245

Forestry in the MAGNET model

A.N. Walker & G.B. Woltjer

werkdocumenten

wot
Wettelijke Onderzoekstaken Natuur & Milieu

WAGENINGEN UR
For quality of life

Forestry in the MAGNET model

The 'Working Documents' series presents interim results of research commissioned by the Statutory Research Tasks Unit for Nature & the Environment (WOT Natuur & Milieu) from various external agencies. The series is intended as an internal channel of communication and is not being distributed outside the WOT Unit. The content of this document is mainly intended as a reference for other researchers engaged in projects commissioned by the Unit. As soon as final research results become available, these are published through other channels. The present series includes documents reporting research findings as well as documents relating to research management issues.

This document was produced in accordance with the Quality Manual of the Statutory Research Tasks Unit for Nature & the Environment (WOT Natuur & Milieu).

WOt Working Document **245** presents the findings of a research project commissioned by the Netherlands Environmental Assessment Agency (PBL) and funded by the Dutch Ministry of Economic Affairs, Agriculture and Innovation (EL&I). This document contributes to the body of knowledge which will be incorporated in more policy-oriented publications such as the National Nature Outlook and Environmental Balance reports, and thematic assessments.

Forestry in the MAGNET model

A.N. Walker

G.B. Woltjer

Werkdocument 245

Wettelijke Onderzoekstaken Natuur & Milieu

Wageningen, juli 2011

Abstract
Walker, A. and G. Woltjer, 2011. *Forestry in the MAGNET model.* Wageningen, Wettelijke Onderzoekstaken Natuur & Milieu, WOt-rapport 245. 39 p.; 3 Fig.; 10 Tab.; 12 Ref.; 1 Appendix

Forestry data have been included in the global general equilibrium MAGNET model at LEI Wageningen UR. This provides the opportunity to analyse substitution between forestry, natural forests and agriculture with the model, which is essential to analyse biodiversity and greenhouse gas effects of different policies options with respect to feed, food and fuel. The report discusses the background of the GTAP land use database used for the implementation, the way it has been implemented and some first simulation results. The report investigates the weaknesses of the implementation determining a research agenda for further improvements of modeling forestry into the MAGNET model.

Trefwoorden: forestry, agriculture, biodiversity, greenhouse gas, modeling

 LEI Wageningen UR
P.O. Box 29703, 2502 LS Den Haag
Phone: (070) 335 83 30; Fax: (070) 361 56 24; e-mail: informatie.lei@wur.nl

The Working Documents series is published by the Statutory Research Tasks Unit for Nature & the Environment (WOT Natuur & Milieu), part of Wageningen UR. This document is available from the secretary's office, and can be downloaded from www.wotnatuurenmilieu.wur.nl.

Statutory Research Tasks Unit for Nature & the Environment
P.O. Box 47, NL-6700 AA Wageningen, The Netherlands
Phone: +31 317 48 54 71; Fax: +31 317 41 90 00; e-mail: info.wnm@wur.nl;
Internet: www.wotnatuurenmilieu.wur.nl

F-0010 vs. 1.7 [2011] Project WOT-04-002-219 [Werkdocument 245 - juli 2011]

Contents

Summary

Forestry data have been included in the global general equilibrium MAGNET model at LEI Wageningen UR. This provides the opportunity to analyse substitution between forestry, natural forests and agriculture with the model, which is essential to analyse biodiversity and greenhouse gas effects of different policies options with respect to feed, food and fuel. The report discusses the background of the GTAP land use database used for the implementation, the way it has been implemented and some first simulation results.

The GTAP land use database combines global land cover and cropland data from Monfreda *et al.*(2008) and global timber data from Sohngen and Tenity (2004). The database has data about land cover, harvested crop area, crop production quantities, timberland area, and timberland land rent. The data are available per region (group of countries) and agro-ecological zone, where the last will not be used in MAGNET.

In practice there is only a rough estimate of total crop land rents in agriculture available. In order to distribute these land rents it is assumed that the share in the value of output determines the share in total land rent, where also a maximum land rent share in value added is applied. Land rents per ha for forestry are estimated as sales value minus cost. The prices for timber and the productivity of forestry are on a high aggregation level. So, the method is very rough.

With respect to expansion of forestry or agricultural land at the cost of natural land, Gouel and Hertel (2006) assume that an investment has to be made till natural land is transferred into useful agricultural or forestry land. A potential investor will compare these access costs with the expected net present value of the return on land, i.e. land rents. It is assumed that costs increase exponentially when less natural land is available. Lacking information, it is assumed that when 95% of accessible land is used, the cost elasticity is 5%. Given the chosen functional form and the current land rent this determines the access cost function for each country. For short term analysis a quadratic term is added to this cost function. In MAGNET always a land supply curve has been used to determined expansion of agricultural land. Because the way of calibration and the form of the function is largely similar to the one derived by Gouel and Hertel (2006), there is no reason to change the approach. In the future it may be good to include also a short term adjustment cost term to the MAGNET land supply curve.

