Development of nature-oriented dairy farm systems with an optimization model: the case of 'Farming for Nature' in 'de Langstraat', the Netherlands

Entwicklung naturnaher Betriebssysteme der Milchvieh-haltung mittels eines Optimierungsmodells: Der Fall „Farming for Nature" in „de Langstraat"

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Abstract

'Farming for Nature', a relatively new policy instrument being tried out in the Netherlands, is evaluated. The concept has been designed to allow dairy farmers to improve nature conservation on their farms. Under the scheme, no manure, fertilizer, or feed - concentrates or roughage - may be imported into farm systems from external sources. The feasibility of such a self-sustaining system and the conditions required for it to deliver the desired results, are explored with a farm-based linear programming model known as FIONA (Farm based Integrated Optimization Model for Nature and Agriculture). The model is explained and applied to 'de Langstraat', a region in southern Netherlands.

The results show that levels of production under the 'Farming for Nature' regime are dependent upon soil fertility and the proportion of land that is suitable for growing arable crops. If all available land on a dairy farm in the scheme is arable land, then high production levels of up to 7,500 kg milk per hectare can be realized. If only 30% of the farm area is suitable for arable crops, then only lower production levels, of about 6,600 kg milk per hectare can be realized. The scheme has positive ecological effects.

Both nature and cultural landscape values may benefit significantly from the concept. Improvement in ecological terms however, carries a price in terms of agricultural income. An average dairy farm adopting the concept of 'Farming for Nature' experiences an income loss of approximately € 840 per hectare in the short-run (5-10 years). More important is the observation that the scale of such farms in the short-run might be too small to earn an attractive income for its workers, even when fully compensated according to European Union regulations.

Key words

nature management; dairy farming system; linear programming; farm-economics

Zusammenfassung

Das relativ neue Politikinstrument „Farming for Nature" wird zur Zeit in den Niederlanden erprobt. Dieses Konzept wird im vorliegenden Beitrag evaluiert. Das Konzept wurde so gestaltet, dass es Milch-viehhaltern auf der Basis eines flexiblen Systems die verbesserte Erhaltung der natürlichen Gegebenheiten auf ihren Betrieben er-möglicht. Milchviehhalter, die dieses Konzept umsetzen, dürfen im Betrieb weder außerhalb des Betriebes erzeugte organische und mineralische Düngemittel noch außerhalb des Betriebes erzeugte Kraftfutter- und Wirtschaftsfuttermittel einsetzen. Die Frage, ob dieses geschlossene Betriebssystem praktikabel ist und – falls ja – unter welchen Bedingungen, wird mittels des linearen Optimie-rungsmodells FIONA (Farm-based integrated Optimization Model for Nature and Agriculture) untersucht. Das Modell wird vorgestellt und angewandt für eine Region im Süden der Niederlande, genannt „de Langstraat". Die Ergebnisse zeigen, dass die Produktionsniveaus nach Maßgabe des Konzeptes „Farming for Nature" vor allem von der Fruchtbarkeit des Bodens und von den Anteilen der betriebli-chen Flächen abhängen, die für eine ackerbauliche Nutzung geeig-net sind. Wenn die gesamte Nutzfläche eines Betriebes ackerbaulich genutzt werden kann, können bis zu 7 500 kg Milch je ha LF erzeugt werden. Sind nur höchstens 30% der betrieblichen Nutzfläche für den Ackerbau geeignet, können maximal 6 600 kg Milch je ha LF erzeugt werden. Das Konzept führt zu guten Ergebnissen in Bezug auf ökologische Kriterien, weil es ein gesamtbetrieblicher Ansatz ist. Noch wichtiger ist vielleicht das Ergebnis, dass die gegenwärtigen Betriebsgrößen für die Erwirtschaftung eines angemessenen Ein-kommens der betrieblichen Arbeitskräfte zu klein sind, auch dann noch, wenn die Betriebe für die Umstellung nach den Regeln der EU in vollem Umfang kompensiert werden.

Schlüsselwörter

Naturmanagement; Milchviehhaltung; lineare Programmierung; Agrar-wirtschaft

1. Introduction

As elsewhere in Europe, dairy farmers in the Netherlands experience economic pressure from low output prices and declining financial support associated with overabundant production in the dairy sector. A common strategy to com-pensate for this is for farmers to increase the scale of pro-duction in order to improve returns. Farmers are tempted to take this option because routes to achieving productivity gains through intensification are hampered by environ-mental legislation. Scaling-up of production can carry with it a desire to increase the size of plots. However, in older, small-scale, man-made landscapes in particular, increase of plot size is often not permitted, as it has negative effects on the landscape.

The Dutch Government introduced a number of pro-grammes to maintain landscape elements in agricultural areas, and others to compensate farmers for income losses associated with the uptake of 'agri-environment schemes'. However, none of these programmes addressed the funda-mental issues described above. Current agri-environment scheme contracts are highly prescriptive in how farmers must carry out measures. Many farmers feel curtailed in their entrepreneurial independence (HEIJMAN et al., 2005).

In addition, current agri-environment schemes have also received much criticism because of poor ecological results (WILLEMS et al., 2004).

'Farming for Nature' (FN) (STORTELDER et al., 2001) is a recently developed Dutch policy instrument designed to give farmers more choices and deliver better ecological results. The program incorporates zoning, based on three farm management strategies; nature-oriented, landscape-oriented and large-scale.

In nature-oriented management, the farmer adopts a zero-input system. No manure, fertilizer, feed – concentrates or even roughage – are brought in from outside the farm. The natural watercourse of the farm is restored and a proportion of actively farmed land is converted into non-productive landscape such as wooded banks or reed borders. The farm, thus, incorporates areas of natural habitat and contributes towards achieving landscape and biodiversity goals.

'Farming for Nature' is currently being tried out in a number of regions in the Netherlands. Selecting one particular trial region, 'de Langstraat' – a typical man-made landscape of approximately 1,000 hectares near the City of Tilburg, in the south of the country – a linear programming model was applied to assess the economic consequences of this concept on dairy farms.

