DP 2003/7

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October 2003

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Abstract. The European Union has decided to reform its agricultural policy, and decouple CAP support partially from production. The aim of this study is to predict diversity effects of agricultural policy reforms in which direct aid payments are disconnected from production, and compare the outcomes with effects of such a policy in which CAP support is coupled. The study employs the dynamic regional sector model of Finnish agriculture. The sector model predicts regional land use, stocking densities, pesticide application areas, and nutrient balances. Diversity of arable land use is measured by Shannon's evenness index which describes diversity at landscape level. The results indicate that if agricultural support is independent from production, the amount of fallow land will increase considerably in the future. This will decrease diversity of agricultural land use at landscape level, but may not be harmful at species level since green fallow has some positive effects especially on densities and richness of farmland birds. Instead, the decrease in bovine animals is likely to run down biological diversity, since it simplifies crop rotation and diminishes grazing.

Index words: agricultural policy reform, agricultural sector model, arable land use, biodiversity, landscape diversity, nutrient balances, pesticides, production intensity

Suggested citation: Miettinen, A., Hietala-Koivu, R. & Lehtonen, H. 2003. On diversity effects of alternative agricultural policy reforms in Finland: An agricultural sector modelling approach. MTT Economic Research, Agrifood Research Finland. Discussion Papers 2003/7.

Selostus

Maatalouspolitiikkareformien vaikutuksista luonnon monimuotoisuuteen

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Euroopan unioni uudistaa yhteistä maatalouspolitiikkaamme. Valtaosa EU:n kokonaan rahoittamista maataloustuista irrotetaan tuotannosta ja maksetaan viljelijöille tuotannosta riippumattomana maatalouden tulotukena. Tutkimuksessa ennustettiin maatalouden sektorimallin avulla kuinka CAP-tukien irrottaminen tuotannosta vaikuttaa maatalousmaan käyttöön, tuotannon intensiteettiin sekä maisema- ja lajitason monimuotoisuuteen Suomessa. Tarkasteltavia skenaarioita oli kaksi: yhteisen maatalouspolitiikan väliarvioinnin ehdotusten mukainen skenaario sekä vapaakauppaskenaario. Politiikkavaihtoehtojen tuloksena saatuja ennusteita maatalousmaan käytöstä ja maiseman monimuotoisuudesta, torjunta-aineilla käsitellystä peltoalasta, eläintiheyksistä sekä ravinnetaseista vuonna 2015 verrattiin perusskenaarion ennusteisiin vastaavana ajankohtana. Perusskenaariossa oletettiin, että myös tulevaisuudessa jatketaan Agenda 2000:n mukaista politiikkaa, jossa CAP-tuet on sidottu tuotantoon. Yhteisen maatalouspolitiikan väliarvioinnin ehdotusten mukainen CAP-tukien irrottaminen tuotannosta pienentää viljelymaiseman monimuotoisuutta ja johtaa lähes neljä kertaa suurempaan viherkesantojen pinta-alaan vuonna 2015 kuin Agenda 2000:n mukainen politiikka. Vapaakauppaskenaarion seurauksena syntyvät pellonkäytön muutokset ovat samansuuntaisia, mutta voimakkaampia kuin väliarvioinnin ehdotusten perusteella tulevat muutokset. Maankäytön muutoksesta johtuvat vaikutukset maatalousluonnon monimuotoisuuteen eivät kuitenkaan todennäköisesti ole kokonaisuudessaan haitallisia, sillä viherkesannoilla on todettu olevan myönteisiä vaikutuksia etenkin peltolinnustoon. Lisäksi torjunta-aineilla käsitelty peltoala pienenee, jos CAP-tuet on irrotettu tuotannosta. Sen sijaan kotieläintuotannossa tapahtuvilla muutoksilla on todennäköisesti haitallisia vaikutuksia luonnon monimuotoisuuteen, sillä erityisesti nautakarjan määrä vähenee, mikäli tuen suuruus ei riipu viljelijän tuotantopäätöksistä. Tällöin ravinneylijäämät pienenevät, mutta samalla myös karjan laiduntamisesta luonnon monimuotoisuudelle koituvat hyödyt vähenevät. Lisäksi karjasta luopuneiden tilojen viljelykierto yksinkertaistuu.

Contents

1. Introduction

Diversity within an ecosystem enables the ecosystem to survive and be productive. Species diversity, in terms of both natural plants and crop species and their varieties, may also provide a buffering effect against losses to diseases and pests or adverse weather conditions. (Olson and Francis 1995, Collins and Hawtin 1999) Therefore, diversity at the agroecosystem level contributes to greater food security and employment opportunities, and a risk-averse farmer may prefer to cultivate various crops in order to reach a higher expected profit.

In Finland as well as in the other EU countries agricultural support plays a significant role in the formation of farmers' income, and production-linked support affects significantly farmers' decision-making. The Council of Agricultural Ministers of the EU reached agreement on fundamental reform of the Common Agricultural Policy (CAP) in June 2003. The environmental and social effects of agricultural policy reforms and trade liberalisation are important public concerns. The environmental effects of policies may be identified with the help of the pressure-state-response framework (OECD 2001). Agricultural policy measures (i.e. pressures) influence the state of the environment via farmers' input use and production decisions. Different agricultural production lines compete for the limited agricultural land. Hence land use reflects relative profitability of different products and crops. The diversity of agricultural land use is a particularly important ecological and economic indicator, because land use patterns capture and combine the effects of several simultaneous policy measures and provide information concerning economic, social and biological dimensions of diversity (Olson and Francis 1995, OECD 2001). Therefore, a decrease in environmental state variables (e.g. in variables measuring diversity) may trigger a response, for example, in agri-environmental policy. Altogether, the evaluation of land use, diversity and other environmental indicators may provide relevant information for policy-makers who consider various effects when formulating new policies.

