The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

MULTIFUNCTIONAL AGRICULTURE:
The effect of non-public goods on socially optimal policies

Markku Ollikainen[1] and Jussi Lankoski[2]
1) Department of Economics and Management, P.O. Box 27, 00014 University of Helsinki.
E-mail: markku.ollikainen@helsinki.fi.
2) Agrifood Research Finland, Economic Research, P.O. Box 3, FIN-00411 Helsinki. Finland.
E-mail: jussi.lankoski@mtt.fi

Paper prepared for presentation at the XIth International Congress of the EAAE
(European Association of Agricultural Economists),
'The Future of Rural Europe in Global Agri-Food System '
Copenhagen, Denmark, August 24-27, 2005

Copyright 2005 by [authors]. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

Multifunctional agriculture:
The effect of non-public goods on socially optimal policies

Abstract

We develop a general framework for multifunctional agriculture, which includes not only public goods but also rural viability as a non-public good item. We contribute to the literature in two ways. First, we demonstrate how the broader definition of multifunctional agriculture differs from the agri-environmental multifunctionality, and how agri-environmental policy should be reformed to include these aspects. We show that rural viability entails adjusting fertilizer tax and buffer strip subsidy below their first-best Pigouvian levels to reflect the direct and indirect employment effects of agricultural production. Moreover, we show that when non-agricultural land use is present, an additional, non-agricultural instrument is needed to adjust the amount of land allocated to agriculture to its optimal level. In a parametric model calibrated to Finnish agricultural conditions and Finnish valuation of agri-environmental amenities and rural viability, we assess how the socially optimal provision of non-public good multifunctionality relates the socially optimal agri-environmental multifunctionality.

Keywords: biodiversity, employment, nutrient runoffs, rural viability

1. Introduction

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 includes also socio-economic viability of rural areas, food safety, national food security and the welfare of production animals together with cultural and historical heritage. There is no universally accepted definition of multifunctionality, and 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 of the non-commodity outputs exhibit the characteristics of externalities or public goods (OECD, 2001: 13). OECD emphasizes that in developing the notion, it is useful in the first phase focus predominantly on positive and negative agricultural environmental non-commodity outputs; we call this *agri-environmental multifunctionality* in what follows. Also, it is acknowledged that including food security and rural viability to multifunctionality is disputed and they do not fit well the framework of multifunctionality (OECD, 2001: 31).

While OECD is rather cautious, the European Union Commission applies this broad view of multifunctionality, which includes environmental aspects, food safety, animal and plant health and animal welfare standards. Its proposals for the CAP Mid-Term Review (MTR) presented these multifunctional elements as key ingredients of the future agricultural policy in Europe. CAP reform means, in fact, that multifunctionality is promoted by cross-compliance and modulation. Cross-compliance refers to the fact that a single payment scheme introduced in the CAP reform is linked to the aspects of multifunctionality. Modulation stands for reductions in direct payments for the biggest farms to finance the new rural development policy, which includes methods that promote the environment and animal welfare as well as production of high quality food.

Defining multifunctionality is complicated by international trade liberalization and the conflicting views upon it among the WTO members, mostly between the former Cairns Croup and some countries practicing agriculture under unfavourable natural conditions (like the Nordic countries).[1] While the

[1] Members of the Cairns group were: Argentina, Australia, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Guatemala, Indonesia, Malaysia, New Zealand, Paraguay, the Philippines, South Africa, Thailand and

latter countries fear that reductions in domestic support would reduce the ability of governments to pursue their domestic non-commodity objectives, the former group considers multifunctionality merely as a pretext for maintaining high levels of production-related support (see Burrell, 2001). WTO Ministerial Conference in 2001 obtained a consensus about the importance of agriculture in preserving or developing the economic and social environment obligatory to sustain rural population. Every nation should guarantee food security for its citizens through a mixture of domestic production, imports and public stock holding. Furthermore, agriculture is important for conservation of biodiversity and maintenance of rural amenities. It was emphasized that the non-trade concerns (NTCs) are public goods and, hence, not fulfilled through market mechanisms. Domestic agricultural support is needed to maintain production of these public goods on adequate level. (LD, 2001.) Cairns Group members agreed that support to maintaining production of NTCs could be recognized in the WTO negotiations, provided that this support is WTO-consistent, targeted and transparent not distorting the trade (Cairns Group, 2001). There is, however, plenty of room for further negotiations on defining the NTCs. Hence, the concept of multifunctionality will remain a subject for vivid discussion and further elaboration.

Above discussion indicates that there is a consensus that multifunctional agriculture associates at least with the concept of agri-environmental multifunctionality, that is, positive or negative environmental non-commodity outputs produced jointly with the commodities. This has been also the starting point of the sparse academic research made on multifunctionality. Boisvert (2001), Romstad et al. (2000), Guyomard et al. (2004), Anderson (2002), Paarlberg et al. (2002), Vatn (2002), Peterson et al. (2002) and Lankoski and Ollikainen (2003), 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. Boisvert (2001) exemplifies the qualitative role of both public goods and public bads by focusing on two agricultural commodities and two non-commodities produced with a land input and a purchased input. Land allocated to both commodities produce landscape amenities and the use of purchased input creates environmental residual. Using similar approach Peterson et al. (2002) provide a comprehensive analysis of multifunctionality. Policy instruments include taxes and subsidies on output, land and non-land inputs. They show that, although commodity intervention may be part of the optimal policy-mix, it is not necessary, since a set of input taxes and subsidies can internalise all externalities in the absence of commodity intervention. Moreover, the optimal policy necessarily consists of a mix of instruments including input subsidies, taxes or regulations, used in perfect synchrony.

Vatn (2002) argues that there is a trade-off between the precision of instrument design and its transaction costs. If targeted instruments imply high transaction costs it may be reasonable to pay for provision of non-commodity properties by supporting the commodity output. Thus, it may not be rational to have free trade for commodity outputs while paying separately for non-commodity outputs. Lankoski and Ollikainen (2003) allow for spatial heterogeneity and endogenous land allocation between two crops. This modifies the previous findings of Boisvert (2001) and Peterson et al. (2002) to reflect heterogenous conditions and suggests the use of differentiated corrective instruments to attain the socially optimal multifunctionality. They also analyze the social welfare of using second-best, undifferentiated instruments.[2]

Romstad et al. (2000) and Guyomard et al. (2004) focus on alternative policies towards multifunctionality. Romstad et al. (2000) analyze a Norwegian case with transaction costs when private and public outputs may be i) joint, ii) complementary or competing and iii) public goods are relational. In the case i), a price support is the most efficient instrument if agricultural sector is unprofitable. Direct payments for the public goods become more feasible for the case ii), but designing the first-best payment scheme is difficult in case iii). Guyomard and Levert (2001) allow for

---

Uruguay.