Linear programming models are often utilised to analyse environmental-economic issues, because they provide an optimization procedure that takes into account the many relevant activities, internal and external restrictions and their mutual dependency. For this analysis, an existing optimization model for a dairy farm (BERENTSEN and GIESEN, 1995) was extended with activities and restrictions relevant for nature management. The extended model, named FIONA (Farm based Integrated Optimization Model for Nature and Agriculture), can be considered an auxiliary tool for the evaluation for both farmers and authorities.

The investigation is aimed at finding out which farm design maximizes family income within the 'Farming for Nature' concept, given the restriction that no inputs are allowed, and also what the effects of the concept are on biodiversity. In order to examine these issues, relationships between the restrictions imposed by the 'no-input' concept, possibilities for fodder-, milk- and manure-production and biodiversity have been applied. The effects on biodiversity were established using the model results concerning cropping plan and nutrient level. Ecological results were then interpreted with the use of tables derived from the extensive vegetation database SynBioSys (SCHAMINÉE and HENNEKES, 2001).

This paper will firstly elucidate the concept of 'Farming for Nature' (FN) (section 1) and then address some of the most urgent questions related to this concept and its application on a larger scale (section 2). The structure of the extended model will be examined and explored with respect to its adaptability (section 3). Following this, the case study area and selected scenarios will be discussed (section 4). The results of the analysis with FIONA of a virtual farm, with similar characteristics as farms in the study region will then be presented (section 5). Results focus on economic and technical parameters, as FIONA normally uses an economic objective function. Ecological results are assessed by use of other models. Finally, some concluding remarks will be drawn (section 6).

2. The concept of 'Farming for Nature'

'Farming for Nature' has been developed to restore certain elements of man-made agro-ecosystems, including the ecological gradients of the physical system (STORTELDER et al., 2001). The fundamentals of the concept are as follows:

- **An integrated concept.**
  A key problem preventing effective protection of nature in the Netherlands is fragmentation of conservation area. Therefore, the 'Farming for Nature' concept involves a whole farm approach, which can be easily expanded to a whole region.

- **No import of fodder and fertilizer.**
  Under the scheme, it is forbidden to import any kind of feed or fertilizer (including manure) from outside the farm. An exception is made only for salt licks, as they are considered necessary from a veterinary perspective. Utilization of minerals from surrounding nature conservation areas, or other landscape elements, is allowed if the farmer is appointed as the manager of the land involved. Participants must otherwise only agree on an overall operating plan (including the spatial arrangement of various productive and non-productive landscape elements within the farm).

- **Multi spatial gradients**.
  Due to the von Thünen effect, farmers utilise plots further away from the farm less intensively. Quite often, this will coincide with a high-low and a dry-wet gradient along this axis.

- **Socially and ecologically durable.**
  The farmer must be able to realize an overall income, which is attractive enough to stay in farming.

- **Extensification of agricultural land use and reduction of production.**

The most radical element of the concept is the discontinuation of mineral fertilizer use. Since there are many conceivable alternatives to reaching the ultimate policy goals on landscape and biodiversity, there must be some reasoning behind such a drastic step.

Contemporary nature policy in the Netherlands focuses on 'nature target types' (BAL et al., 2001). Nature target types are based on the criteria 'naturalness' and 'biological diversity'. Aside from the discussion on the appropriateness of these criteria (e.g. the fact that 'natural' landscapes consist of exactly the same subset of habitats as 'semi-natural' landscapes), a feature of these systems is its focus on relatively rare species. A conservation target is satisfied when the required minimum number of those species is present. In practice, the degree to which a specific target can be achieved is dependent upon:

a) the size of the object and;

b) the degree of heterogeneity within the object.

As a result, neither government nor farmers are in control of the outcome.

As an alternative, 'Farming for Nature' focuses on the general quality of the vegetation in terms of vegetation types (SCHAMINÉE et al., 1996) found on the farm at large. According to the fundamentals of 'Farming for Nature', ecological gradients play a crucial role in nature conservation on farms on several levels. This is illustrated in figure 1.

Figure 1. Location of farms in a river catchment area and lateral zones with high or low potential for establishing nature target types

Zone:	I	II	III

Zone I		Eutrophic
Zone II		Mesotrophic
Zone III		Oligotrophic
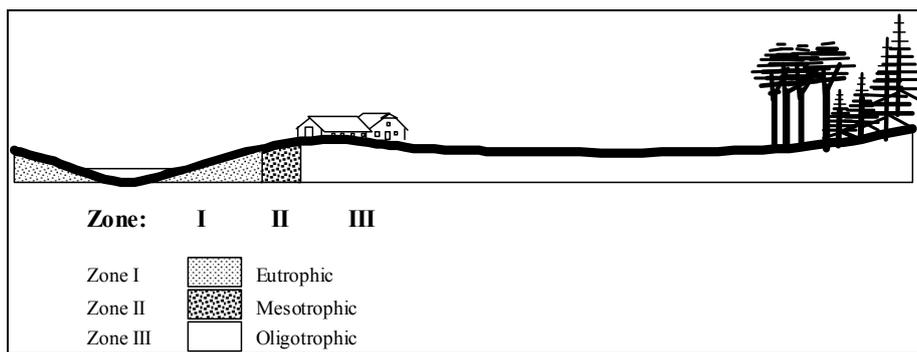
Source: own

Figure 1 presents a schematic representation of part of a catchment area with the location of farms on the transition of nutrient-poor to nutrient-rich soil. In historic times, (from early settlements in medieval times until the industrial era in the second half of the nineteenth century) farm communities formed around nutrient-rich arable land (VERVLOET et al., 1994). Thus, settlements are often found on the edge of poor and rich soils. This is also true for the case examined, in the North Brabant region (DE BONT, 2003). There are three zones that may be distinguished:

a) Zone I: Eutrophic zone with a high density of ecological gradients and relatively few plant species;

b) Zone II: Mesotrophic zone with a high density of ecological gradients, relatively high plant species richness. In pre-industrial times farmers tried to expand this zone (in the direction of III with material from zones I and III);

c) Zone III: Oligotrophic zone with a low density of ecological gradients and with relatively few plant species.

