Promoting Location Suitable Land Use

Changing demands on the cultivated and natural landscape lead to land use conflicts between agricultural production, work and recreation purposes, and environmental protection. An economic land use model also integrating environmental factors enables us to assess the developments in agrarian structures and agricultural land use and to deduce their impacts on the environment.

Agricultural land use is associated with both negative and positive effects. The positive effects are primarily the productive use and the cultivation of the landscape. Among the most serious negative effects is the input of nitrogen, phosphorus, and pesticides into surface and ground waters, resulting from losses during use. In addition, these inputs are increased by land use activities which are unsuitable to their location.

Where Is Swiss Agriculture Heading to?

The scale of the positive and negative effects of land use depends on two interconnected factors: the choice of land use activities by landowners and the allocation of land use activities to a particular location. The decisions of farmers are determined by production techniques and other business management considerations, such as prices, direct payments and technical regulations. On top of these considerations, location choice is influenced by the availability of suitable land. If a farm has little suitable land at its disposal, there is a risk that some land will be used for unsuitable purposes. And furthermore, the agricultural basic conditions are constantly changing, requiring farm management to adapt appropriately.

In order to assess structural developments and future land use, we have developed a so-called sectoral land use model as part of the project "Sustainable land use and forestry production in Greifensee Watershed Area". Our model allows us to predict the development of the agricultural sector at a regional level, in our case for the Greifensee region. The model shows, on the one hand, how agricultural enterprises react economically to changing agricultural basic conditions. On the other hand, the model was extended to a series of environmental parameters [1]. It is therefore possible to investigate the effects of land use changes on the environment. In this article, we focus on the question of whether expected land use is suitable to the specific location and what effects land use activities will have on the pesticide load in the environment.

Scenarios and Basic Conditions

Reference Scenario 2000: In this scenario the year 2000 was simulated, meaning that all the prevailing basic conditions (political and market environment) which the farmer was confronted with in 2000 were used. Due to the census of agricultural holdings and the geo-referenced land use database [2], there are no gaps in the knowledge of factors which are important for the model. We are therefore in the position to validate the land use model, and to identify the effects of the model's assumptions.

Scenario Swiss Way 2011: In this scenario, no further liberalization steps are implemented other than decided in the Agricultural Policy 2007. The greatest changes are the lifting of the production quotas and the liberalization of the cheese market. So for milk in 2011, a price of 55 centimes is assumed, while the remaining produce prices sink by 20–30% compared to 2000. For costs there is no clear trend and the direct payments system is maintained in its current form.

Scenario Opening 2011: In comparison to the scenario Swiss Way 2011, this scenario assumes that the market price support is entirely abolished, and border protection with the EU is eliminated. Produce prices re-orient towards the European prices and lie at 35–75% below the initial level in the year 2000. The decline in costs is primarily felt in the concentrated feedstuffs sector in an European environment.

Land Use Model and Scenarios

Using the land use model, the total income of the agricultural sector in the Greifensee region was maximized. In addition, it derived optimal land use and animal husbandry for the farms and the region as a whole. Agricultural production is therefore modeled so as to reflect the real farms in the Greifensee region. For the model calculations, a series of assumptions has to be made, the most important of which concern:

- the available production factors like land and manpower,
- the production functions,
- the labor costs of family-owned manpower,
- the structural changes: the total number of enterprises should not decrease by more than 2.6% per annum, corresponding to the structural change seen over recent years.

The agricultural structural development was calculated for a reference scenario and two future scenarios (see box). 2011 was chosen as the time horizon. Table 1 summarizes the key figures for the two future scenarios.

Scenario Swiss Way 2011

If in the Swiss Way 2011 scenario full labor costs are assumed, today's structures shift in the direction of more extensive farming. Livestock is relatively heavily reduced, which is primarily the result of a lower milk production. With the assumed milk price of 55 centimes per litre, only 80% of the current milk volume would be produced. In comparison to dairy animals, the reduction of livestock in labor-extensive animal husbandry is less pronounced. Suckler cow husbandry would, on the other hand, increase considerably. As a result of the changes in animal husbandry, the feed crop farming would decrease. Ecological compensation areas would increase greatly, mainly fallow land on arable land and extensively used meadows. The increase in ex-