[2] Implications for trade policy can be summarized as follows. Paarlberg et al. (2002) show that multifunctionality never justifies trade intervention. It can be promoted by production related subsidies or taxes provided that the level of externality is linked to commodity output levels. Peterson et al. (2002) and Latacz-Lohmann (2000) analyze the trade and welfare implications of agri-environmental policies deriving e.g. following results. Peterson et al. (2002) show that results very much depend on whether the country in question is large or small. Latacz-Lohmann (2000) show that government intervention to internalize environmental externalities increases domestic social welfare even though it may affect the quantities produced and traded.

endogenous determination of market equilibrium under free entry/exit for farms, and analyze how traditional farm income support programmes (price support, production-linked direct payments, land-based direct payments, and decoupled direct payments with and without mandatory production) meet the objectives of multifunctionality. A decoupled direct payment without mandatory production is found to affect only farmers' income, but with a mandatory production it increases the number of farms, while the other effects are indeterminate. A land-based direct payment increases farmers' income and reduces input intensity. A production-linked direct payment increases farmers' income, exports, and intensification. In both cases the effect on the number of farms is indeterminate. Guyomard et al. (2004) provides extension to the work of Guyomard and Levert (2001) by ranking agricultural support programmes to each multifunctionality objective.

None of previous papers has focused on the non-public good aspects (such as rural viability or food security) of multifunctional agriculture. The reason is evident. Pareto optimality requires that all positive and negative externalities should be internalized, giving thus a firm theoretical basis to the concept of agri-environmental multifunctionality. The decision of whether or not other aspect than these public goods should be introduced to the social welfare function of agriculture, is a complex question. OECD (2001) notifies that in some occasions or from certain angles food security or rural viability can be interpreted as public goods. When this holds they boil down to the frame of agri-environmental multifunctionality, and the general Pigouvian policy applies: discourage producing public bads and encourage provision of public goods.

As OECD (2001) observes and, for instance, Anderson (2002) forcefully argues, food security and rural viability cannot entirely be subsumed into the category of public goods. Beyond public goods aspect, the inclusion of food security and rural viability to the notion of multifunctional agriculture is a question of domestic social values. Hence, the question whether they should belong to the notion of multifunctionality is more an ethical than economic question and cannot be decided by theoretical work alone. However, economic analysis helps to clarify the consequences and policy implications of food security and rural viability when included into the broader definition of multifunctionality.

In this paper we focus on the implications of the inclusion of rural viability as a non-public good item to the notion of multifunctional agricultural.[3] By doing this we contribute to the literature in two ways. First, we demonstrate how the broader definition of multifunctional agriculture differs from the agri-environmental multifunctionality, and how agri-environmental policy should be reformed to include these aspects. We will predominantly focus on just one non-public good aspect, namely viability of rural areas. In line with OECD (2001), we describe the core economic content of rural viability by employment in agriculture and in the rural sectors serving agriculture, and include the rural viability valuation component to the social welfare function. We neglect trade policy aspects, because our primary purpose is to examine the optimal design of multifunctional agriculture, which inherently is domestic policy question, even though has important connections to trade policy, as Anderson (2002) points out.

The rest of this paper is organized as follows. Section 2 provides a theoretical model of multifunctional agriculture and develops the first-best policies to address it. By using Finnish data we assess in section 3 empirically how the socially optimal provision of non-public good multifunctionality relates the socially optimal agri-environmental multifunctionality and private solution. A concluding section 4 ends the paper.

2. Multifunctional Agriculture: Towards a General Framework

A natural framework for multifunctional agriculture is a model where the emphasis is given to heterogeneity and spatial aspects of agriculture and on the changes in farmers' incentives because of changes in profitability between crops under alternative policies. We extend and re-examine the agri-environmental multifunctionality model by Lankoski and Ollikainen (2003). In this model of agri-

[3] Like us, Hediger and Lehman (2003) provide a welfare theoretical analysis of multifunctional agriculture in a small open economy framework. Their focus differs from ours in many ways. They assume homogenous land, which can be allocated between agriculture, forestry and manufacturing. Labor and land are inputs in production and environmental quality depends on land use and emissions.

environmental multifunctionality, biodiversity and runoff damages are the representatives of external and public good aspects of crop production (they qualitatively represent all other externalities/public goods such as landscape valuation or cultural/rural heritage). We extend this model to cover the broad definition of multifunctionality, that is, also non-public good aspects. The representative of non-public goods is the viability of rural areas, approximated by rural employment. Again, the number of types of non-public goods could be larger, but analytically this extension is sufficient to show the qualitative effects of the broader definition of multifunctionality.

2.1 *Agricultural landscape*

Consider a watershed with a single river running through it and agricultural land bordering this stream. For analytical convenience we treat this river as a straight line, and divide the agricultural land into production units, rectangular parcels, each of which having an edge along the stream and extends perpendicularly away from the stream. The production units are normalised to have the size of each parcel to 1 unit (hectare) of the land area. Let the overall fixed amount of arable land be *G*. The land quality is assumed to be uniform in each parcel but it differs over parcels, and land quality is ranked by a scalar measure q, $0 \le q \le 1$ (see Lichtenberg, 1989). Thus, *G(q)* is the cumulative distribution of q (acreage of having quality q at most) and *g(q)* is its density that is assumed continuous and differentiable, $G'(q) = g(q)$.

$$G = \int_0^1 g(q)dq \qquad (1)$$

The arable land can be allocated between two cereal crops, crop 1 and crop 2, and some of the land may be allocated to non-agricultural uses. The shares of land devoted to crop 1 and 2 are defined as $L_1 = \int_{\hat{q}}^{q^c} g(q)dq = G(q^c) - G(\hat{q})$ and $L_2 = \int_{q^c}^{1} g(q)dq = G(1) - G(q^c)$, where $G(1) = N$ and denotes the total amount of land. The share devoted to non-agricultural land use is defined by $L_{NA} = \int_0^{\hat{q}} g(q)dq = G(\hat{q}) - G(0)$. Profits from non-agricultural use are by assumption independent of land quality and the return to it, π_{NA}, is exogenous.

Figure 1 describes the sketched spatial structure of this model. The land is divided into uniform rectangular parcels and land quality improves from left to right. Through allocation of the land between the two crops as well as non-agricultural use, this landscape will be structured into various patches representing different land uses.