There is a number of questions related to 'Farming for Nature', which need to be answered. They include:

a) What is the feasible level of agricultural output of the system?

When the concept of 'Farming for Nature' was launched in 2001, very little was known about feasible levels of production that could be expected. Historical data is not available. Not only is finding useful data from pre mineral fertilizer times difficult, but any historical data, which might be available, does not reflect technological changes. Comparable situations do not exist in present dairy farming systems. Based on expert judgement, a level of 5,000 kg of milk per hectare and per cow was used as a working hypothesis.

b) What is the labour demand compared to prevailing systems?

In 'Farming for Nature' up to ten percent of the agricultural land can be used non-productively to restore landscape elements. Although farmer receives a compensation payment for these areas, they deliver a lower level of agricultural output per hectare and an increase in the number of relatively laborious plots.

c) At what level can mineral balances within the system be achieved?

In a 'no-input' system the net outflow of important soil nutrients, such as Potassium and Phosphorus, will be larger than the input. The efflux can be measured by the amount of milk and other (animal) products that leave the farm. Over time, shortages of certain elements will emerge. Reducing mineral levels, in order to improve nature conservation, is one of the intentions of the concept. The system will come to a point where some kind of source is needed to keep the balance. When the system is in its equilibrium, two sources are allowed to keep this balance To prevent animal health problems due to mineral deficiencies, a salt lick is allowed. As a secondary source, minerals from background deposition, via the water supply upstream, or from nearby nature conservation areas (e.g. woodland or swamp) can be used.

d) What is the best spatial allocation of the farm in relation to achieving nature conservation policy goals?

In the first half of the last century, many farms were created on heathland reclamations with the introduction of synthetic fertilizers, especially on the higher sandy soils in the eastern and southern parts of the country. Now, farms are often situated on the edge of former wasteland – frequently designated nature conservation area. 'Farming for Nature' systems are most easily implemented where farmland can be restored to pre synthetic fertilizer status. The feasibility of the concept depends on the soil quality and on the availability of minerals.

e) What is the best spatial distribution of land use within the farm and what does this mean in terms of ecological benefits?

What are the best locations for hay meadows, permanent grassland and arable land within the farm unit and what is the optimal ratio between different types of land use?

f) How is farm income affected by the implementation of the system?

The income loss compared to the present situation of the farm has to be calculated.

3. FIONA, a farm based optimization model

3.1 Introduction to FIONA

FIONA has been developed as tool to support nature conservation management decisions made by both policy makers and farmers. A linear modelling approach was chosen in order to:

• describe the production process of a (dairy) farm as precisely as possible;

• incorporate specific conditions and farm characteristics;

• explore production possibilities;

• take all relevant options and restrictions into account and find optimal solutions;

• integrate with the use of other models to build consistent policy options/scenarios.

The starting point for developing FIONA has been a linear programming model developed by BERENTSEN and GIESEN (1995) which already had most of the required features. The model has been modified from four to ten periods per annum.

3.2 Model specification

The general structure of FIONA is shown in table 1. It has the form of a standard linear programming model:

Maximize $\{Z=c'x\}$
Subject to $Ax \leq b$
and $x \geq 0$

Where x = vector of activities; c = vector of gross margins or cost per unit of activity; A = matrix of technical coefficients; and b = vector of right hand side values. The activities and constraints are simplified and grouped in table 1, following BERENTSEN and GIESEN (1995).

The groups of activities (x) are presented in table 1. Compared to the model of BERENTSEN and GIESEN (1995) one group (rations) is added. Thus, there are nine groups of activities distinguished:

a) **Animal production** including dairy cows with young stock for replacement and suckling cows. In this study, a fixed replacement rate of 25% of the cows is assumed. The rate of heifer calves and yearlings is corrected for discharges and dropouts. The addition to the model of BERENTSEN and GIESEN (1995), leasing out of milk quota is possible. This feature means that the number of cows becomes endogenous;

b) **Rations** are closely linked to animal production. A ration consists of a mixture of ingredients that meets the feeding requirements (energy, protein, fibre), but does not exceed intake capacity. BERENTSEN (1999) established a direct relationship between feeding requirements of the herd and feed production and purchase in his model. He extended his model by seasonal and spatial elements to add variations in the use of grassland (BERENTSEN et al., 2000). Ration is entered as an intermediate activity between feed production and feed requirements of the cattle. This reduces the number of activities because feed production for silage is now inde-

Table 1. **General structure of the linear programming model**

Activities / *Constraints*	Animal prod.[1]	Rations	Feed prod. for on-farm use	Feed prod. for sale	Purchase of feed	Manure appl.	Appl. of purchased fertilizer	Manure deposit	Labour activities[2]	*Right hand side*
Land requirements			+1	+1						$\leq$ Available hectares
Milk production plus leasing out milk quota	a_{ij}[3]									$\leq$ Available quota (kg)
Housing requirements	a_{ij}									$\leq$ Available places[4]
Labour requirements	a_{ij}	a_{ij}	a_{ij}	a_{ij}		a_{ij}	a_{ij}		a_{ij}	$\leq$ Available labour
Feeding requirements	a_{ij}	$- a_{ij}$								≤ 0
Fertilizing requirements			a_{ij}	a_{ij}		$- a_{ij}$	$- a_{ij}$			≤ 0
Manure balance	$- a_{ij}$					a_{ij}		a_{ij}		$=0$
Nutrient use animal N[5]	a_{ij}		$- a_{ij}$	$- a_{ij}$				$- a_{ij}$		≤ 0
Nutrient use total N[5]	a_{ij}		$- a_{ij}$	$- a_{ij}$			a_{ij}			≤ 0
Fodder balance		a_{ij}	$- a_{ij}$	a_{ij}	$- a_{ij}$					$=0$
Linking production activities and labour activities	a_{ij}		a_{ij}	a_{ij}		a_{ij}	a_{ij}		$- a_{ij}$	≤ 0
Object function	Gross margins		Costs per ha	Gross margin	Costs per unit	Costs per unit	Costs per unit	Costs per unit	Costs per unit	