The two policy reforms studied here are the mid-term review of the Common Agricultural Policy of the EU (MTR) and free agricultural trade (FAT). MTR stands for EU Commission's reform proposals of CAP, and FAT is a radical trade liberalisation scenario. Agenda 2000 represents the baseline scenario, i.e., no CAP reform after Agenda 2000. These reforms differ in terms of policy parameters, i.e., support for farmers and institutional prices of agricultural products. In addition, in the MTR and FAT scenarios agricultural support is decoupled (i.e. direct aid payments are disconnected) from production. The effects of farm policy reforms on Finnish agricultural sector are predicted and evaluated using the dynamic regional sector model of Finnish agriculture (Lehtonen 2001). This particular model has been used in this study, because it is detailed in terms of agricultural products and policy description. The sector model simulates agricultural production along with land and input use resulting from a given policy alternative. A dynamic sector model can also deal with several simultaneous or sequential changes in policy instruments.

The recent applications of agricultural sector models includes Topp and Mitchell (2003) who forecast the environmental and socio-economic effects of the Agenda 2000 proposal on the Dumfries and Galloway region in Scotland. The environmental sub-model estimated that approximately 2.6% of the land area would change its vegetation type, and the authors concluded that diversity in landscapes would be reduced by the Agenda 2000 proposals. The literature also includes impact analyses of the mid-term review proposals of the Common Agricultural Policy (European Commission, Directorate-General for Agriculture 2003a and 2003b). However, these analyses which evaluate impacts on agricultural production, income and land use on the EU level, do not consider diversity effects explicitly.

In addition to diversity in agricultural land use, we also make an effort to predict biodiversity effects of policy scenarios. According to Duelli (1997), biodiversity evaluation at regional level can be based on landscape parameters. Even though landscape diversity indicators give an overview about biological diversity, there are no general models which relate overall species diversity to landscape diversity (Jeanneret et al. 2003). The relationship thus depends strongly on the organism examined. Furthermore, according to Southwood and Way (1970), cited in Altieri (1999), the degree of biodiversity in agroecosystems depend on four main characteristics:

1. The diversity of vegetation within and around the agroecosystem.
2. The permanence of the various crops within the agroecosystem.
3. The intensity of management.
4. The extent of the isolation of the agroecosystem from natural vegetation.

In this study, we predict policy driven changes in the diversity of arable crops and set-aside, and consider the effects of agricultural land use on diversity of natural species. Furthermore, we discuss the permanence of vegetation as a result of different land use forms and evaluate the intensity of management resulting from a given policy alternative.

The policy scenarios and the main elements of the modelling strategy are introduced in the second section of this paper. The third section presents arable land use predictions and the corresponding values of Shannon's evenness index. In addition to diversity index values, environmental indicators quantifying intensity of agricultural production, i.e., stocking densities, aggregate nutrient balances and pesticide application areas, are used to improve the analysis on potential policy effects on the state of the environment and biodiversity. It is especially interesting to see the environmental performance of the MTR scenario, because the Commission of the European Union has announced that the CAP reform will promote the environment. Finally, land use implications on biological diversity are discussed, and some conclusions are drawn in the last section of the study.

2. Methods

2.1 Dynamic Regional Sector Model of Finnish Agriculture

Our study employed the dynamic regional sector model of Finnish agriculture (DREMFIA), which, when given the reform-specific policy parameters, simulated the Finnish agricultural sector up to the year 2020. The main elements of the DREMFIA model are briefly presented in Appendix, and a thorough description of the model is found in Lehtonen (2001). The sector model assumes that farmers maximise their profits when there are fixed resources (land) and competitive markets. Hence the relative profitability between different products, affected by agricultural and environmental policy measures, determine the long-term changes in land use. The outcomes of the sector model include hectares planted to 13 different crops, areas of bare and green set-asides, and the amount of marginal land left out of agricultural production (Table 1). The last category consists of areas in which land rent in agricultural use is negative. The sector model also predicts stocking densities, regional aggregates of nutrient balances and pesticide application areas, which are indicators of intensity of agricultural production.

Because agricultural support varies regionally in Finland, it is logical to examine also the effects of policy reforms in differing geographical areas. The sector model includes four main regions, northern Finland, Ostrobothnia, central Finland, and southern Finland (Fig. 1). According to Uusitalo (2003), most of the crop production in Finland is located in southern and south-western Finland and in Ostrobothnia. Dairy farming is regionally quite evenly distributed, but a dominant line of production in central and northern Finland. Most of the piglet and pork farms are located in southern and western Finland. The location of livestock production is reflected in the regional distribution of land use. The share of grassland in the cultivated area is large outside southern Finland.

Fig. 1. Main regions in the DREMFIA model.

2.2 Policy Scenarios

The base scenario (i.e. Agenda 2000) provided the baseline forecast for the development path of agriculture. The predictions of alternative policy scenarios, MTR and FAT, were compared with the results of the base scenario. Since adjustment to a policy change takes a long time, we compared the diversity of arable land use between policy scenarios based on the sector model predictions of agricultural land use in the year 2015.

