of labour and the age of production capital.

In addition, it should be noted that the above results depend on the environmental cross-compliance requirement of keeping the land in good agricultural condition. Without this requirement, the decoupling of support payments may lead into land abandonment.

A significant reduction of agricultural support is another factor that may also provide land abandonment. This can be seen in the 'attack on domestic support' scenario where CAP payments were reduced by 20%. As a result, idled land increased to nearly 25% of the total agricultural land area. Since agricultural land comprises only 8% of all land in Finland, one could argue that any reduction in agricultural land would mean a loss in biodiversity or at least diversity at the landscape level.

The habitat index calculated does not assign any value for idled or afforested agricultural land but considers agricultural land only. But the calculated habitat index does show that in any policy scenario the remaining cultivated agricultural land would become biologically richer due to increased green set-aside areas. Expanded field edges, required in the cross-compliance scenario, would provide significantly richer habitats for various species, such as butterflies. Since the increased set-aside area is a major expected outcome of CAP reform, providing sufficient incentives for green set-aside areas would make it possible to attain a higher level of biodiversity. On the other hand, our results show that changes in field edges (a change from 0.5 to 2 metre-wide edges were studied) do not imply any increase in the overall habitat value of agricultural lands. On the contrary, the enlarged field edges result in a lower level of dairy and beef production, which may result in reduced grass areas and increased grain areas, decreasing the habitat index. Nevertheless, this result, as well as the calculation procedure of the habitat index, needs to be discussed with environmental scientists.

At the landscape level, these policy reforms, in which support is decoupled, change land use and decrease the diversity of agricultural land-cover classes in almost all parts of the country, except in northern Finland. The effect on biological diversity, however, may not be equal to changes in Shannon's diversity index, since at the species level, green fallows seem to have some positive effects, especially on the densities and abundance of farmland birds (Haukioja et al. 1985; Helenius et al. 1995; Tiainen & Pakkala 2000; Tiainen & Pakkala, 2001). Firbank et al. (2003) concluded that particularly rotational set-aside provides suitable habitats for breeding birds, but the benefits of short-term set-aside for arable plants in England were small. Corbet (1995), on the other hand, considered long-term set-aside as a possibility to establish patches of undisturbed perennial herbaceous vegetation and their associated fauna. Furthermore, Steffan-Dewenter & Tscharntke (1997), Critchley & Fowbert (2000) and Kuussaari & Heliölä (2004) remarked that green fallows are poorer habitats than meadows considering the species diversity of vascular plants or butterflies and other insects.

Further research work and new data is necessary to evaluate the employment effects. Closer cooperation with environmental scientists is needed in the development of the habitat index, especially as production techniques (no-till cultivation, etc.) are changing. Furthermore, different habitat indexes may be constructed in order to quantify animal and plant species richness separately. Interdisciplinary work is also important in terms of the overall credibility of the economic modelling approach in evaluating the multifunctionality issue: the material flows and production biological relationships in the sector model need to be regularly updated with new research and data on farm level. Hence the assessment of different agricultural policies on many aspects of multifunctionality is a continuous research agenda rather than one single research project providing fixed coefficients for future indicator calculations. The credibility of the production economics and biological relationships of the economic model determine the validity of the indicator results. The overall framework and economic logic of microeconomic simulation models provides a consistent assessment of the many aspects of multifunctionality in comparison with a number of different expert opinions.

Bibliography

Anderson, K. (2000), "Agriculture's Multifunctionality and the WTO", *Australian Journal of Agricultural and Resource Economics*, Vol. 44, No. 3, pp. 475-94.

———— (2002), "Peculiarities of Retaliation in WTO Dispute Settlement", *World Trade Review*, Vol. 1, No. 2, pp. 123-34, July.

Armington, P. (1969), *A Theory of Demand for Products Distinguished by Place of Production,* IMF Staff Paper No. 16, IMF, Washington, D.C., March, pp. 159-78.

Boisvert, R. (2001), "A note on the concept of jointness in production" in OECD *Multifunctionality: Towards an analytical framework,* Technical Annexes (Annex 1, pp. 105-23 Annex 2 pp. 125-32), OECD, Paris.

Bäckman, S., S. Vermeulen and V.-M. Taavitsainen (1997), "Long-term fertilizer field trials: Comparison of three mathematical response models", *Agric. Sci. Finl.* Vol. 6, pp. 151-60.

Corbet, S.A. (1995), "Insects, plants and succession: Advantages of long-term set-aside", *Agriculture, Ecosystems and Environment*, 53, pp. 201-17.

Cox, T.L. and J.-P. Chavas (2001), "An interregional analysis of price discrimination and domestic policy reform in the US dairy sector", *American Journal of Agric. Econ.*, Vol. 83, No. 1, pp. 89-106.

Critchley, C.N.R. and J.A. Fowbert (2000), "Development of vegetation on set-aside land for up to nine years from a national perspective", *Agriculture, Ecosystems and Environment*, 79, pp. 159-74.