[1] milk, meat, leasing out milk quota
[2] Farmers own labour (incl. family), hired labour or contract work.
[3] a_{ij} is the technical coefficient that relates activity i to constraint j.
[4] cows, young stock
[5] according to recent Dutch legislation propositions (MINLNV, 2004)

Source: modified from BERENTSEN and GIESEN (1999)

pendent of the period in which it is fed. In order to ensure that the right amount of each fodder type is produced or purchased, a fodder balance is added to the system;

c) **Feed production for on-farm use**. In addition to the production of silage maize and fodder beet, production of triticale is permitted. Grassland with a delayed cutting regime is used for hay making, rather than for silage production. Regular grassland management remains the same, with two yields for cuttings (i.e. mowing grass for silage making at 3,500 kg dm*ha^{-1} (kg of dry matter per hectare) and grazing of grass by various categories of cattle at 1,700 kg dm*ha^{-1}). Small adaptations are made for the beginning of the growing season, where a grazing cut yields 800 kg dm*ha^{-1}, and for delayed cutting regimes which are usually heavier than 3,500 kg dm*ha^{-1}. The data (i.e. the number of growing days needed to reach the pre-assigned yield) are retrieved from the Experiment Station for Cattle Production (VELLINGA, 1989). Soil type and groundwater table affect the yield. In FIONA the pre-assigned yield is adjusted following the depression rates given by HEMMER et al. (2003) which is a condensed version of the tables given by BROUWER and HUININK (2002);

d) **Feed production for sale**. Surpluses of roughage can be sold;

e) **Purchase of a variety of concentrates and roughage**. In the 'Farming for Nature' scenarios, this option is excluded;

f) **Manure application** consisting of different methods of applying manure on grassland and arable land. In addition to the model of BERENTSEN and GIESEN (1995), manure can be applied over a period of time in order to simulate a steady release of nitrogen;

g) **Purchase and application of synthetic fertilizer;**

h) **Manure deposit** if necessary. The model is adapted to new legislation soon to be effective (MINLNV, 2004);

i) **Labour activities** related to feed production, feeding, manure spreading and animal production. Some operations, such as mowing and harvesting can be done by either contractors or the farmers own (or hired) labour and machinery.

Each activity has its own specific vector of inputs and output coefficients. All vectors together form the matrix **A**. The rows of the matrix indicate the type and form of the constraints used:

- The first four constraints link the different activities to the fixed assets of the farm (e.g., land area, milk quota, and animal housing) and to labour, which includes family labour and hired working hours. The available fixed assets and total labour capacity are part of the vector of right-hand side values (**b**). Available working hours per period can only be utilized inside the farm.

- Other constraints ensure that necessary tasks are undertaken (e.g. applying manure) or system elements are kept in balance (e.g. feeding requirements vs. feed production).

- Specifications of the feeding requirements in BERENTSEN's model are updated in FIONA with new rules given by ZOM et al. (2002). Values for each fodder type are derived from data from the Central Bureau for Livestock Feeding (CVB, 2002).

- The last row contains the objective function of the model, which is to be maximized. This result includes the returns and variable costs. Fixed costs are not included here. Fixed costs include all costs related to buildings and machinery which are calculated separately according to the pre-defined settings and also an assumed paid rent which is determined by the individual farm's history.

- Final outcome, after subtraction of fixed costs from net return, is a family income which represents remuneration for own labour and for capital.

3.3 Assumptions and pre-calculations in FIONA related to 'Farming for Nature'

In the previous section, a general description is given of the model FIONA along with its general assumptions. In this section, the assumptions specifically related to 'Farming for Nature' are addressed. In answer to the questions raised in section 2, concerning 'Farming for Nature':

Feasible level of agricultural production (milk and meat).

Since milk production per cow is exogenous in the model and because the attainable milk production per cow under the 'Farming for Nature' conditions is unknown, certain pre-calculations with the model are necessary to ascertain a feasible milk production level.

Levels of agricultural production in a 'no-input' farming system depend on:

- Soil fertility;

- Efficiency of manure application within the system;

- Supply of minerals through background deposition, from the non-agriculture area of the farm and from flooding with water from upstream.

Nitrogen supply originates from soil processes and manure application.

The amount of nitrogen in bovine manure that can be utilized by crops depends on:

- Number of cattle;

- Milk production per cow (manure production increases with milk production increases);

- Nitrogen losses to the environment;

- The nitrogen content in bovine manure.

Outside to be a 'Farming for Nature' system, the concentration of nitrogen in the manure is assumed constant by FIONA in both the organic (2.23 g*kg^{-1}) and mineral (2.17 g*kg^{-1}) parts. From the organic part only a proportion becomes available for plant growth over time, whereas the mineral part can be taken up directly as a whole.

With 'Farming for Nature', the assumption of a constant nitrogen-content in bovine manure is inconsistent with high levels of milk production per cow and, therefore, a correction is made. The nitrogen-content of bovine manure is reduced by a factor determined by relative changes in protein demand (in terms of intestinally-digested protein, see (TAMMINGA et al., 1994) and active nitrogen at the herd level as milk production per cow increases.

In FIONA, both quantity and quality of crop production depend on the amount of active nitrogen. While quantity is expressed directly in kg dry matter (dm) per hectare (ha^{-1}),

quality is expressed by a number of parameters of which energy content (in MJ NEL*ha^{-1}) and protein content in terms of intestinally digested protein (TAMMINGA et al., 1994) are the most important.

In nature conservation areas, quality of grass is affected by composition of grassland species (KOREVAAR, 1986; GEERTS and KOREVAAR, 2004). Under a 'Farming for Nature' regime, quality of grass is adjusted according to the findings of KOREVAAR (1986) and GEERTS and KOREVAAR (2004). Energy content is reduced by approximately 10% and protein content reduced by approximately 30%. Arable crops receive manure according to biological production (VINK and WOLBERS, 1997) and yields correspond to this. Triticale serves as replacement for concentrates in 'Farming for Nature', with excellent energy and average protein content.

When there are no limitations in the use of land (i.e. all land is suitable as arable land) a milk production per cow of 8,000 kg*year^{-1} is optimal. At 8,500 kg milk*cow^{-1} protein demand becomes the limiting factor.