2.2.1 Agenda 2000

On the basis of Agenda 2000 agreement, adopted at the European Council in Berlin in March 1999, the price support for cereals and beef was reduced in 2000 and 2001. The resulting income losses to producers were partly compensated by increasing direct support, a share of which was paid from national funds. Furthermore, with Agenda 2000, silage grass was included in the CAP support for arable crops, and a special supplementary compensation for the drying costs of cereals and oilseed plants (a.k.a. drying aid) was implemented in Finland. The reform of milk and milk products will be realised starting from the 2005/06 marketing year. The administrative prices of butter and skimmed-milk powder will be cut by 15% in total until 2007/08 marketing year. (Ala-Mantila et al. 2000)

2.2.2 Mid-Term Review Proposals of Common Agricultural Policy

A radical suggestion in MTR proposals is the decoupling of most direct CAP subsidies from production (Commission of the European Communities 2002). As a result, a new single, lump-sum income payment per farm will replace most of the direct EU payments currently offered. At first, the level of single payment will be based on historical payments. In addition, farms will face a cap of direct aid payments of €300.000 per holding. Under a policy called dynamic modulation, all direct payments will be decreased annually by 3%, until in 2011 a final total of 20-per-cent decrease is reached. The money thus saved will be allocated from market support to rural development measures in the EU budget. The intervention price of cereals will be cut by 5% in 2004, and the intervention for rye will be abolished. Four alternative reform options were suggested to dairy sector. In the calculations below, it was assumed that the Agenda 2000 measures continue with a further price cut – 15% in the intervention price of butter, and 5% in the intervention price of skimmed-milk powder – and a further 3% increase in quota. Furthermore, it was also presumed that there is an additional LFA support for milk and beef farms.

The MTR scenario above was based on the Communication on the mid-term review of the Common Agricultural Policy (Commission of the European Communities 2002) and the legal proposals for CAP reform (Commission of the European Communities 2003). The MTR scenario used in this study includes greater price reductions and full decoupling of CAP payments compared to June 2003 CAP reform agreement (Agra Europe 2003 and CAP Reform Summary 2003), and hence it can be considered a scenario which includes further price reductions and further decoupling in the long run.

2.2.3 Free Agricultural Trade

In the FAT scenario, it was assumed that the global liberalisation of agricultural trade will lead to following policy adjustments and reforms in the CAP: National aid for Finnish agriculture will be withdrawn. Prices of agricultural products in the EU will fall into world market price level which is assumed to be 5-20% lower than the MTR price level. Agricultural support will be decoupled from production. Direct area payments will be equal for all crops as well as set-aside, and support includes a requirement of maintaining land in good agricultural condition. In addition, application of milk quota system was presumed to continue until the end of 2010.

2.3 Diversity of Agricultural Land Use

The diversity of agricultural land-use comprises of richness and evenness (Olson and Francis 1995). Richness of agricultural land use refers here to the number of different land-cover classes i.e. cultivated crops as well as bare and green fallow on utilised agricultural area (Table 1). Evenness of agricultural land use, for its part, refers to the uniformity of distribution of the area among land-cover classes. Uncultivated marginal land area left out of agricultural production was not included in the land-cover classes, since the further use of marginal land areas is not known.

Since richness is a function of scale, and because cultivated agricultural areas (including fallow) vary in size among scenario outcomes, Shannon's evenness index (*SHEI*) was applied in the land-cover diversity calculations (McGarigal and Marks 1995). The value of *SHEI* was calculated according to the formula:

$$SHEI = \frac{-\sum_{i=1}^{m}(P_i \times \ln P_i)}{\ln m},$$

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. In theory, the values of *SHEI* range from the minimum of 0 to the maximum of 1. Maximum diversity is reached when the distribution among land-cover classes is perfectly even.

2.4 Stocking Densities, Nutrient Balances and Pesticide Application Areas

Livestock stocking densities measure the intensity of production. Stocking density for bovines was calculated by dividing the livestock units (LU) by hectares of area under grass. Instead, when calculating stocking densities for pigs and poultry, hectares of fodder cereals (barley, oats and mixed cereals) were used as a denominator.

Aggregate 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 depositions, and subtracting the mineral content of the harvest and losses to the atmosphere. The nutrient surplus (kg/ha) provides an indicator of the production intensity as well as potential nutrient losses and environmental damage to surface and ground waters.

The amount of pesticide application area is 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.

2.5 Links to Biological Diversity

The whole spectrum of biodiversity is complex and impossible to measure thoroughly (Duelli 1997). Therefore we focused on agricultural land use and measured its diversity at landscape level. According to Jeanneret et al. (2003), the relationship between landscape and species diversities strongly depends on the organism examined. Since agricultural land provides habitat area for both crops and wildlife (especially weeds, vascular plants, insect pollinators and birds) we based our analysis on previous studies. The effects of land use changes to wildlife species diversity were discussed by means of some examples from the literature. Furthermore, in many OECD countries the expansion of farm production and intensification of input use are considered a major cause of the loss of biodiversity (OECD 2001). Our approach also caters for these things even though the share of agricultural land in Finland is less than 10% of the total area (Yearbook of Farm Statistics 2002).

While the Finnish agricultural sector model is applicable when predicting agricultural land use diversity, there are also some shortcomings in the approach used. Most importantly, since not designed for that purpose, the sector model ignores areas of field verges, buffer zones, traditional rural biotopes and other semi-natural habitats which are important from the point of view of biological diversity. Furthermore, if the land use predictions of the agricultural sector model were disaggregated to field parcel level, this feature would enable more accurate spatial analyses and predictions of the environmental effects of agriculture.