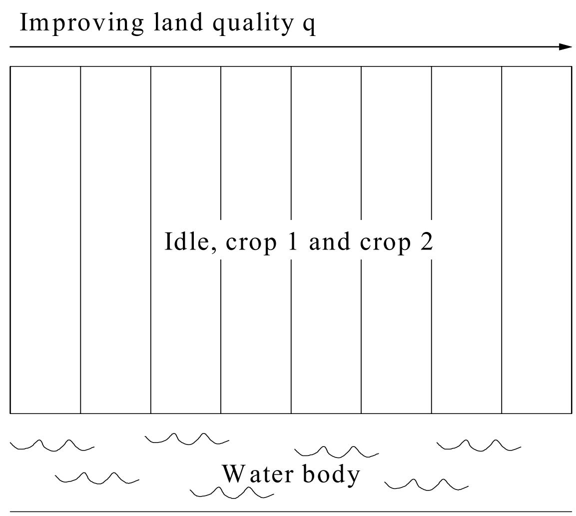

Figure 1. The spatial properties of agricultural landscape

Other features of the landscape will depend on the nature of agricultural production. For crop production we assume constant returns to land of any given quality, but decreasing returns with respect to inputs and land quality. The production function of crops 1 and 2 in each parcel is a function of land quality *q*, and fertilizer intensity, l_i. Hence, the per parcel production function is defined by $y^i = f^i(l_i;q)$. We make the following conventional assumptions concerning the partial derivatives: $f^i_{l_i} > 0$, $f^i_{l_i l_i} < 0$.

Also, we assume that cultivation requires employing per parcel a constant amount of labor input (measured in working hours) and capital, and denote them by n_i and k_i, respectively. Capital intensity may differ between the crops. Moreover, higher capital intensity requires by assumption more labor input (working hours). The profit function of crop *i* per parcel is defined as the difference between the revenue and input costs: Also, we allow for a possibility that the farmer establishes buffer strips:

$$\pi^i = (1-m_i)\left[p_i f^i(l_i;q) - cl_i - wn_i\right] - rk_i \ , \qquad (2)$$

where m_i denotes the buffer strip, and p_i refers to the prices of crops and *c* to the fertilizer price, *w* to wage and *r* to the cost of capital. In accordance with the actual practice, we assume in (2) that the wage cost per parcel is fixed (as working hours are fixed) and depends on the actually cultivated share of the parcel. Capital cost is another fixed cost term but independent of the size of the buffer strip. This is natural, as machinery and equipment related to capital costs, such as depreciation, accrue irrespective of the size of the buffer strip. Both fixed cost terms affect our analysis: the size of the buffer strips is dependent on labor costs, and both labor and capital will affect directly land allocation and, hence, the social optimum.

Choice of fertilizer input, the size of the buffer strip and land allocation affect the environmental quality of our rural landscape. Assume that the society regards biodiversity and surface water quality as the most important non-commodity outputs in our agricultural landscape. We refer to Lankoski and Ollikainen (2003) as regards to the general discussion of these aspects. We express the valuation of biodiversity as a function of aggregate land use of each type including also non-agricultural use. Runoffs depend on the use of fertilizer and size of the buffer strips. For simplicity, non-agricultural land use does not cause pollution.

$$\Omega = \Omega(L_1, L_2, L_{NA}, M)\,, \quad (3)$$

$$Z = \int_{\hat{q}}^{1} \sum_{i=1}^{2} v_i\left[(1-m_i)l_i(q), m_i(q)\right]L_i g(q)dq\,, \quad (4)$$

where $M = \int_{\hat{q}}^{1} \sum_{i=1}^{2} m_i(q)L_i g(q)dq$, L_1, L_2 are defined above, $v_i(\cdot)$ denotes the runoff from parcels devoted to crop 1 and crop 2, with $v_{\bar{l}_i} > 0, v_{\bar{l}_i\bar{l}_i} > 0$, where $\bar{l}_i = (1-m_i)l_i$ and $v_{m_i} < 0, v_{m_i m_i} > 0$. Given Z, the society's monetary valuation of runoff damages defines a damage function, $D(Z)$, which is assumed to be convex ($D'(\cdot) > 0$ and $D''(\cdot) > 0$).

2.2. Agriculture and rural viability

Denote now the overall amount of labor related directly or indirectly to agricultural production, by *N*. This total amount consists of two streams of labor: labor used directly in agriculture (direct employment) and indirect employment created by agricultural activities. The total actual direct use of labor in agriculture, denoted by N^a, is defined by $N^a = \int_{\hat{q}}^{1} \sum_{i=1}^{2} (1-m_i)n_i L_i g(q)dq$. The second, indirect employment effect emerges in agriculture serving intermediary sectors, such as retailers of fertilizer and capital, and services related to the use of capital. We denote this indirect labor by N^I and assume that it is a function of the actual use of fertilizers and capital via commerce and services. The actual use of fertilizer and capital is defined as $\hat{l} = \int_{\hat{q}}^{1} \sum_{i=1}^{2} (1-m_i)l_i L_i g(q)dq$ and $K = \int_{\hat{q}}^{1} \sum_{i=1}^{2} k_i L_i g(q)dq$, Using these we have $N^I = \sum_{i=1}^{2} N_i^I(\hat{l}, K)$, with $N_{\hat{l}}^I > 0$ and $N_K^I > 0$. Finally, we also account for the (exogenous) employment in the non-agricultural land use and denote it by N^{NA}.

One could introduce explicitly the agriculture serving sectors into the model and define the agriculture-dependent employment there, but this is not necessary for our theoretical treatment. As pointed out in OECD (2001), conventional market effects from agriculture to the employment of sectors serving it do not provide a cause of including rural viability into multifunctionality, rather it is the special emphasis given by the society to rural viability in the form of employment. Therefore, we next introduce the social valuation of rural employment calling it rural viability valuation function, B, and define it as $B = B(N)$, where $N = N^a + N^I + N^{NA}$. We assume that *the marginal viability effect* increases in *N*, but in a decreasing fashion, i.e., $B'(N) > 0$ and $B''(N) < 0$. Thus, for changes in the use of inputs we have, $B_{l_i} = B'(N)N_{l_i}^I > 0$, $B_{K_i} = B'(N)N_{k_i}^I > 0$, and for the change in the size of the buffer strip $B_{m_i} = -B'(N)N_{m_i}^I < 0$.[4]

2.3 Socially Optimal Agri-Environmental and Rurally Viable Multifunctionality

---

[4] From the definition of N^I we have for the derivatives: $N_{l_i}^I = dN^I/dl_i = (1-m_i)L_i \dfrac{\partial N_i^I}{\partial \hat{l}} > 0$,

$N_{k_i}^I = dN^I/dk_i = L_i \dfrac{\partial N_i^I}{\partial K} > 0$ and $N_{m_i}^I = dN^I/dm_i = -l_i \dfrac{\partial N_i^I}{\partial \hat{l}} L_i < 0$.