In many cases in the Netherlands, the soil is too wet to be suitable for arable crops, or its use, for cropping is restricted by regulation. In 'Farming for Nature', the highest nature value is attached to permanent grassland. Limitations in the amount of arable quality land can have considerable impact on maximum levels of production achievable per hectare. In this study 6,500 kg milk*cow^{-1} is used.

Labour demand compared to prevailing systems

Under 'Farming for Nature', the model assumes a relationship between the amount of landscape elements on a farm and its average field (parcel) size with the latter determining the amount of labour required. Finally, consideration of different activities by the model determines the total labour demand.

Level at which mineral balances within the system are achieved

The level at which mineral balances can be maintained is largely dependent on the complexity of the soil and water system. At present, the model only recognises one home- and one field-plot. In addition, there is a knowledge gap related to nitrogen recovery under the conditions of 'Farming for Nature', for different type of soils and crops. Therefore, the model relies upon on the figure of 140 kg N*ha^{-1} delivery from the soil and on a constant level of mineral content in manure. Under these assumptions it is possible to calculate the necessary compensation area, i.e. the non-agricultural area of the farm needed to gather minerals from, at the optimum production level presented by FIONA.

Optimal spatial distribution of land use within the farm and what this mean´s in terms of ecological benefits

Although it is not possible to pinpoint the exact location of a specific form of land use, the model's outcome does suggest the best proportions of possible forms of land use. From this an assessment can be made of the ecological and landscape benefits. Given the optimum allocation for land use in the categories meadow, permanent grassland and arable land suggested by FIONA and the resulting man-agement on those fields, the underlying physical conditions will reveal the ecological potentials. For this an ecological model based on the work of SCHAMINÉE et al. (1996) has been used. From the model in question (SynBioSys) (SCHAMINÉE and HENNEKES, 2001) tables are derived which yield the expected vegetation type for given physiological conditions (geological situation, climate, soil type, ground water table) under different management regimes (land use, nutrient level) (SCHRIJVER et al., 2005 forthcoming).

4. Application in 'de Langstraat'

Location in the Netherlands

The study area is situated in the south-west of the Netherlands, between the Cities of Waalwijk and Geertruidenberg and covers approximately 1,000 hectares. Recently, large parts of the area have been obtained by the Dutch State Forest Service to complement the National Ecological Network. However, there are 12 active farms in the area with eight of these interested in working within the 'Farming for Nature' concept. The farms involved in the project are located on the extended ecotone (ecological gradient) of 'cover sand' to peat and the former floodplain of the river Meuse. Their buildings are elevated above fields on sandy, dry soil or dikes. The ecotone consists of drier parts of grassland and arable land near farms to somewhat wetter conditions at some distance. The area was formerly an important groundwater seepage area and it is possible to restore those physical conditions. This setting establishes 'de Langstraat' as particularly suitable for 'Farming for Nature'.

Scenarios

FIONA is used to evaluate production possibilities and associated income for two (similar) dairy farms within the group of eight interested farms. Although they differ slightly in farm size and management from the reference farm (RF) described in this paper, the adopted farm characteristics can be considered to be representative for the actual situation in 'de Langstraat'.

From the reference farm (with 40 ha cultivated land, a stable capacity of 55 cows, a mik production per cow of 7,500 kg, an average high ground water level of 40 cm to 80 cm below ground level and an average plot size of two ha), two circumstances are identified along with their respective alternative development paths. These circumstances relate to the ground water table on grassland (going to an average high ground water level of less than 40 cm below ground level) and average parcel size of the farm (decreasing to one ha).

Scenario 1: FN 40 ha, is the state, which the farm can reach under 'Farming for Nature' with the present surface area.

Scenario 2: FN 40 ha+ represents the same conditions with a higher ground water table on grassland and smaller parcels.

Applying the second development path the farmer chooses to increase stable capacity fully, in order to minimise the surplus of milk quota. The farm needs to expand physically. It is assumed that this amount cannot be attracted overnight and therefore indicates a time element; it is also assumed that the land attracted is of the same quality as the land presently farmed.

Scenario 3: FN 55 cow, the farm has enlarged by 13 hectares of land

Scenario 4: FN 55 cow+, even more land is obtained in order to compensate for the higher ground water table on grassland.

5. Farm results

5.1 Technical results

The technical results of a transition from a prevailing dairy farm to a nature oriented farm according to 'Farming for Nature' are presented in table 2.

One of the key features of 'Farming for Nature' is that the farmer produces all fodder for the stock. From table 2, it can be seen that even the reference dairy farm produces 70 metric tons of triticale in the optimum. Therefore, this farm significantly reduces reliance on imported concentrates. Apart from this, the farm is comparable to an average dairy farm. The farm uses the maximum space of the preset arable land proportion (30%).

After transition to 'Farming for Nature' (FN 40 ha) milk production declines significantly . The effect on agricultural production is that less grass becomes available and more hay is produced. The loss of quantity is then compensated far by a relatively high proportion of fodder beets. Landscape elements are not modeled in the present version of FIONA (only the effect they have on the plot size), so labour input for maintenance of these landscape elements are neglected here.

Technical coefficients related to environmental quality indicate that in all 'Farming for Nature' systems the nitrogen-removal with the farm products (e.g. milk and meat) is almost as high as the yearly amount of active nitrogen from manure application. This suggests that there are practically no losses of nitrogen to the environment.

The transition to a 'Farming for Nature' system was expected to create extra employment. Table 3 exhibits labour required for different kind of activities. Transition to a FN 40 ha scenario reduces working hours needed by almost 400 hours due to the fact that there are fewer cattle to tend. There is, however, more time required to feed the herd, mainly caused by the production of fodder beet in the system.

The overall work capacity of the family is hardly ever exceeded. Only in the case of the 'FN 50 cow' scenario there is a small number of working hours of hired labour.

The results of an expansion of the farm by three hectares of arable land are: a small increase in the production of fresh grass and hay, followed by a drastic decrease of grass for silage. Fodder beet production is largely substituted by maize and for a smaller part, triticale.