3. Results

3.1 Diversity of Agricultural Land Use

The aggregate agricultural land-use results of base, MTR and FAT scenarios for 2015 are presented in Table 1. The table also shows the initial land allocation which corresponds to year 2002 and was also calculated by the DREMFIA model.

Table 1. Use of Agricultural Land in Finland as Result of Policy Scenarios.

Land-cover	2002		Base		MTR		FAT	
class	1000 ha	%	1000 ha	%	1000 ha	%	1000 ha	%
Spring wheat	110.113	5.09 %	120.888	6.33 %	115.665	5.48 %	91.825	4.26 %
Winter wheat	32.590	1.51 %	0.852	0.04 %	0.729	0.03 %	1.173	0.05 %
Rye	27.195	1.26 %	27.734	1.45 %	0.210	0.01 %	0.153	0.01 %
Barley	526.419	24.31 %	330.654	17.30 %	295.111	13.98 %	183.029	8.48 %
Oats	456.011	21.06 %	543.605	28.45 %	459.184	21.75 %	340.067	15.76 %
Mixed grain	14.377	0.66 %	21.786	1.14 %	19.513	0.92 %	8.193	0.38 %
Oilseed plants	66.840	3.09 %	63.147	3.30 %	60.802	2.88 %	34.208	1.59 %
Peas	5.845	0.27 %	4.133	0.22 %	4.049	0.19 %	2.671	0.12 %
Potatoes	30.515	1.41 %	28.301	1.48 %	28.358	1.34 %	3.397	0.16 %
Sugar beet	29.208	1.35 %	27.372	1.43 %	27.731	1.31 %	8.402	0.39 %
Dry hay	79.925	3.69 %	55.820	2.92 %	47.566	2.25 %	18.563	0.86 %
Silage	259.782	12.00 %	227.303	11.89 %	205.344	9.73 %	78.368	3.63 %
Green fodder	329.230	15.21 %	300.781	15.74 %	258.971	12.27 %	111.253	5.16 %
Bare fallow	19.197	0.89 %	0.186	0.01 %	0.549	0.03 %	14.889	0.69 %
Green fallow	177.933	8.22 %	158.493	8.29 %	587.217	27.82 %	1,261.483	58.46 %
TOTAL	2,165.180	100.00 %	1,911.056	100.00 %	2,111.000	100.00 %	2,157.675	100.00 %
Uncultivated agricultural land	28.294		282.418		82.474		35.799	

2002 = initial land allocation in 2002
Base = Base scenario (i.e. Agenda 2000) in 2015
MTR = Mid-Term Review in 2015
FAT = Free Agricultural Trade in 2015

Agricultural land use predictions for four regions (southern Finland, central Finland, Ostrobothnia, and northern Finland) are summarised in Table 2, where certain land-cover classes are pooled and some others are excluded to save space. The diversity of arable-land use in each region as well as in whole Finland was measured by Shannon's evenness index, the values of which are reported in Table 3.

3.1.1 Continuation of Agenda 2000

The base run of the agricultural sector model indicated with certain exceptions that if Agenda 2000 policy continued, there would be no substantial changes in the proportional areas of land-cover classes in the future (Table 1). However, the total amount of cultivated area, including fallow and cultivated grassland, would decrease significantly in the future. The most important change therefore concerns the amount of marginal farming land taken out of production, the amount of which would increase in Finland approximately ten times, i.e., from 0.7% to 7% of total agricultural land, from 2002 to 2015. Such a change results from investments in larger dairy facilities, which, in turn, lead to a regional concentration of production in all parts of the country. Consequently, the demand for feed (grain and grass) decreases in many areas. This weakens market prices and profitability of grain production, and some land is left idle. Because also pork and poultry production continue to concentrate into large production units, both relative and absolute increase in the uncultivated land area will be largest in southern Finland and smallest in northern Finland (Table 2).

Table 2. Regional Use of Agricultural Land as Result of Policy Scenarios.

	2002		Base		MTR		FAT	
	1000 ha	%	1000 ha	%	1000 ha	%	1000 ha	%
Southern Finland								
Cereal area[1)]	747.148	66.50 %	621.795	64.27 %	538.464	51.72 %	414.095	36.89 %
Grass area[2)]	176.899	15.74 %	162.383	16.78 %	138.360	13.29 %	57.637	5.14 %
Fallow area[3)]	92.463	8.23 %	76.350	7.89 %	258.689	24.85 %	607.722	54.14 %
Cultivated area[4)]	1,123.580	100.00 %	967.542	100.00 %	1,041.166	100.00 %	1,122.435	100.00 %
Uncultivated agricultural land	0.008		156.046		82.422		1.153	
Central Finland								
Cereal area[1)]	124.961	33.29 %	117.900	35.99 %	87.050	22.07 %	70.110	18.15 %
Grass area[2)]	219.292	58.42 %	183.856	56.13 %	150.058	38.04 %	68.332	17.69 %
Fallow area[3)]	28.482	7.59 %	25.362	7.74 %	156.849	39.76 %	246.007	63.70 %
Cultivated area[4)]	375.377	100.00 %	327.572	100.00 %	394.452	100.00 %	386.225	100.00 %
Uncultivated agricultural land	19.080		66.885		0.005		8.232	
Ostrobothnia								
Cereal area[1)]	286.488	49.51 %	303.465	55.43 %	254.450	43.97 %	137.213	23.71 %
Grass area[2)]	199.215	34.43 %	173.632	31.72 %	171.613	29.66 %	56.665	9.79 %
Fallow area[3)]	70.461	12.18 %	54.875	10.02 %	137.817	23.82 %	380.874	65.82 %
Cultivated area[4)]	578.665	100.00 %	547.450	100.00 %	578.665	100.00 %	578.665	100.00 %
Uncultivated agricultural land	0.047		31.262		0.047		0.047	
Northern Finland								
Cereal area[1)]	8.108	9.26 %	2.359	3.44 %	10.449	10.80 %	3.022	4.30 %
Grass area[2)]	73.532	83.98 %	64.032	93.49 %	51.849	53.61 %	25.551	36.32 %
Fallow area[3)]	5.723	6.54 %	2.092	3.05 %	34.410	35.58 %	41.769	59.37 %
Cultivated area[4)]	87.559	100.00 %	68.492	100.00 %	96.717	100.00 %	70.350	100.00 %
Uncultivated agricultural land	9.158		28.225		0.000		26.367	