We assume that the government maximizes the sum of the producers' and consumers' surplus, but augments the social welfare function by the extra weight given to the rural viability. Thus, the social welfare function reads now,

$$W = \int_0^1 (L_1\pi_1^*(q) + L_2\pi_2^*(q) + L_{NA}\pi_{NA}^*)g(q)dq - D(z) + \Omega(L_1, L_2, L_{NA}, M) + B(N). \tag{5}$$

The first-best optimum is solved by choosing first the use of inputs and then allocating the land to its best use. The choices of inputs are characterized by

$$W_{l_i}^i = p_i f_{l_i}^i - c - D'(Z)Z_{l_i} + B'(N)N_{l_i}^I = 0 \tag{6a}$$

$$W_{m_i}^i = -\frac{\pi_i^*}{(1-m_i)} - D'(Z)Z_{m_i} + \Omega_M + B'(N)N_{m_i}^I = 0, \tag{6b}$$

where $Z_{l_i} = (1-m_i)\dfrac{\partial v_i}{\partial l_i} > 0$ and $Z_{m_i} = \dfrac{\partial v_i}{\partial m_i} - l_i \dfrac{\partial v_i}{\partial l_i} < 0$.

From (6a), fertilizer intensity in each parcel is chosen so that the value of the marginal product of fertilizer equals its unit cost adjusted with the sum of the marginal social costs and marginal viability benefits of fertilizer application. According to (6b) the size of the buffer strip in each parcel is socially optimal when the net loss of income due to decreased production equals the marginal benefits from runoff reduction and the constant marginal benefits from biodiversity production minus the marginal decrease in rural viability due to lowered employment. Given that the land quality varies over parcels, the socially optimal l_i and m_i will vary over parcels, as well.

A comparison of this outcome with agri-environmental multifunctionality entails setting $B'(N) = 0$, that is, assuming that rural viability does not matter. This comparison is condensed to

Proposition 1. The Socially Optimal Use of Inputs under NPG-MFA
Relative to agri-environmental multifunctionality, the effect of NPG-MFA, expressed through rural viability, is to moderate policy towards public goods and bads, because now the society trade-offs public goods aspects with viability aspects. Thus, fertilizer intensity is higher, buffer strips are smaller and employment in agriculture is higher than under AE-MFA.

Proposition 1 implies that now socially optimal policy shifts away from the first-best Pigouvian policy due to employment considerations.

Next the social planner allocates land to crops 1 and 2 taking into account the effects of land allocation on diversity, nutrient runoffs and rural viability. To facilitate the land allocation we make the following assumptions. First, there is some land quality level for each crop, denoted by $\hat{q}_i$, for which the social rent is zero. Without a loss of generality we assume that this marginal land quality is lower for crop 1 than for crop 2. Second, the social returns are higher for crop 2 on the land of highest quality. Third, the social returns as a function of land quality increase more rapidly for crop 2 on all parcels. Fourth, by assumption profits from non-agricultural land use are constant and independent of land quality. Moreover, non-agricultural land use is more profitable than crop production only on the lowest qualities of land. Under these assumptions the critical switching land quality, q^c, and the marginal land quality $\hat{q}_i$ become uniquely determined, and the whole area of arable land is divided into a unique, compact ranges of land qualities for both crops and non-agricultural land use.

The critical switching land quality, q^c, and the marginal land quality $\hat{q}$ are defined by

$$\pi_1^* - D'(\cdot)v_1 + \Omega_{L_1} + B_{L_1} = \pi_2^* - D'(\cdot)v_2 + \Omega_{L_2} + B_{L_2} \tag{7a}$$

$$\pi_1^* - D'(\cdot)v_1 + \Omega_{L_1} + B_{L_1} = \pi_{NA}^* + \Omega_{L_{NA}} + B_{L_{NA}} \tag{7b}$$

Assuming, again, for a moment that $B'(N) = 0$, allows us to trace the land allocation under agri-environmental multifunctionality. Now the condition (7a) for the switching land quality becomes: $\pi_1^* - D'(\cdot)v_1 + \Omega_{L_1} = \pi_2^* - D'(\cdot)v_2 + \Omega_{L_2}$, which is the same as in Lankoski and Ollikainen (2003). It simply requires land allocated between the two crops so that the social returns from both crops in terms of revenue, runoff damages and biodiversity benefits are equal. From (7b) we have a new condition for the marginal land quality $\pi_1^* - D'(\cdot)v_1 + \Omega_{L_1} = \pi_{NA}^* + \Omega_{L_{NA}}$. This requires that land is allocated to agriculture up to the point where the social return from agriculture equals the social return of the land allocated to non-agricultural use.

Allowing now $B'(N) > 0$ reveals how rural viability changes land allocation relative to AE-MFA. We collect these findings in Proposition 2.

Proposition 2. Socially Optimal Land Allocation under NPG-MFA
Relative to agri-environmental multifunctionality, NPG-MFA, expressed through rural viability, changes land allocation: a) within agriculture towards the crop which entails higher use of labour within agriculture and b) between agricultural and non-agricultural land use towards land use which entails higher use of labour.

Proposition 2 implies that if the labour intensity is higher in the production of more polluting crop 2, some additional land will be allocated to it via marginal viability effect. Interestingly, inclusion of rural viability had implications to the marginal land quality as well. Marginal land quality may increase or decrease depending on whether the land in crop 1 or in the non-agricultural land use has higher marginal viability effect. Ceteris paribus, if non-agricultural land use has higher marginal impact on rural viability, more land is allocated outside agriculture and vice versa. This also means that the concept of rural viability applies also outside agriculture and has broader implications to general regional policy.

2.4 Socially optimal design of multifunctional policy instruments

We next ask how does rural viability affect the design of multifunctional policy? Recall Propositions 1 and 2. They imply that one needs instruments within agriculture to affect the use of inputs and land allocation between crops. Moreover, as the marginal land quality is a function of social returns to non-agricultural land use, an additional instrument is needed to ensure the achievement of optimal allocation of land between agricultural and non-agricultural use. In what follows we establish these findings in a more rigorous way.