5.2 Economic results

As a consequence of a transition to nature oriented farming system, the cost price of milk production will rise (from approximately 0.45 € per kg milk for contemporary farming to 0.54 € per kg milk in scenarios 'FN 40 ha+' and 'FN 55 cow+'). A decrease in production capacity (from 13% in the 'FN 55 cow' scenarios to 40% in the 'FN 40 ha+' scenario, (Table 4) is at the basis of the rising cost. Hence, with higher cost per unit of production and a reduced farm size, family income drops.

Table 2. Technical results

		Scenarios			
	RF	FN 40 ha	FN 40 ha+[1]	FN 55 cow	FN 55 cow+[1]
Milk production (kg)	412,500	266,500	247,000	357,500	357,500
Num. cows	55	41	38	55	55
Milk production / cow (kg)	7,500	6,500	6,500	6,500	6,500
Milk production / ha (kg)	10,312.5	6,662.5	6,175	6,745.3	6,163.8
Grassland (ha)	28	28	28	37.1	40.6
Arable land (ha)	12	12	12	15.9	17.4
Production in 1,000 kg dm					
- grass	181	103.7	84.5	131.4	125.4
- grass silage	106.4	70	58.6	100.4	84.1
- grass hay	0	25	34.1	37.6	54.6
- maize	36.8	40.4	39.4	45.5	51.7
- triticale (grain)	70.2	36.5	34.7	49.7	58.7
- fodder beet	0	44.2	48	60.8	62.5
Purchased fodder,*1,000kg dm					
- concentrates standard	20.4	-	-	-	-
- concentrates protein rich	7.7	-	-	-	-
- maize silage	2.3	-	-	-	-
Fertilization					
N-supply / ha	191	-	-	-	-
Active N / ha (above 140 kg N)	241	44.1	41	43.8	40.9
Active N grassland/ ha	305	37.3	32.8	36.8	32.7
N-removal / ha	64.5	42.5	39.4	43	39.3
Labour					
Total labour hours (own labour)	4,668	4,278	4,281	5,168	5,090
Work load,% of permitted load	92	84	84	100	100
Grassland					
Average net energy yield / ha [2]	66,185	39,330	33,976	40,061	34,486
Mowing percentage	136	119	123	131	126
Meadows (ha)	0	9	11	13	19
Surplus milk quota (kg)	0	146,000	165,500	55,000	55,000

[1] higher ground water table and smaller parcels
[2] (MJ NEL/ha)
Source: own results

Compensation payments may be necessary to close the gap. According to FADN data (LEI, 2005) a dairy farm of average size earned about € 40,000 in profit in 2002 with roughly the same amount of labour and slightly more cows.

The EU permits national governments to offer an incentive on agri-environment schemes of 20% above associated income loss and additional costs (EC, 2004 and 2005).

In this case, it would mean that compensation payments in the order of € 1,000 per hectare would be the maximum allowable amount. Income could then total around € 56,500 (€ 37,500 per annual working unit) in the short-term (10 years).

5.3 Ecological results

The ecological results are assessed with SynBioSys (SCHAMINÉE and HENNEKES, 2001). Table 5 provides an overview of the expected vegetation types for the physiological conditions on sandy soils in 'de Langstraat' under different management regimes (land use, nutrient level). It is known from the pertinent literature that in the FN 40[+] scenario, species composition is comparable to that prevailing in the moist to wet reserve areas.

6. Concluding remarks

A linear programming model approach is used to explore the feasibility of a 'no-input' dairy system. The results suggest, that if it is possible to realize a production of at least 6,600 kg milk per hectare. With sufficient arable land the maximum level of production might be as higher as 7,500 kg milk per hectare and per cow.

Compared to the total production capacity of over 100,00 kg milk per hectare of a conventional system, the decline in production is considerable and there are other issues which need consideration and further investigation in future research. Especially with respect to the mineral inputs in the long-term the model outcome is subject to uncertainties.

The economic results of a transition from present-day farming towards nature oriented farming clearly show that the scale of production will decline on the original surface area of

Table 3. Labour results

	Scenarios				
	RF	FN 40 ha	FN 40 ha+[1]	FN 55 cow	FN 55 cow+[1]
Milking	654	506	474	654	654
Transporting cattle	65	65	65	65	65
Maintenance / nursing	515	491	487	511	511
Feeding	605	764	771	1,035	1,035
Cleaning out stables	290	216	200	290	290
Care for young stock	752	635	614	752	752
Grassland management	526	501	575	602	478
Work on arable land	18	32	40	49	57
Manuring	181	68	85	90	101
Other	1,062	1,000	970	1,120	1,147
Total	4,668	4,278	4,281	5,168	5,090

[1] higher ground water table and smaller parcels

Source: own results

Table 4. Economic results (€)*

	Scenarios				
	RF	FN 40 ha	FN 40 ha+[1]	FN 55 cow	FN 55 cow+[1]
Revenues					
- milk	136,955	88,481	82,007	118,694	118,694
- cattle sold	17,299	12,868	12,008	17,299	17,299
- other	0	0	0	0	
total	154,254	101,349	94,015	135,993	135,993
Variable costs:					
- livestock costs cows	16,533	12,325	11,423	16,533	16,533
- livestock costs young stock	4,247	3,165	2,934	4,247	4,247
- grassland maintenance	3,644	1,708	1,708	2,263	2,477
- grassland harvest [2]	6,821	7,009	8,122	11,843	17,193
- arable land [2]	4,696	7,359	7,566	9,999	10,474
- purchased fodder	4,903	-	-	-	-
- fertilisation	4,289	-	-	-	-
- hired labour	0	0	0	1,578	0
sub total	45,133	31,566	31,753	46,463	50,924
Fixed costs:					
- machinery and equipment	11,141	11,141	11,141	11,141	11,141
- land and buildings	22,939	22,939	22,939	22,939	22,939
- other	25,000	25,000	25,000	25,000	25,000
sub total	59,080	59,080	59,080	59,080	59,080
total	104,213	90,646	90,833	105,543	110,004
Net return	109,121	69,783	62,262	89,530	85,069
surplus milk quota	0	11,680	13,240	4,400	4,400
land costs extra land				7,995	11,070
Family income	50,041	22,383	16,422	26,855	19,319
Cost price* kg milk[-1]	0.45	0.51	0.54	0.53	0.54
income difference [3]		27,658	33,619	23,186	30,722
income difference /ha		691.5	840.5	579.5	768

* Table 4 does not include opportunity cost for the households own labour and capital inputs It is assumed that these costs account for an additional 0.20 € per kg milk. The differences in labour demand (table 3) between the scenarios are valued at € 20 per hour.