2002 = initial land allocation in 2002

Base = Base scenario (i.e. Agenda 2000) in 2015

MTR = Mid-Term Review in 2015

FAT = Free Agricultural Trade in 2015

1) Cereal area includes spring wheat, winter wheat, rye, barley, oats, and mixed grain.

2) Grass area includes dry hay, silage, and green fodder.

3) Fallow area consits of open and green fallow.

4) Oilseed plants, peas, potatoes and sugar beet are excluded.

Of the single crops, the area under oats increases, and the area under barley decreases along with the continuation of Agenda 2000. Table 1 also indicates that cultivation of winter wheat becomes unprofitable, and the area under winter wheat decreases markedly by 2015. This is due to higher production costs of winter wheat compared to spring wheat, while there is little difference in the crop yields between them. Also the amount of bare fallow land diminishes in the future.

Table 3. Values of Shannon's Evenness Index (*SHEI*).

	2002	Base	MTR	FAT
Southern Finland	0.78	0.76	0.73	0.53
Central Finland	0.65	0.58	0.57	0.49
Ostrobothnia	0.70	0.68	0.68	0.44
Northern Finland	0.61	0.41	0.63	0.61
WHOLE FINLAND	0.79	0.76	0.73	0.53

2002 = initial land allocation in 2002
Base = Base scenario (i.e. Agenda 2000) in 2015
MTR = Mid-Term Review in 2015
FAT = Free Agricultural Trade in 2015

The above-mentioned changes in land allocation lead to a bit more uneven arable land-use distribution in 2015. Therefore the value of *SHEI* in 2015 calculated for whole Finland is slightly lower than the corresponding value in 2002 (Table 3). Regionally, the biggest decline in diversity occurs in northern Finland, where the value of *SHEI* decreases from 0.61 in 2002 to 0.41 in 2015. The cause of this drop is the significant increase in the relative amount of grassland area (specifically silage area).

3.1.2 Agenda 2000 vs. Mid-Term Review of Common Agricultural Policy

When comparing the agricultural land use predictions of the MTR scenario for 2015 to the corresponding results of the base scenario, we found that the MTR resulted in almost four times larger green fallow area than Agenda 2000 (Table 1). This is due to large reductions in milk price and decoupled CAP payments. These cuts significantly reduce incentive to invest in milk production. Since farms are small and production costs are high, most dairy farmers exit milk production and make only the minimum effort to receive the CAP payments, i.e., they leave their land as set-aside. 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 green set-aside area will increase significantly as a result of MTR.

Compared to Agenda 2000, the areas devoted to oats, barley, green fodder and silage will be smaller under MTR scenario. Table 1 also indicates that the cultivation of rye almost comes to an end as a consequence of the mid-term review policy proposals, which include elimination of the intervention system for rye. In addition, the amount of winter wheat cultivated in 2015 is minimal as a result of both scenarios.

As a whole, the land-use predictions for the year 2015 indicated that arable land-use diversity, measured by *SHEI*, will typically be a little lower due to the MTR policy reform when compared to the continuation of Agenda 2000. The only exception occurs in northern Finland, where the distribution of arable land-cover classes will be more even and the corresponding value of *SHEI* higher as a result of MTR compared to the base scenario (Tables 2 and 3). This is mainly because MTR in northern Finland, as opposite to other regions, will increase the area under cereals. This occurs because northern dairy farmers exit unprofitable dairy production, increase cereal area and hence remain eligible for CAP payments. It is also worth mentioning that the CAP payments per hectare, including compensatory payments for milk, are relatively high in northern Finland under MTR scenario.

3.1.3 Agenda 2000 vs. Free Agricultural Trade

Under FAT scenario, over 58% of the used arable area in 2015 will be devoted to green set-aside (Table 1), the area of which will be almost eight times larger than under the base scenario. Such a dramatic increase in fallow area is due to the fact that the world market prices alone do not provide a sufficient incentive to carry on animal and cereals production on most farms in Finland. Area-based flat rate support, however, can be obtained if land is kept in good agricultural condition, which is the case in fallow land. The vegetated set-aside provides a low cost alternative to bare fallow, because the vegetation need not be renewed every year.