Duelli, P. (1997), "Biodiversity evaluation in agricultural landscapes: An approach at two different scales", *Agriculture, Ecosystems and Environment*, 62, pp. 81-91.

European Commission (1999), *Reform of the Common Agricultural Policy (CAP)*, Brussels (retrieved from http://europa.eu.int/scadplus/leg/en/lvb/l60002.htm).

———— (2003), Explanatory memorandum: A long term perspective for sustainable agriculture, 5586/03 COM(2003) 23 final, Brussels.

Farm Register (2002), Agriculture, Forestry and Fisheries 2003:60, Official Statistics of Finland, Information Centre of the Ministry of Agriculture and Forestry, Helsinki (retrieved from http://tike.mmm.fi).

Firbank, L.G., S.M. Smart, J. Crabb, C.N.R. Critchley, J.W. Fowbert, R.J. Fuller, P. Gladders, D.B. Green, I. Henderson and M.O. Hill (2003), "Agronomic and ecological costs and benefits of set-aside in England", *Agriculture, Ecosystem and Environment*, 95, pp. 73-85.

Guyomard, H. and F. Levert (2001), "Multifunctionality, trade distortion effects and agricultural income support: A conceptual framework with free entry and land price endogeneity", paper presented at the seminar Multifunctional Agriculture, February 2001, Bergen, Norway.

Guyomard, H., C. Le Mouel and A. Gohin (2004), "Impacts of alternative agricultural income support schemes on multiple policy goals", *European Review of Agricultural Economics* 31, pp. 125-48.

Haukioja, M., P. Kalinainen and K. Nuotio (1985), *Maatalouden vaikutus peltolinnustoon: esitutkimusraportti,* Ympäristöministeriön ympäristön- ja luonnonsuojeluosaston julkaisu A:34, Ympäristöministeriö, Helsinki.

Heckelei, T., P. Witzke and W. Henrichsmeyer (2001), "Agricultural Sector Modelling and Policy Information Systems" in *Proceedings of the 65th European Seminar of the European Association of the Agricultural Economics (EAAE)*, 29-31 March 2000, Bonn, Germany.

Heikkilä, A.-M., L. Riepponen and A. Heshmati (2004), "Investments in new technology to improve productivity of dairy farms", paper presented at the 91st EAAE seminar Methodological and Empirical Issues of Productivity and Efficiency Measurement in the Agri-Food System, Rethymno, Greece, 24-26 September 2004.

Helenius, J., S. Tuomola and P. Nummi (1995), Viljely-ympäristön muutosten vaikutus peltopyyn ravintoon, *Suomen Riista*, 41, pp. 42-52.

Hietala-Koivu, R., J. Lankoski and S. Tarmi (2004), "Loss of biodiversity and its social cost in an agricultural landscape", *Agriculture, Ecosystem and Environment*, 103, pp. 75-83.

Hietala-Koivu, R., L. Tahvanainen, I. Nousiainen, T. Heikkilä, A. Alanen, M. Ihalainen, L. Tyrväinen and J. Helenius (1999), *Visuaalinen maisema maatalouden ympäristöohjelman vaikuttavuuden seurannassa*, Maatalouden tutkimuskeskuksen julkaisuja, Sarja A 50, Maatalouden tutkimuskeskus, Jokioinen, Finland.

Jeanneret, Ph., B. Schüpbach and H. Luka (2003), "Quantifying the impact of landscape and habitat features on biodiversity in cultivated landscapes", *Agriculture, Ecosystem and Environment*, 98, pp. 311-20.

Jensen, H.G. and S.E. Frandsen (2003), *Impacts of the Eastern European Accession and the 2003-reform of the CAP*, FOI Working Paper No. 11/2002, Danish Research Institute of Food Economics.

Knuuttila, M. (2004), Elintarvikesektorin työllisyysvaikutukset – Panos-tuotosanalyysi maakunnittain, Maa- ja elintarviketalous 56: 87 s, (retrieved from http://www.mtt.fi/met/pdf/met56.pdf).

Kuussaari, M. and J. Heliölä (2004), "Perhosten monimuotoisuus eteläsuomalaisilla maatalousalueilla", in M. Kuussaari, J. Tiainen, J. Helenius, R. Hietala-Koivu and J. Heliölä (eds), *Maatalouden ympäristötuen merkitys luonnon monimuotoisuudelle ja maisemalle: MYTVAS-seurantatutkimus 2000-2003*, Suomen ympäristö (in press).

———— (2004), Butterfly diversity in agricultural landscapes of southern Finland (in Finnish), Suomen ympäristö, 709.

Lankoski, J. and M. Ollikainen (2003), "Agri-environmental externalities: A framework for designing targeted policies", *European Review of Agricultural Economics*, 30, pp. 51-75.

Lankoski, J., E. Lichtenberg and M. Ollikainen (2004), *Performance of alternative policies in addressing environmental dimensions of multifunctionality*, Discussion Paper No. 4, Department of Economics and Management, University of Helsinki.