[1] higher ground water table and smaller parcels
[2] includes contract work
[3] compared to reference farm

Source: own results

the farm. As a result, the cost of producing milk will rise significantly from an original 0.45 € to around 0.55 € per kg milk. Consequently, income losses per hectare add up to as much as € 840 per ha. Compensation payments for these income losses are provided for under the present EU-regulations (EC, 2004 and 2005).

The key issue is whether this incentive is sufficient.

The family income in the original position of the farm approximates € 33,333 per annual working unit. In practice, it is likely to be less, considering that the average farm income of such a unit is likely to be even lower in reality due to risk aversion, imperfect information and knowledge (BERENTSEN et al., 1996). Even on the best performing, average-sized, conventional Dutch dairy farms, the family workers earn less than the average hourly wages outside of agriculture.

Income levels obtained in dairy farming have led to an outmigration over many years. With income comprising of compensation payments for income forgone and additional cost, a future nature oriented farm appears unsustainable.

From the perspective of governments, there are considerable risks involved when investing 'nature conservation'

Table 5.   Example of expected vegetation types on a wind born sand deposit given land use and manurial level

Physiotope: Hz3d, moist cover sand

Manurial gift in kg N / year	Temporary grassland	pasture / meadow	pasture	hayland	phase Bax & Schippers[1]	Manurial gift in kg N / year	Arable land crop rotation/ root crops	Arable land permanent grain	non-agriculture roughage/ scrub
>200	TC[2] Stellaria-Lolium perenne [Stellarietea / Plantaginetea] 3p44	TC Poa trivialis-Lolium perenne-[Plantaginetea / Cynosurion] 12RG1	TC Poa trivialis-Lolium perenne-[Plantaginetea / Cynosurion] 12RG1	TC Poa trivialis-Lolium perenne-[Plantaginetea / Cynosurion] 12RG1	0	150	TC Stellaria media - [Stellarietea]	TC Stellaria media - [Stellarietea]	
150-200	TC Stellaria-Lolium perenne [Stellarietea / Plantaginetea]' 3p44	TC Poa trivialis-Lolium perenne-[Plantaginetea / Cynosurion] 12RG1	TC Poa trivialis-Lolium perenne-[Plantaginetea / Cynosurion] 12RG1	TC Poa trivialis-Lolium perenne-[Plantaginetea / Cynosurion] 12RG1	1		TC Capsella-[Aperion/Artemisietea]	TC Capsella-[Aperion/Artemisietea]	
50-150	TC Stellaria-Lolium perenne [Stellarietea / Plantaginetea]' 3p44	TC Holcus lanatus-Lolium perenne-[Molinio-Arrhenatheretea] 16RG1	TC Holcus lanatus-Lolium perenne-[Molinio-Arrhenatheretea] 16RG1	TC Holcus lanatus-Lolium perenne-[Molinio-Arrhenatheretea] 16RG1	2		TC Viola arvensis-[Aperion/Digitario-Setarion]	TC Viola arvensis-[Aperion/Digitario-Setarion]	
25-50		TC Festuca rubra-Lotus uliginosus-[Molinietalia] 16RG3	TC Festuca rubra-Lotus uliginosus-[Molinietalia] 16RG3	TC Holcus lanatus-Lychnis flos-cuculi-[Molinietalia] 16RG2	3		TC Matricaria recutita-Spergula arvensis-[Aperion spicae-venti] 30RG2	TC Matricaria recutita-Spergula arvensis-[Aperion spicae-venti] 30RG3	
<25		Lolio-Cynosuretum lotetosum uliginosi 16Bc1b	Lolio-Cynosuretum lotetosum uliginosi 16Bc1b	TC Carex nigra-Agrostis canina 9RG2	4		Spergulo arvensis-Chrysanthemetum typicum 30Bb1a	Papaveretum argemones scleranthetosum 30Ba2b	
0(-25)		Lolio-Cynosuretum lotetosum uliginosi 16Bc1b	Lolio-Cynosuretum lotetosum uliginosi 16Bc1b	Carici curtae-Agrostietum typicum 9Aa3a	5	0		(TC Vicia angustifolia-Vicia hirsuta-[Aperion sicae-venti] 30RG6)	

[1] Bax & Schippers, 1999
[2] TC = Trunk community

Source: own results

money in small scale farms. For the Dutch government, the costs of 'Faming for Nature' together with this risk should be weighed against alternatives. One obvious alternative to establish better nature conservation on current agricultural land is to purchase farms and transfer it to the State Forest Service for management. In this case, it would mean that in addition to operational costs, the government would have to support the costs associated with of owning the land (BOERS and LUIJT, 2005).

Future research could reveal the position of the Farming for Nature policy relative to alternative policies, including policies with minor adaptations. Further investigation of possible ecological consequences of different policies is most urgent.

The FIONA model requires further adaptations in order to be able to fully address all the issues raised by the 'Farming for Nature' policy. Especially the gradient in soil quality within a farm needs attention by distinguishing plots of different soil quality.

Acknowledgements

References

BAL, D., H.M. BEIJE, M. FELLINGER, R. HAVEMAN, A.J.F.M. van OPSTAL and F.J. van ZADELHOFF (2001): Handboek Natuurdoeltypen. Wageningen, Expertisecentrum LNV, Neth. (in Dutch).

BAX, I.H.W. and W.SCHIPPERS (1999): Ontwikkeling van botanisch waardevol grasland. Veldgids, Utrecht/Wageningen, DLG/ IKC-N, Neth.(in Dutch).

BERENTSEN, P.B.M. and G.W.J. GIESEN (1995): An environmental-economic model at farm level to analyze institutional and technical change in dairy farming. In: Agricultural Systems 49 (2): 153-175.