Note first that the privately optimum solution, extracted from equations (6a) - (6d), entails $\pi_{l_i}^i = p_i f_{l_i}^i - c = 0$, $\pi_{m_i}^i = -\left[p_i f^i(l_i;q) - cl_i - wn_i\right] \leq 0$. Thus, while the use of fertilizer is higher, the size of the buffer strips is smaller than in the social optimum. In fact, without any socially-induced incentives, the privately optimal level of buffer strips is zero due to net loss of income. Hence, it is optimal to choose a tax/ subsidy to handle the (positive or negative) externality of each input.

Postulate now a crop specific unit tax τ_i on the use of fertilizer (the after-tax unit price is $c_i^* = c(1+\tau_i)$) and a buffer strip subsidy is $b(m_i)$ with $b'(m_i) < 0$. Inserting these instruments into privately optimal conditions and setting them equal to the socially optimal conditions (6a) and (6b) allows us after some subtractions to define the optimal tax and subsidy rates from the following two equations system: $-c\tau_i = -D'(Z)\dfrac{\partial v_i}{\partial l_i} + B'(N)N_{l_i}^I$ and

$c\tau_i l_i + b'(m_i) = -D'(Z)\dfrac{\partial v_i}{\partial m_i} + \Omega_M + B'(N)N_{m_i}^I$. Solving this system for fertilizer tax and buffer strip subsidy gives:

$$\tau_i^* = D'(Z)Z_{l_i} - B(N)N_{l_i}^I \tag{8a}$$
$$b'(m_i)^* = -D'(Z)(Z_{m_i} + Z_{l_i}l_i) + B'(N)(N_{m_i}^I + N_{l_i}^I l_i) + \Omega_M \tag{8b}$$

The implications of rural viability on the use of agri-environmental instruments become evident in (8a) and (8b). In the absence of rural viability, the optimal effective fertilizer tax ($\tau_i^* = \tau_i c$) would reflect the social costs of fertilizer use only. When rural viability is present fertilizer tax is decreased from its Pigouvian level to reflect the employment effects of fertilizer use. Similarly, if $B'(N) = 0$, the optimal marginal buffer strip subsidy would reflect only its environmental effects, that is, the constant marginal biodiversity effect, its direct effect of reducing runoffs and indirect effects of allowing for a slightly higher fertilizer intensity. Accounting for rural viability effect would clearly decrease its size, because buffer strips tend to decrease the direct and indirect labour.

Proposition 3. The Design of Instruments under NPG-MFA
The socially optimal multifunctional agriculture under heterogeneous land quality requires the use of differentiated instruments on fertilizer and buffer strips inputs, set below their first-best levels because trade-offing the rural viability effect via employment with promoting public goods and reducing public bads.

Equations (8a) and (8b) and Proposition 3 entail that the switching land quality between crops 1 and 2 becomes determined in a socially optimal way (to ascertain this insert the optimal instruments in private land allocation condition to see that they become identical with the socially optimal one). They do not, however, define the marginal land quality, which partly depends on the social returns on non-agricultural use of land. To see how rural viability affects the use of instruments between agricultural and non-agricultural land use, re-express condition (8b) governing marginal land quality as private solution where socially optimal instrument are used in agriculture but no instruments are used in non-agricultural land use: $\pi_1^* - D'(\cdot)v_1 + \Omega_{L_1} + B_{L_1} = \pi_{NA}^*$. Comparing this with (8b) immediately reveals that too much land is allocated to agriculture, because agents in non-agricultural land use do not account for their effects on biodiversity and rural viability. Hence, NPG-MFA implies that

Corollary. Policy targeted to Non-Agricultural Land Use
Under NPG-MFA it is socially optimal to subsidize non-agricultural land use according to its biodiversity and rural viability effects so as to ensure optimal land allocation between agricultural and non-agricultural land use.

Hence, not only concerns but also design of policies will go beyond the limits of agriculture. Economic intuition of Corollary is the following. Tax and subsidy policies within agriculture adjust the input intensities and land allocation between two crops to the social optimum. Any attempt to correct land allocation between crop 1 (cultivated on the lower quality land) and non-.agricultural use by using agri-environmental instruments would distort land allocation between crop 1 and crop 2. Hence, affecting profitability of non-agricultural use by subsidies is the only way of adjusting the marginal land quality its socially optimal level without distorting land allocation within agriculture.

Figure 2 illustrates socially optimal multifunctional landscape. The social optimum implies that a buffer strip is established on each parcel of cultivated crops and the buffer strip width decreases with land quality (this is indicated by descending graph). Note that private market solution does not entail buffer strips.

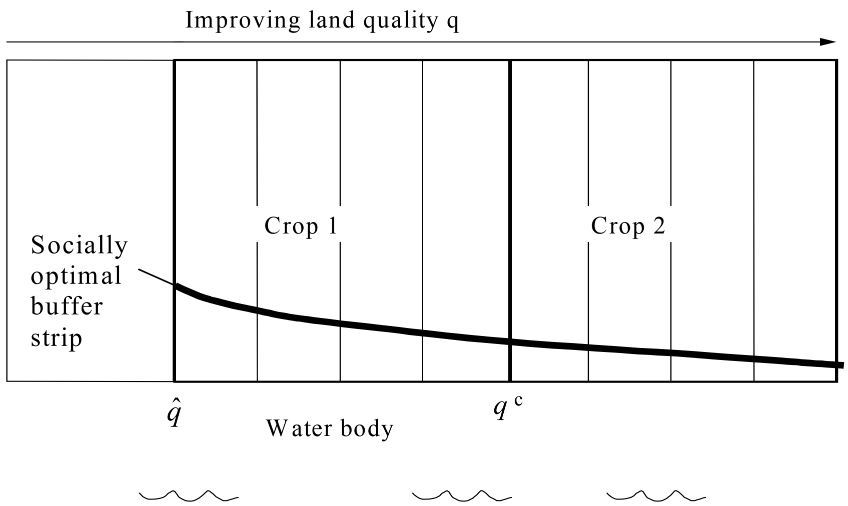

Figure 2. The socially optimal multifunctional landscape.

Armed with our two models of multifunctionality and their characterizations we next go on to empirical application by using Finnish data.

3. A parametric model of multifunctionality in Finnish agriculture

In this section we apply our general framework of multifunctional agriculture to Finnish agriculture by developing a parametric model comprising all parts of our theoretical model. We wish to examine quantitatively how much the inclusion of rural viability affects the socially optimal design of agriculture as compared with agri-environmental multifunctionality and free market solution.