Due to the high dominance of vegetated fallow land, the values of *SHEI* for FAT scenario are clearly lower than that of the other scenarios everywhere except in northern Finland (Table 3). The relative differences between results of the two scenarios concerning the green set-aside area were once again largest in northern Finland and smallest in Ostrobothnia, implying that as a result of FAT scenario, the proportion of green set-aside will increase most in northern Finland.

Under free agricultural trade, the areas under fodder cereals, green fodder and silage decrease markedly. Table 1 also implies that compared to the base scenario, the amount of cultivated grassland is almost three times smaller under FAT. The area under each cereal (except for winter wheat) is also considerably smaller in the FAT scenario. In addition, free agricultural trade will bring down potato and sugar beet areas.

3.2 Stocking Densities, Nutrient Balances and Pesticide Application Areas

The effects of the different agricultural policies on livestock densities are shown in Table 4. Although the amount of livestock is typically lowest under FAT scenario, free agricultural trade resulted in highest aggregate bovine (0.94 LU/grass hectare) and pig densities (0.31 LU/feed hectare) in 2015. This somewhat unexpected result is due to the fact that under FAT scenario some feed grain is imported and animal production is concentrated in large production units in the most feasible agricultural areas. Due to reduced crop prices and substitution of grain for grass in feeding, the grass and forage areas decline considerably more than the amount of livestock units. Hence the livestock densities increase despite of lower animal product prices. The highest aggregate poultry density (1.54 LU/feed hectare) was achieved as a result of MTR scenario, but regional differences in poultry densities are large. The lowest pig and poultry densities in 2015 were due to base scenario. Aggregate bovine density was lowest as a result of mid-term review proposals. This is because the cut in milk price is in relative terms larger than the price reduction of grain, which also affects the value and amount of grass fodder used in feeding.

Table 4. Livestock Units (LU) per Grass or Feed Hectare.

	2002	Base	MTR	FAT
Bovines (LU/grass hectare)				
Southern Finland	1.04	1.02	0.95	1.13
Central Finland	0.81	0.85	0.80	0.77
Ostrobothnia	0.96	0.98	0.97	1.12
Northern Finland	0.69	0.62	0.50	0.57
WHOLE FINLAND	0.90	0.91	0.87	0.94
Pigs (LU/feed hectare)				
Southern Finland	0.27	0.28	0.30	0.28
Central Finland	0.15	0.10	0.13	0.19
Ostrobothnia	0.27	0.25	0.29	0.45
Northern Finland	0.23	0.42	0.09	0.33
WHOLE FINLAND	0.25	0.25	0.28	0.31
Poultry (LU/feed hectare)				
Southern Finland	1.77	2.46	2.55	2.05
Central Finland	0.02	0.01	0.01	0.02
Ostrobothnia	0.27	0.27	0.33	0.79
Northern Finland	0.03	0.08	0.02	0.02
WHOLE FINLAND	1.11	1.42	1.54	1.47

2002 = initial land allocation in 2002
Base = Base scenario (i.e. Agenda 2000) in 2015
MTR = Mid-Term Review in 2015
FAT = Free Agricultural Trade in 2015

Regional differences in nutrient balances (kg/ha) are considerable (Table 5). Both nitrogen and phosphorus surpluses are clearly highest in northern Finland already in 2002. This is due to the dominance of dairy production and the use of purchased feeds, such as concentrates and grain, in feeding. Table 5 also indicates that the continuation of Agenda 2000 policy would slightly increase aggregate nitrogen surplus on the agricultural land which remains in production. This is because grain is further substituted for grass in the feeding of bovine animals, and the fact that total of 7% of agricultural land in less productive areas becomes idled while production quantities remain unchanged from 2002 to 2015. In 2015, the preference order between scenarios in terms of reduced aggregate nutrient balances is unambiguous at the level of whole country. Free agricultural trade will result in lowest aggregate nitrogen and phosphorus surpluses in Finland as a whole. The second in succession is MTR. Thus highest aggregate surpluses are due to base scenario. There are, however, regional differences. MTR will result in lowest nitrogen and phosphorus surpluses in northern Finland and lowest nitrogen surplus in central Finland.

Table 5. Nutrient Balances (kg/cultivated ha).

	2002	Base	MTR	FAT
Nitrogen				
Southern Finland	39.2	39.2	36.4	32.7
Central Finland	43.0	42.4	41.2	42.2
Ostrobothnia	40.7	40.0	36.6	33.0
Northern Finland	84.1	100.5	85.5	92.9
WHOLE FINLAND	42.1	42.3	39.2	36.2
Phosphorus				
Southern Finland	5.2	5.8	5.5	3.8
Central Finland	8.6	8.1	7.6	6.3
Ostrobothnia	7.6	6.9	7.0	6.7
Northern Finland	12.3	12.5	9.4	11.1
WHOLE FINLAND	6.7	6.7	6.4	5.1

2002 = initial land allocation in 2002
Base = Base scenario (i.e. Agenda 2000) in 2015
MTR = Mid-Term Review in 2015
FAT = Free Agricultural Trade in 2015

Table 6 shows that the agricultural areas treated with pesticides will typically be smaller in the future than today. The only exception occurs in Ostrobothnia under base scenario, where larger cereal area in 2015 will lead to a larger pesticide application area. In 2015, the pesticide application areas are largest as a result of base scenario and smallest as a result of FAT scenario everywhere, except in northern Finland. There, base scenario will lead to the smallest pesticide application area, and the largest area treated with pesticides occurs in northern Finland under MTR scenario.

Table 6. Pesticide Application Area (1000 ha).