	Swiss Way 2011		Opening 2011	
	Exclusive labor costs	Inclusive labor costs	Exclusive labor costs	Inclusive labor costs
Sector income	98%	72%	83%	65%
Income/labor unit	64%	104%	54%	94%
Arable land/ASA	110%	76%	106%	40%
Open arable land/ASA	79%	89%	76%	42%
Fodder cultivation/ASA	192%	59%	189%	47%
Livestock (LU)	147%	76%	149%	83%
LU/Fodder cultivation area	121%	75%	121%	72%
Milk production	335%	80%	338%	95%
Ecological compensation areas/ASA	127%	237%	146%	287%

Tab. 1: Agricultural structural development in the future scenarios Swiss Way 2011 and Opening 2011 (relative to Reference Scenario 2000). Labor unit = one fully employed person, ASA = agricultural surface area, LU = livestock unit (e.g. 1 cow = 1.0 LU or 1 bull = 0.6 LU).

tensively used meadows is related to the lower labor requirements, high direct payments, and the lower fodder quality requirements of suckler cows.

Clearly, the level of the assumed labor costs has a strong influence on the agricultural structures. Should these costs be disregarded, then the decrease of product prices in animal husbandry is compensated by higher stock levels and more intensive production. In this case, the entire sector income stabilizes at today's level, whereby the income per labor unit falls significantly. If one includes labor costs and the changeover to (labor-)extensive systems, the opposite picture appears: despite reductions in sector incomes, agricultural enterprises achieve today's income levels per labor unit.

Scenario Opening 2011

Basically, the effects described for the scenario Swiss Way 2011 also apply for the scenario Opening 2011 (Tab. 1). The differences between the two scenarios are due to the different assumptions regarding prices, costs and direct payments. In particular, falling prices for cash crops have considerable impacts in this scenario. As a result, arable farming is reduced significantly. As in the scenario Swiss Way 2011, lower product prices have an effect on incomes. Taking full labor costs into account, income per labor unit in the scenario Opening 2011 is 10% lower than in the scenario Swiss Way 2011.

Is Today's Land Use Optimized for Location?

Along with the general structural developments in agriculture, we were interested to know to what extent land use would change and whether land would be cultivated in a location suitable way. In Figure 1A, the land use distribution for the year 2000 is shown as derived from a supervised classification of air photographs [2]. Figure 1B shows the optimal land use in Reference Scenario 2000. Clearly, there is unfavorably located arable farming in the current situation: approximately 20% of land which is suitable for extensive perennial grassland only is used for arable farming, and only 44% of land which is classed as unrestricted crop rotation area is used for arable farming (Fig. 1A). On the contrary, the Reference Scenario 2000 chooses more arable farming on the yield rich locations and uses the land predestined for perennial grassland exclusively for roughage production (Fig. 1B).

This raises the question why agricultural enterprises do not use their land for location suitable activities. An important reason is ownership and leasehold. In the current situation, there is a shortage of suitable arable land for single operators, who are consequently obliged to use unsuitable land. In the model, on the other hand, individual single-operator ownership and leasehold are not represented [1]. The model farms are therefore much more flexible in the composition of their properties, so that in Reference Scenario 2000 exclusively crop rotation land is used for arable farming.

Is Future Land Use Optimized for Location?

The land use model does not answer this question in an unambiguous way:

- On the one hand, the share of open arable land in the two future scenarios declines (Tab. 1). This induces a corresponding decrease in the shortage of crop rotation land in the future scenarios, so that it would be theoretically possible to re-establish arable farming in suitable locations.
- On the other hand, in the future scenarios the land area for cereals, potatoes and sugar beet declines, while fallow land area on arable land increases. As a conse-