3.1 Parametric model of multifunctional agriculture

The parametric model consists of a quadratic nitrogen response function, exponential nitrogen runoff function, damage function from nitrogen runoffs, agrobiodiversity valuation function, and rural viability valuation function. The model has been described in detail in Lankoski and Ollikainen (2003) and here we describe it briefly. The private profits from the agriculture in the absence of government intervention are

$$\pi^i = (1-m_i)\left[p\left(a_i + \alpha_i l_i + \beta_i l_i^2\right) - cl_i - wn_i\right] - rk_i \quad \text{for i =i,2,} \qquad (9)$$

We use a quadratic nitrogen response function $y_i = a_i + \alpha_i l_i + \beta_i l_i^2$ which has been estimated for rape (crop 1) and spring wheat (crop 2) in clay soils by Heikkilä (1980) and Bäckman et al. (1997), respectively. The land quality is incorporated into response function through the intercept parameter a_i and slope parameter α_i by calibrating the nitrogen response function to reflect actual yields in clay soils in Southern Finland in years 2000-2002.

$$\begin{aligned} a_1 &= e_0 + e_1 q & \alpha_1 &= \mu_0 + \mu_1 q \\ a_2 &= h_0 + h_1 q & \alpha_2 &= \eta_0 + \eta_1 q \end{aligned} \qquad (10)$$

All prices and costs are from year 2002 (see Table 1 for parameter values). For the estimation of labor and capital costs we have developed standard activity set for field operations: primary tillage, seedbed tillage, planting, herbicide application.[5] Labor cost is based on estimated hours/ha for

[5] We assume here that machinery is same for both crops but the number of tillage operations (e.g. seedbed

different operations and farmer's wage rate per hour. Capital cost is based on machinery required for aforementioned field operations and machinery expense per hectare (which is measured by depreciation cost).

Besides rents from agriculture, π^i, the social welfare function contains runoff damages, agrobiodiversity benefits, and rural viability benefits. While other components are generally similar to Lankoski and Ollikainen (2003), rural viability benefits are the new component of the model. We assume that rural viability valuation is a linear function of direct and indirect labor effects of agriculture. In defining the indirect effects of agricultural production on labor, we utilize regional input-output tables for Uusimaa region in Southern Finland, which is a representative area for crop production in Finland (Knuuttila 2004). According to Knuuttila (2004) the direct employment in agriculture was 7790 years and the overall indirect effect in turn was 379 years. This suggests that one hour of work in agriculture causes a 0.0487 hour's increase in the indirect employment. Given that farmers spend 6.57 working hours per hectare, we obtain 0.32 hour as the indirect employment effect per hectare from agriculture. We assume somewhat arbitrarily that the indirect employment effect from this work can be imputed to capital and fertilizer inputs in shares 0.6 and 0.4. Thus, we can define the employment (direct agricultural employment plus indirect employment) with the help of the following coefficients

$N = N^a + N^I = \int_{\hat{q}}^{1} \sum_{i=1}^{2} 6.57 * (1 - m_i) + (0.0013933 k_i + 0.0009288(1 - m_i) l_i)$. From a recent study by Yrjölä and Kola 2004 we have as the marginal valuation 5.4 €, so that rural viability valuation is given by *5.4N*.

The social welfare function for agriculture can now be expressed as

$$SW = \int_0^1 \sum \pi^i - 3.57Z + 54M^{0.0977} + 5.4N \,. \qquad (11)$$

In the second term Z denotes the nitrogen runoff and the social value of marginal damage (3.57) which is estimated on the basis of Yrjölä and Kola (2004). The nitrogen runoff function is $z_i = [1 - m_i^{0.2}]\phi\, e^{-0.7[1-0.01(1-m_i)l_i]}$. The first term on the right hand side of equation, $1-m_i^{0.2}$, models nitrogen uptake by buffer strips. The calibration is based on Finnish experimental studies on grass buffer strips (Uusi-Kämppä and Yläranta, 1992, 1996, Uusi-Kämppä et al. 2000). The term $\phi\, e^{-0.7[1-0.01(1-m_i)l_i]}$ represents nitrogen runoffs from crop i generated by a nitrogen application rate of l_i per hectare when buffer strips take up a share of land m_i. The parameter ϕ calibrates this expression so that it equals the level of nitrogen runoffs generated by a nitrogen application rate of 100 kilos per hectare in the absence of buffers strips. On the basis of Finnish experimental studies on the runoff of nitrogen (Turtola and Jaakkola, 1987, Turtola and Puustinen, 1998), we set the parameter ϕ at 15 kg N/ha.

The third term denotes the agrobiodiversity valuation. We link the buffer strip areas to species diversity with the help of a study by Ma et al. (2002). They describe the relationship between floral species richness and buffer strip area by $S = \psi \Lambda^{\varphi_\alpha} W^{\varphi_\beta}$, where φ_α (φ_B) is an estimate for the average change in species richness due to an increase in the length (width) of the area while keeping the width (length) of the area constant ($\psi = 1.6331$, $\varphi_\alpha = 0.0009$, $\varphi_\beta = 0.0977$). Since the length of the area is fixed, the buffer strip size m uniquely defines the width of buffer strip and thus, after having solved for m, we can assess the floral species richness by using the coefficients estimated by Ma et al. (2002). Our estimate for agrobiodiversity valuation function is given in terms of buffer strip hectares and taken from Yrjölä and Kola (2004), which suggests € 54 as average WTP per hectare for biodiversity.

The alternative non-agricultural land use form in our model is forestry. This is an obvious choice, as forests are the natural cover of the Finnish landscapes. Moreover, the border between agricultural

---

tillage by harrowing) may differ between crops.

fields and forests has varied across time. We assume that if a parcel of forest is converted to agriculture, there is a lump sum conversion cost but the yields obtained from this converted land will reflect typical agricultural yields. If a previous cultivated land is forested, it will take a long time for this parcel to produce regular forest income. From Finnish studies we have an estimate of € 47.8 per ha annual forest income over one rotation period of trees in reforested agricultural land. Hence, we set $\pi^{NA} = 47.8$ €. According to Statistical Yearbook of Forestry (2001) employment effects of agriculture are 4.5 times to those of forestry when measured by the employment effects of an increase of € 10 million in final demand for agricultural and forestry products. We will apply this employment information when solving the land allocation between agriculture and forestry. Finally, given that forests are so plentiful in Finland, we do not impose any special biodiversity value to changes in the forest land.

Other parameter values for our parametric model are reported in Table 1. The arable land area is assumed to be 40 hectares (the width of the field area, that is, the distance from the water border to the other edge of each parcel is 200 m and the length, that is, border along the waterway is 2000 m so that the length of each parcel is 50 m). The base case of our parametric model represents the private market solution (without taxes and subsidies) for cereals and oilseeds in Finland in 2002.