	2002	Base	MTR	FAT
Southern Finland	850.926	724.990	640.439	456.073
Central Finland	127.372	118.346	87.526	70.602
Ostrobothnia	306.667	318.636	268.882	140.741
Northern Finland	8.304	2.368	10.457	3.031
WHOLE FINLAND	1,293.268	1,164.340	1,007.304	670.447

2002 = initial land allocation in 2002
Base = Base scenario (i.e. Agenda 2000) in 2015
MTR = Mid-Term Review in 2015
FAT = Free Agricultural Trade in 2015

When interpreting the above results, it is worth noting that the DREMFIA model does not include organic farming where artificial fertiliser or pesticides are not used. Hence only the relative differences between the scenario results are important, not the absolute nutrient surpluses or pesticide application areas.

4. Discussion and Conclusions

The aim of this study was to predict and compare diversity effects of alternative agricultural policy reforms in Finland. When we evaluated the effects of policies on agricultural land use, the main finding was that the amount of fallow land will increase considerably, if agricultural support is decoupled from production. At the landscape level this change decreases diversity of arable crops and set-aside as a result of both MTR and FAT scenarios in all other parts of the country except in northern Finland. The effect to the biological diversity, however, may not be as harmful as Shannon's evenness index implies, since at species level, green fallows seem to have some positive effects especially on densities and richness of farmland birds (Haukioja et al. 1985, Helenius et al. 1995, Tiainen and Pakkala 2000, Tiainen and Pakkala 2001). Firbank et al. (2003) concluded that especially rotational set-aside provides suitable habitats for breeding birds, but the benefits of set-aside for scarce arable plants in England were little. Furthermore, Steffan-Dewenter and Tscharntke (1997) and Critchley and Fowbert (2000) remark that green fallows are poorer habitats than meadows when considering species diversity of vascular plants or insects.

It is also interesting to note that if the future agricultural policy will resemble the current Agenda 2000 policy, there would be a risk that the area of land taken out of agricultural production may increase especially in southern Finland and Ostrobothnia. This is because it may be economically rational to leave land as it is, since agricultural support under Agenda 2000 is linked to production and the establishment of set-aside or fallow includes costs. In this case, at least the loss of agricultural landscape is evident, but it is not easy to say whether biodiversity in its entirety is enhanced or not when an open field is converting (or converted) into forest.

Of the single crops, it seems that the cultivated area of winter wheat will decrease from the current level as a result of each scenario studied. This is unfavourable development from the point of view of biological diversity and nutrient leaching, since winter cereals offer vegetation cover for soil during winter. The area under another winter cereal, rye, is highly dependent on the crop price paid. In the calculations above, it was assumed that the 2002 price level for rye is retained only under Agenda 2000. The amount of cultivated grassland is closely linked to the reforms in the dairy sector. Differences in grassland area and bovine units are moderate between the base and MTR scenarios, but both scenarios differ significantly from free agricultural trade which results in minor livestock units and grass area.

The pesticide application area is smaller under MTR and FAT scenarios than as a result of base scenario, since cereal, potato and sugar beet areas will decrease if agricultural support is decoupled from production. This will benefit for example farmland birds, since reduced use of pesticides may increase the amount of insect prey. Furthermore, reduced chemical pesticide risks are evident in Finland if agricultural trade is further liberalised.

There are large regional variations in the agricultural nutrient balances in Finland. There will be such variations also in the future: both nitrogen and phosphorus surpluses will be high in northern Finland as a result of all scenarios studied. In the whole Finland, MTR and FAT scenarios result in lower nitrogen and phosphorus surpluses than the base scenario in 2015. This is because livestock production, and especially that of dairy and beef cattle, decreases more as a result of those scenarios in which CAP support is decoupled. Although decrease in nutrient surpluses is desirable, decline in livestock farming has also negative environmental effects, since outdoor grazing also declines. Furthermore, the crop rotation on a farm becomes more simplified when the farmer exits animal husbandry, since grassland is no longer needed in the farm (Pitkänen 2001).

The fact that FAT scenario resulted in highest livestock densities was due to the concentration of production in most favourable areas and the low price of purchased feed, which in turn leads to small grass and forage areas. In addition to lower diversity at landscape level, the potential environmental concern when CAP support is decoupled from production is that although the resulting agricultural land use may be extensive at the aggregate level, there may be some large production units and intensive geographical regions in Finland where animal production is concentrated. On one hand, this may cause environmental problems, but on the other hand, concentration may ease the control of these problems.

Acknowledgements

The authors are indebted to Professor Anni Huhtala for her constructive comments and cheery encouragement. Reija Hietala-Koivu and Antti Miettinen acknowledge also Professor Ilkka P. Laurila and the other members of BIAPIA/Fibre research group for valuable discussions. We were privileged to belong to such a research group.

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Appendix

Main elements of dynamic regional sector model of Finnish agriculture

The dynamic regional sector model of Finnish agriculture (DREMFIA) is a dynamic recursive model which simulates the development of agricultural investments and markets from 1995 up to 2020. The structure of the model is presented in Figure A-1. The model consists of two major parts: (1) a technology diffusion model which determines sector level investments in different production technologies; and (2) an optimisation routine which 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.