BERENTSEN, P.B.M. (1999): Economic-environmental modelling of Dutch dairy farms incorporating technical and institutional change. PhD thesis. Landbouwuniversiteit Wageningen.

BERENTSEN, P.B.M., G.W.J. GIESEN and J.A. RENKEMA (2000): Introduction of seasonal and spatial elements in grass production and grassland use in a dairy farm model. In: Grass and Forage Science 52 (2): 125-137.

BOERS, A. and J. LUIJT (2005): Uitgaven – en kosteneffect van een koerswijziging in het natuurbeleid van LNV. LEI-rapport 6.05.20. Den Haag, LEI, Neth. (in Dutch).

BROUWER, F. and J.T.M. HUININK (2002): Opbrengstdervingpercentages voor combinaties van bodemtypen en grondwatertrappen. Geactualiseerde help-tabellen en opbrengstdepressiekaarten. Wageningen, Alterra, Neth.(in Dutch).

CVB (Central Bureau for Livestock Feeding) (2002): Tabellenboek Veevoeding 2002. Lelystad, Centraal Veevoederbureau, Neth.(in Dutch).

DE BONT, C. (2003): A Dutch Atlantis Five Metres Below Sea Level. Reconstructing the medieval landscape of the Groote Waard. In: Unwin, T. and T. Spek (2003): European Landscapes. From mountain to sea Proceedings of the 19th Session of the permanent European Conference for the Study of the Rural Landscape (PECSRL) at London and Aberystwyth (UK), 10-17 September 2000. Hama Publishers, Tallinn.

EC (European Commission) (2004): Commission Regulation (EC) No 817/2004.

– (2005): Agri-Environment Measures. Overview on General Principles, Types of Measures, and Application. European Commission, Brussels (internet document).

GEERTS, R.H.E.M. and H. KOREVAAR (2004): Economisch perspectief van gras- en bouwland bij meervoudig duurzaam landgebruik. Wat zijn de opbrengsten van multifunctioneel landgebruik? Plant Research International, Wageningen, Neth. (in Dutch).

HEIJMAN, W., P. BERENTSEN, A. HENDRIKSEN and H. VLOKHOVEN (2005): Boeren in het landschap: Een studie naar de kosten van agrarisch natuurbeheer in de noordelijke Friese wouden. Mimeo, Economics of Consumers and Households, Wageningen University.

HEMMER, H., B. BOSMA, A. EVERS and I. VERMEIJ (2003). Kwantitatieve informatie veehouderij 2003-2004. Lelystad, Animal Sciences Group / Praktijkonderzoek, Neth.(in Dutch).

KOREVAAR, H. (1986): Produktie en voederwaarde van gras bij gebruiks- en bemestingsbeperkingen voor natuurbeheer. PhD thesis. Wageningen, Landbouwuniversiteit.

LEI (Agricultural Economics Research Institute) (2005): FADN data. Available on internet at: http://www.lei.nl/uk/statistics.

MINLNV (Dutch Ministry of Agriculture, Nature and Food Quality) (2004): Mestbeleid vanaf 2006. Kamerbrief DL.2004/1608, Neth. (in Dutch).

SCHRIJVER, R.A.M., R. HAVEMAN, J.J. DE JONG and G. KOLKMAN (2005 forthcoming): Regionale bedijfssystemen voor natuurgerichte landbouw. Den Haag/Wageningen, LEI/Alterra, Neth.(in Dutch).

SCHAMINÉE, J.H.J, A.H.F.STORTELDER and E.J.WEEDA (1996): De vegetatie van Nederland. Deel 3. Plantengemeenschappen van graslanden, zomen en droge heiden. Uppsala/Leiden, Opulus Neth.(in Dutch).

SCHAMINÉE, J.H.J. and S.M. HENNEKENS (2001): TURBOVEG, MEGATAB und SYNBIOSYS: neue Entwicklungen in der Pflanzensoziologie. Berichte der Reinhold-Tüxen-Gesellschaft 13: 27-43.

STORTELDER, A.H.F., R.A.M. SCHRIJVER, H. ALBERTS, A. VAN DEN BERG, R.G.M. KWAK, K.R. DE POEL, J.H.J. SCHAMINÉE, I.M. VAN DEN TOP and P.A.M. VISSCHEDIJK (2001): Boeren voor Natuur. De slechtste grond is de beste. Alterra-rapport 312. Wageningen, Alterra, Neth. (in Dutch).

TAMMINGA, S., W.M. VAN STRAALEN, A.P.J. SUBNEL, R.G.M. MEIJER, A. STEG, C.J.G. WEVER and M.C. BLOK (1994): The Dutch protein evaluation system: the DVE/OEB-system. In: Livestock Production Science 40 (2): 139-155.

VELLINGA, T.V. (1989): De Nawerking van eerder gegeven stikstof. Lelystad, Proefstation voor de Rundveehouderij, Schapenhouderij en Paardenhouderij (PR), Neth.(in Dutch).

VAN DE VEN, G.W.J. (1992): Grasmod, a grassland management model to calculate nitrogen losses from grassland. Wageningen, cabo-dlo.

VERVLOET, J.A.J., C.H.M. DE BONT, J. RENES and T. SPEK (1994): Wageningen Studies in Historical Geography 2. Report 87. DLO Winand Staring Centre, Wageningen.

VINK, I. and H. WOLBERS (eds.) (1997): Handboek Melkveehouderij. Lelystad, Praktijkonderzoek Rundvee, Schapen en Paarden (PR).

WILLEMS, F., A. BREEUWER, R. FOPPEN, W. TEUNISSEN, H. SCHEKKERMAN, P. GOEDHART, D. KLEIJN and F. BERENDSE (2004): Evaluatie Agrarisch Natuurbeheer: effecten op weidevogeldichtheden. SOVON, Neth. (in Dutch).

ZOM, R.L.G., J.W. VAN RIEL, G. ANDRÉ and G. VAN DUINKERKEN (2002): Voorspelling voeropname met Koemodel 2002. 11, Praktijkonderzoek Rundveehouderij, Lelystad.

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