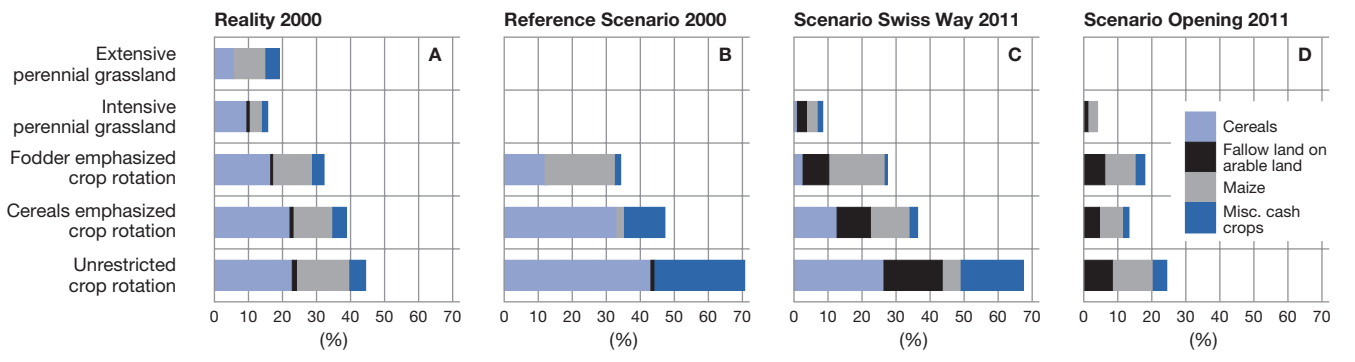

Fig.1: Arable farming by land use suitability in reality [2] (A), in the Reference Scenario 2000 (B), and in the two future scenarios Swiss Way 2011 (C) and Opening 2011 (D). See box for the description of the scenarios. Miscellaneous cash crops: potatoe, sugar beet, rapeseed.

quence, there is an increase in the planting of maize, a crop which can also be planted in less suitable locations. Very likely, a certain share of grassland will continue to be used for arable farming, which is not compatible with location suitability (Fig. 1C + D).

Environmental Impacts

With the expected animal husbandry and land use, the impacts on the environment also change. Table 2 shows how nitrogen and phosphorus losses change, as does the share of cultivated land in pesticide risk locations. While the nitrogen losses remain more or less proportional to the arable farming area, phosphorus losses fall with the livestock sizes. On the other hand, the share of pesticide risk locations used for arable farming clearly increases with full labor costs in the scenario Swiss Way 2011: more than 10% of the risk locations are used for arable farming, instead of around 3–6% as in the other scenarios. This is due to the fact that more land will be used with a lower degree of suitability, and that these locations are often pesticide risk locations [3].

Requirements for Location Suitable Land Use

From our results, it is clear that an extensification of agriculture is to be expected in the future: decreasing animal stocks, lower intensity in roughage production, and expansion of ecological compensation areas. This trend will be further emphasized by structural changes. Evaluations of the current structures in the Greifensee region show that large farms hold fewer animals per land unit than smaller farms [4]. The increasing flexibility due to the structural change makes it possible for farm managers to limit the inappropriate use of land for arable farming, so that in comparison to today's use, a more suitable farming of the arable land can be expected. It can also be expected that the negative effects of agriculture on the environment will decline.

Independent of this long-term development, location suitable use of land can be promoted by the design of the direct payments system, i.e. the requirements for the right to receive direct payments. Under the current system, with the exception of the Ecological Quality Regulation [5], no criteria for location suitability are considered: the hazard potential for water and the revaluation potential for biodiversity, which varies in response to location factors, are not taken into account. Further results obtained with the land use model show that the network of environmental compensation areas can be significantly improved by linking the environmental direct payments to location selectivity [6]. Likewise, the cultivation of crops with high plant protection demands can be limited on pesticide risk locations with incentives or bans. Since there are relatively few pesticide risk locations in the Greifensee region, a ban on cultivation of arable crops with high plant protection demands on these risk locations will have only limited effects [6]. However, in particular areas or on individual farms the structural effects of a ban can be considerably greater. The extent of the effect depends on the shortage of crop rotation land and its classification as risk locations. Furthermore, it must be taken into account that pesticide losses do not only depend on location (un)suitable land use [3]. Along with a restriction of pesticide use in high risk locations, other measures which are designed to reduce the application of pesticides and their losses should also be applied.

The investigations in the Greifensee project highlight that the location characteristics of land should be included in any future agricultural policy. At the same time, it has become clear that the existing state of understanding – in particular regarding the question of how agricultural activities, location characteristics of land, and the resulting environmental impacts, are interrelated – is insufficient. These gaps in knowledge must be closed quickly.

	Swiss Way 2011		Opening 2011	
	Exclusive labor costs	Inclusive labor costs	Exclusive labor costs	Inclusive labor costs
N losses	→	↘	→	↓
P losses	→	↘	→	↘
Proportion of arable farming on pesticide risk locations	→	↑	→	→

Tab. 2: Changes in substance losses in the Greifensee watershed area in the future scenarios Swiss Way 2011 and Opening 2011 (relative to Reference Scenario 2000). The risk locations for pesticide loss were identified with the help of a simple indicator [3].

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