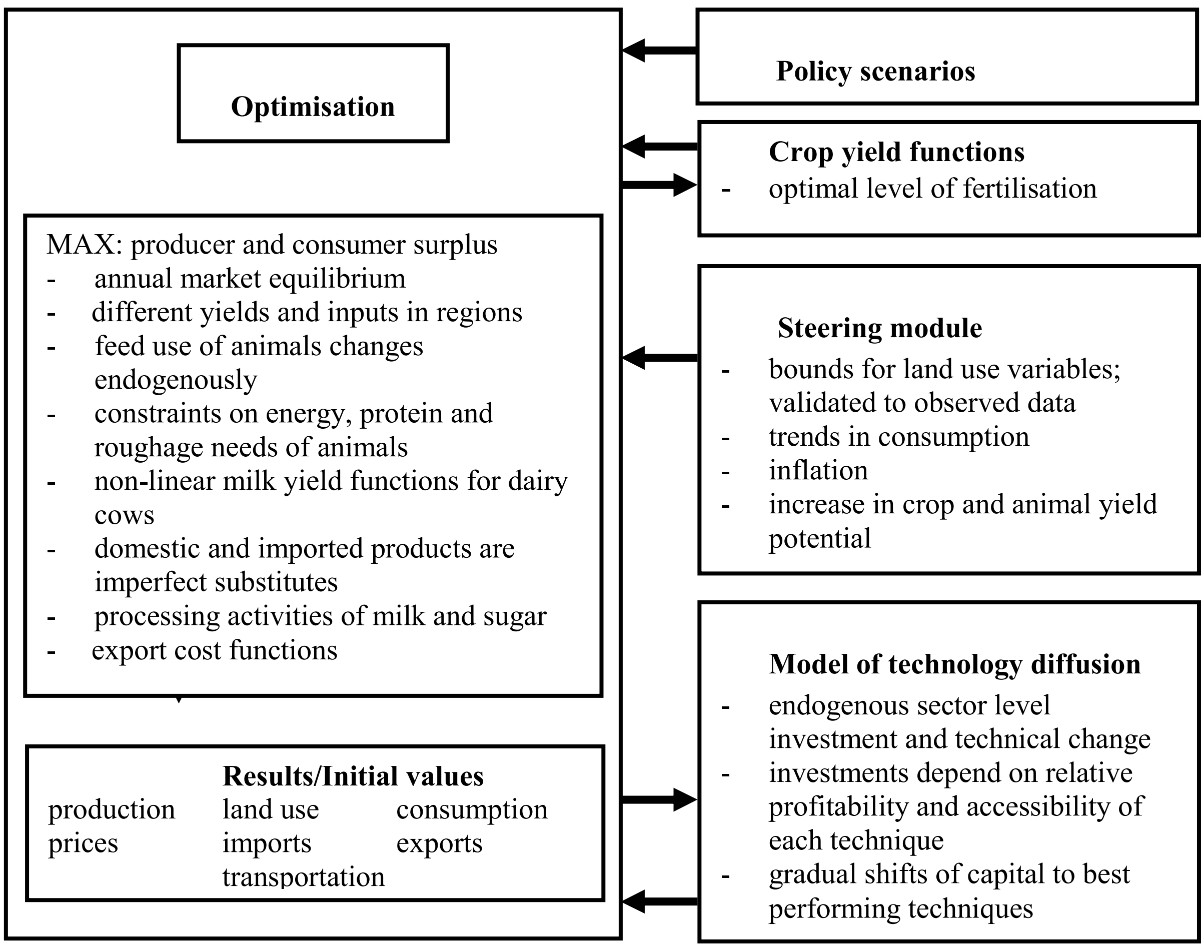

Figure A-1. Basic structure of the DREMFIA model.

The most important medium- and long-term driving force of agricultural production in the model is the module of technology diffusion. Nevertheless, if major changes take place in production, price changes, as simulated by the optimisation model, are also important to consider. The Armington assumption, which means that imported and domestic products are imperfect substitutes, is utilised. The changes in domestic production and foreign trade of agricultural products imply price changes. Parameters of the demand system have been calibrated in order to replicate ex-post price development in 1995-2002. Optimisation provides the annual market balance using the outcome of the previous year as the initial value. There are, however, restrictions on the annual changes of some production variables. The restrictions represent short-run technical and biological constraints in each production line. The restrictions are validated so that annual changes may be at least as large as average annual changes in 1990-2002. Hence the changes in land use may be relatively large (10-50%) annually, and very large until 2015. The model reaches a steady-state equilibrium in a 10-15 year period when all variables, including capital, have reached an endogenous optimal solution.

The sector model includes four main regions, southern Finland, central Finland, Ostrobothnia, and northern Finland, and the production of these is further divided into sub-regions on the basis of agricultural support areas. The final and intermediate products can be transported between the main regions at certain transportation costs. Milk products and sugar are priced at the retail level. All other products are priced at the producer price level.

The optimal fertilisation level is determined by fertilisation response function and crop and fertiliser prices. Animal yields grow linearly in time, although feeding affects the milk yield of dairy cows. Certain energy, roughage and protein needs have to be fulfilled. No explicit connections to the other sectors of the economy are made. Inflation rate, price of labour, price elasticity of demand and exogenous trends for consumption are considered to represent general economic conditions and long-run consumer behaviour.

The sector model caters for the most important production lines of agriculture, including crop production, dairy production, production of beef, pork and poultry meat, as well as egg production. The arable crops, as an example, comprise barley, oats, malting barley, mixed cereals, rye, wheat, oil-seed plants, sugar beets, potatoes for human consumption, starch potatoes, silage, green fodder, dry hay, and peas. The open and green set-asides are also included in the model.