Lehtonen, H. (2001), "Principles, structure and application of dynamic regional sector model of Finnish agriculture", PhD thesis, Systems Analysis Laboratory, Helsinki University of Technology, Agrifood Research Finland, Economic Research (MTTL), Publ. 98.

———— (2004), "Impacts of de-coupling agricultural support on dairy investments and milk production volume in Finland", *Acta Agriculturae Scandinavica, Section C: Food Economics*, Vol. 1. No. 1, April, pp. 46-62.

MAF (2005), Tilatukijärjestelmän sisällöstä neuvottelutulos, Press release 1 March 2005, Ministry of Agriculture and Forestry (retrieved from http://www.mmm.fi/tiedotteet/index.asp?ryhma=1).

McGarigal, K. and B.J. Marks (1995), *FRAGSTATS: Spatial Pattern Analysis Program for Quantifying Landscape Structure*, USDA Forest Services, PNW-GTR-351, Portland, OR.

MKL (1995), *Mallilaskelmat*, Suunnitteluosaston sarja A. Maaseutukeskusten liitto, Helsinki.

OECD (2001), *Multifunctionality: Towards an analytical framework*, OECD, Paris.

Ollikainen, M. and J. Lankoski (2004), "Multifunctional agriculture: The effect of non-public goods on socially optimal policies", paper presented at the 90th EAAE Seminar, Multifunctional Agriculture, Policies and Markets: Understanding the Critical Linkage. 28-29 October 2004, Rennes.

Paarlberg, P., M. Bredahl and J. Lee (2002), "Multifunctionality and agricultural trade negotiations", *Review of Agricultural Economics*, 24, pp. 322-35.

Peterson, J., R. Boisvert and H. de Gorter (2002), "Environmental policies for a multifunctional agricultural sector in open economies", *European Review of Agricultural Economics*, 29, pp. 423-43.

Pro Agria (2005), *Production results from dairy farms*, Central Union of Rural Advisory Centres in Finland (retrieved from http://www.proagria.fi/palvelut/tuotantotulokset/maito.asp).

Rantamäki-Lahtinen, L., K. Remes and K. Koikkalainen (2002), *The investment and production plans in Finnish farms*, Working Papers 4/2002, Agrifood Research Finland, Economic Research (MTTL), pp. 6-40.

Romstad, E., A. Vatn, P.K. Rørstad and V. Søyland (2000), *Multifunctional Agriculture: Implications for Policy Design*, Report No. 21, Agricultural University of Norway, Department of Economics and Social Sciences.

Sairanen, A., J. Nousiainen and H. Khalili (1999), Korkean väkirehumäärän vaikutus maitotuotokseen ja tuotannon kannattavuuteen, Poster paper (P7) presented at Agro-Food '99 2-4 February 1999, Tampere (in Finnish).

———— (2003), "Milk yield responses to concentrate supplementation on pasture" in O. Niemeläinen and M. Topi-Hulmi (eds), *Proceedings of the NJF's 22nd congress Nordic Agriculture in Global Perspective*, 1-4 July 2003, Turku, Jokioinen: MTT Agrifood Research Finland, NJF, p. 23 (retrieved from http://portal.mtt.fi/pls/portal30/docs/folder/agronet/yhteiset hankkeet/njf/njf2003/2.pdf).

Soete, L. and R. Turner (1984), "Technology diffusion and the rate of technical change", *The Economic Journal*, 94, pp. 612-23.

Steffan-Dewender, I. and T. Tscharntke (1997), "Early succession of butterfly and plant communities on set-aside fields", *Oecologia*, 109, pp. 294-304.

Vatn, A. (2002), "Multifunctional agriculture: Some consequences for international trade regimes", *European Review of Agricultural Economics*, Vol. 29, pp. 309-27.

Tiainen, J. and T. Pakkala (2000), "Population changes and monitoring of farmland birds in Finland" in *Linnut-vuosikirja 1999*, Helsinki: BirdLife Suomi, pp. 98-105.

———— (2001), "Birds" in M. Pitkänen and J. Tiainen (eds), *Biodiversity of Agricultural Landscapes in Finland*, BirdLife Finland Conservation Series, No. 3, Helsinki, pp. 33-50.

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ENARPRI is a network of European agricultural and rural policy research institutes formed for the purpose of assessing the impact of regional, bilateral and multilateral trade agreements concluded by the European Union or currently under negotiation, including agreements under the WTO, EU accession, Everything But Arms (EBA), EuroMed and Mercosur. It also addresses the wider issues of the multifunctional model of European agriculture and sustainable development of rural areas. Participants in the project include leading national institutes and research teams from 13 countries (11 EU member states and 2 accession countries).

Aims

- Creation of an institutional structure linking key research institutes with major benefits for improved exchange of information and policy analysis both in the short and long run,
- Development of improved tools for impact assessment,
- More effective impact assessment of trade agreements on a variety of important social, economic, and environmental indicators and an assessment of multifunctionality, and
- Clearer analysis of the need for EU policy adjustments.

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The ENARPRI Network is financed by the European Commission under its 5th Research Framework Programme (contract no. QLRT-2001-02481).

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