Table 1. *Parameter values in the numerical application.*

Parameter	*Symbol*	*Value*
price of rape	p_1	€ 0.255/kg
price of wheat	p_2	€ 0.13/kg
price of nitrogen fertilizer	c	€ 1.2/kg
basic level of response for crop 1	μ_0	9.72
basic level of response for crop 2	η_0	30.8
slope of the response change for crop 1	μ_1	0.01
slope of the response change for crop 2	η_1	0.05
parameter of quadratic nitrogen response function	β	-0.0324 for rape -0.094 for wheat
initial level of productivity for crop 1	e_0	700
initial level of productivity for crop 2	h_0	680
slope of the productivity change for crop 1	e_1	10
slope of the productivity change for crop 2	h_1	23
nitrogen leakage at average nitrogen use	ϕ	10-20 kg/ha
farmer's wage rate per hour	w	€ 11.35/h
farmer's labor input per hectare	n	6.57 h/ha
capital cost	rk	€ 144/ha

Notes: All prices and costs are from the year 2002. The price of nitrogen is calculated on the basis of a compound NPK fertilizer.

3.3 Results

Maximizing (11) in the absence and presence of nitrogen runoff, biodiversity and viability effects produces the privately optimal agricultural production (in the absence of government intervention), socially optimal agri-environmental multifunctionality (AE-MFA) and the socially optimal provision of non-public good multifunctionality (NPG-MFA).

We have collected our results concerning the private and social optimums in Tables 2 and 3. We start with Table 2 that reports average use of inputs per parcel.

Table 2. *Average input use per parcel (bold) under alternative solutions (range in parentheses).*

	Fertilizer use Crop 1	Fertilizer use Crop 2	Buffer strip Crop 1	Buffer strip Crop 2

Private opt.	**80.3** (80.2-80.5)	**122.8** (120.3-125.4)	-	-
NPG-MFA	**71.2** (69.8-72.8)	**115.7** (114.4-117.0)	**0.0417** (0.0357-0.0477)	**0.0384** (0.0330-0.0438)
AE-MFA	**72.2** (71.4-73.0)	**116.2** (115.0-117.4)	**0.0491** (0.0438-0.0544)	**0.0484** (0.0399-0.0569)

In accordance with our theoretical analysis, the fertilizer intensity increases and the size of the buffer strips decreases in land quality over all parcels. (Note that for fertilizer use the first figure in parentheses is the lowest land quality cultivated under that crop and for buffer strips the first figure is the highest land quality cultivated under that crop.) Relative to the social optimum, the private input use is too high for fertilizer and too low for buffer strip (in fact, no buffer strips become implemented in private solution). Our model reveals some interesting features concerning the average input use in NPG-MFA and AE-MFA optima. Although one could expect that the average fertilizer intensity is higher in NPG-MFA than in AE-MFA, this feature does not show up in Table 2. The explanation is, however, obvious. From Table 3 indicating land allocation we can find that under NPG-MFA more land of lower quality is allocated in agriculture. Thus, under AE-MFA both crops are cultivated in higher quality parcels with higher fertilizer intensity than under NPG-MFA. Restricting attention only on the same parcels cultivated both under AE-MFA and NPG-MFA reveals that our expectation is actually true. Within this range of qualities, the average fertilizer use under NPG-MFA is higher. While the mean rates of fertilizer application are 68.66 kg/ha (crop 1) and 110.57 kg/ha (crop 2) under AE-MFA, we have for NPG-MFA 69.02 kg/ha (crop 1) and 111.28 kg/ha (crop 2). Finally, in accordance with our theoretical model, the size of buffer strips is larger under AE-MFA than under NPG-MFA.

The optimal use of inputs determines land allocation, profits, nitrogen runoffs, floral species richness, employment and social welfare. They are collected in totals in Table 3. Note that for the floral species richness we account only the number of species sustained by the buffer strips. This number indicates the relevant differences between our solutions, because other aspects of agrobiodiversity are invariant to different solutions.

Table 3. *Multifunctionality indicators*.

Policy	Land allocation (NA: C 1: C 2)	Profit, €	Runoff, kg	Species, #	Employment, #	SW, €
Private optimum	17 : 3 : 20	2056	391	-	158	1514
NPG-MFA	2 : 25 : 13	2115	242	83	250	4178 / 2828
AE-MFA	12 : 15 : 13	1922	177	83	183	3885

Table 3 reveals some striking features of the social optimums. First and in line with the discussion in Lichtenberg (2002), we find that the social optima entail new land entering into agriculture relative to the private market solution, and yet runoffs are lower and biodiversity at a higher level than under market solution. Land allocation under NPG-MFA is driven by the fact that agriculture has higher viability value (recall, 4.5 times higher) than forestry. When rural viability is not accounted for, AE-MFA entails much more land allocated to forestry.

Total agricultural profits are higher in NPG-MFA than in private solution since more land is allocated to agriculture. However, for AE-MFA, profits are lower than in the private solution due to lower fertilizer use and establishment of buffer strips (although agricultural land area is 5 ha higher). Since the size of buffer strips under NPG-MFA and AE-MFA are close to each other the number of floral species produced by buffers in these solutions is same. As expected, Table 3 reveals that the employment rate under NPG-MFA is clearly higher than in the private solution or under AE-MFA.

The overall social welfare in private solution is clearly inferior to both social optimums. NPG-MFA produces highest welfare when rural viability is included in social welfare calculation. If we exclude rural viability, then the social welfare for NPG-MFA is clearly below that of AE-MFA. Note that Table 3 includes social welfare only from agricultural land use. If we add returns from parcels allocated to forestry the ranking changes. Now the levels of welfare relate as follows: Private solution € 2463, NPG-MFA € 4290, AE-MFA € 4458. It is the higher share of (non-polluting) forestry that ranks AE-MFA as the best solution for the whole society.

4. Conclusions

We developed a general framework for multifunctional agricultural which includes besides the public goods also rural viability valuation as a non-public good item. Our framework contributes to the literature in two ways. First, it demonstrates how the broader definition of multifunctional agriculture differs from the agri-environmental multifunctionality. Second it indicates how agri-environmental policy should be reformed to reflect rural viability. We focused on just one non-public good aspect, namely viability of rural areas. In line with OECD (2001), we described the core economic content of rural viability by employment in agriculture and in the rural sectors serving agriculture.

In the theoretical model, we show that rural viability entails adjusting fertilizer tax and buffer strip subsidy below their first-best Pigouvian levels to reflect the direct and indirect employment effects of agricultural production. Moreover, we showed that when non-agricultural land use is present, an additional, non-agricultural policy instrument is needed to adjust the amount of land allocated to agriculture to its optimal level. In a parametric model calibrated to Finnish agricultural conditions, and valuation of agri-environmental amenities and rural viability we assess how the socially optimal provision of non-public good multifunctionality relates to private market solution and socially optimal agri-environmental multifunctionality.

We followed the same strategy as previous AE-MFA literature and focused just on one example of non-public goods aspect. Hence, we ask next: How much our characterization of multifunctionality depends on the chosen aspect of rural viability? Consider first, food security, often mentioned as an important element of multifunctionality. Suppose that food security takes the form of a national buffer or a domestic self-sufficiency in a form of a binding amount of production. Then it is easy to demonstrate that this intensifies the use of inputs and moderate policies promoting public goods. Moreover, more land shifts to cultivation of the crop for which buffers are collected or self-sufficiency requirement is placed. This can be easily seen by replacing the argument of B function with the amount of crop produced. Alternative approach would be to maximize the target function subject to a constraint which requires the production of the crop in question be at least a given amount. In this case it is only the Lagrangian multiplier that has the same marginal utility interpretation as our B.

How about the other possible elements of multifunctionality? The qualitative effects and precise channels will depend on the non-public goods aspects chosen. Interestingly, promoting high food safety and quality would have a dual effect. On the one hand, food safety promotion may result in the reduction of pesticide use to reduce residues in food (which decreases yields in similar way as a reduction in fertilizer application). On the other hand, for some crops food quality promotion may even increase the use of fertilizers. This outcome will emerge, because sometimes higher nitrogen levels are needed to increase the protein content of crops. Promoting animal welfare is an ethical standpoint, and could be described with the help of valuation function, such as our B function above. But of course, this analysis should not be carried in a crop model but in a livestock model.

In sum, our framework demonstrates for a large set on non-public goods aspects of multifunctionality that the first-best Pigouvian policies are amended towards more intensive use of agricultural inputs and more land allocated in the more intensive crop.

References

Anderson, K. (2002). Agriculture's 'multifunctionality and the WTO. Australian Journal of Agricultural and Resource Economics 44: 475-494.

Boisvert, R. (2001). A note on the concept of jointness in production. Technical annexes (Annex 1 pp. 105-123 Annex 2 pp. 125-132) in *Multifunctionality: Towards an analytical framework*. 159 p. OECD, Paris.

Burrell, A. (2001). Multifunctionality and agricultural trade liberalisation. Paper presented at: 77th EAAE Seminar/NJF Seminar No. 325, August 17-18, 2001, Helsinki.

Bäckman, S.T., Vermeulen, S. and Taavitsainen, V.-M. (1997). Long-term fertilizer field trials: comparison of three mathematical response models. *Agricultural and Food Science in Finland* 6: 151-160.

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

Guyomard, H., C. Le Mouel and A. Gobin (2004). Impacts of alternative agricultural income support schemes on multiple policy goals. *European Review of Agricultural Economics* 31: 125-148.

Hediger W. and B. Lehman. (2003). Multifunctional Agriculture and the Preservation of Environmental Benefits. Proceedings of the 25th International Conference of Agricultural Economists (IAAE). Durban South Africa, Auguts 16-22. 2003.

Knuuttila, M. 2004. Elintarvikesektorin työllisyysvaikutukset – Panos-tuotosanalyysi maakunnittain. Maa- ja elintarviketalous 56. MTT Taloustutkimus, Helsinki.

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

Latacz-Lohmann, U. (2000). Beyond the Green Box: The economics of agri-environmental policy and free-trade. *Agrarwirtschaft* 49(2000), Heft 9/10.

LD (2001). Non-Trade Concerns: 40 WTO Members and Observers Meet in Doha. Oslo: Lantbruksdepartmentet. Available: http://odin.dep.no/ld/mf/Conferences/020031-210002/index -dok000-b-n-a.html. Referred: 30.8.2003.

Lichtenberg, E. (1989). Land quality, irrigation development, and cropping patterns in the Northern High Plains. *American Journal of Agricultural Economics* 71:187-194.

Lichtenberg, E. (2002). Agriculture and the environment. In B. Gardner and G. Rausser (eds.), *Handbook of Agricultural Economics*. Vol 2A: Agriculture and its linkages. Amsterdam: North Holland.

Ma, M., Tarmi, S. and Helenius, J. (2002). Revisiting the species-area relationship in a semi-natural habitat: floral richness in agricultural buffer zones in Finland. *Agriculture, Ecosystems and Environment* 89: 137-148.

OECD (2001). *Multifunctionality: Towards an analytical framework*. 159 p. OECD, Paris.

Paarlberg, P., Bredahl, M. and Lee, J. (2002). Multifunctionality and agricultural trade negotiations. *Review of Agricultural Economics* 24: 322-335.

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

Romstad, E., Vatn, A., Rorstad, P.K. and Soyland, V. (2000). Multifunctional agriculture: implications for policy design. Agricultural University of Norway, Department of Economics and Social Sciences. Report No. 21. 139 p.

Simmelsgaard, S. (1991). Estimation of nitrogen leakage functions - Nitrogen leakage as a function of nitrogen applications for different crops on sand and clay soils. In: Rude, S. (ed.).

Nitrogen fertilizers in Danish Agriculture - present and future application and leaching, Institute of Agricultural Economics *Report* 62. Copenhagen.p135-150.

Uusi-Kämppä, J. and Yläranta, T. (1992). Reduction of sediment, phosphorus and nitrogen transport on vegetated buffer strips. *Agricultural Science in Finland* 1: 569-575.

Uusi-Kämppä, J and Yläranta, T. (1996). Effect of buffer strip on controlling erosion and nutrient losses in Southern Finland. In: Mulamoottil, G., Warner, B.G. & McBean, E.A. (eds.). *Wetlands: environmental gradients, boundaries and buffers*. Boca Raton: CRC Press/Lewis Publishers. p. 221-235.

Uusi-Kämppä, J., Braskerud, B., Jansson, H., Syversen, N. and Uusitalo, R. (2000). Buffer zones and constructed wetlands as filters for agricultural phosphorus. *Journal of Environmental Quality* 29: 151-158.

Vatn, A. (2002). Multifunctional agriculture: some consequences for international trade regimes. *European Review of Agricultural Economics* 29(3): 309-327.

Yrjölä T. and Kola, J. (2004). Consumer preferences regarding multifunctional agriculture. International Food and Agribusiness Management Review 7(1).