The implementation of the land use database in the MAGNET model follows roughly the approach used at Purdue University. This implies that substitution between forestry, grassland and cropland is modelled with the help of a Constant Elasticity of Transformation (CET) function with an elasticity of substitution of 0.2, i.e. one per cent increase in relative rent for agricultural land increases agricultural land use as a fraction of forestry land use with 0.2 per cent. This is a standard way to model substitution between different land uses, but has important disadvantages, especially when it is assumed that the average land price is determined by an aggregate land supply curve. For example, when the price of agricultural land rises because of an increase in demand, the relative price of forest land may decrease, resulting in extensification of forestry, which is not very plausible. To find a better function to do the job is one of the challenges for further research.

Next to improvement of the modelling of land use substitution, there are some other priorities for further research discussed in the report. First, a correction to make the GTAP database consistent with the data provided by IMAGE is needed in order to get a good consistency between the IMAGE model of the Environmental Assessment Agency (PBL) and the MAGNET model. Second, the greenhouse gas information from the GTAP database may be included in the MAGNET database. Third, a further investigation of the consequences of the long term investment character of forests may be useful. Finally, a good baseline for policy analyses has to be developed.

In conclusion, a first implementation of forestry in the MAGNET model has been accomplished. Further improvements and investigations are needed before reliable analyses can be made to investigate in a reliable manner the competition between forestry and agriculture for land, the effects of different policy options for deforestation, greenhouse gasses and biodiversity, and to investigate the effects of these scenarios on trade of forestry products.

1 Introduction

A dataset has been created by Purdue University in order to include the forestry sector in general equilibrium models. The purpose of this report is to understand this data (Chapter 2) and then to make the initial steps to implement it in the MAGNET model (Chapter 3). As such, the available data and how it can be incorporated into general equilibrium models will be described and evaluated. In this report, 'forestry' or 'timberland' refers to commercially productive forest.

Before we consider the data and its application, we must first outline the basic principles of forests and forestry in MAGNET. The forestry sector is represented in much the same way as any other industry in MAGNET. It requires the use of inputs (labor etc.) and produces outputs. The price of the output is a function of the costs of production and demand for goods. The goods can be consumed within the region or they can be traded with other regions.

The forestry industry is closely related to agriculture because one of the key inputs for both these industries is land. If the price of agriculture and/or forestry products is high then this encourages the access of forest for use as forestry or agriculture. This shows that there is competition for land between different uses. The allocation of newly accessed land between forestry or agricultural uses is proportional to the relative demand for newly accessed land between them. The use of the newly accessed land and the degree to which the land is accessed has consequences for biodiversity and carbon sequestration and storage. The demand for land is determined by whether or not the net benefits that will be received from the land after it has been accessed are greater than the costs of accessing it.

2 The dataset

This chapter will describe the available data. It will show the processes and assumptions which were used in creating the dataset. Section 2.1 focuses on the available data and how it can be adopted to fit into GTAP style models. Section 2.2 focuses specifically on land rent data. This section discusses land rent separately for crops, livestock and forest and finishes by considering it's validation. Section 2.2 also finishes with possible ways to improve the data. Section 2.3 considers the access cost function through an in depth discussion of it's functional form and calibration. Section 2.4 offers conclusions on how to move forward towards a test version.

2.1 Data availability

Introduction

The database which will be used in this report is version 7 of the GTAP land use database (Avetisyan *et al*., 2010). This database integrates two sources of data:

i) Global land cover and cropland data provided by Monfreda *et al*. (2008). Referred to here on as MRF;
ii) Global timber land area provided by Dr. Brent Sohngren of Ohio State University (Sohngen and Tenity, 2004). This is also a source for forest carbon stock information.

In this way, the 'Integrated Global Land Use Database' has been created. This database of land use and CO_2 information was developed for use in global computable general equilibrium models aimed at assessing the economic costs of climate change policy. The database can also be used to better model forestry. This data is designed to be applied to general equilibrium models. As such, it has a large spatial agregation. This makes the data unsuitable to many other potential uses. The data is available in HAR format. As such it is accessed and applied through the GEMPACK set of software. Normal computers with high processing power are sufficient to run the MAGNET model.
The relevant data outputs for our concerns are:

1) Land cover data: physical area (thousands of hectares), ca. 2004, of 7 land cover types, in 160 countries/regions;
2) Crop(land) use data: harvested area (thousands of hectares) for the year 2004, covering 175 crop types, grown in 160 countries/regions;
3) Crop yield data: production (metric tons) per thousand hectare of harvested area, of year 2004, of 175 crop types, grown in 160 countries/regions, by 18 agro-ecological zones;
4) Timberland area data: timberland area (thousands of hectares), of circa 2004, of three tree species in various management types, in 124 countries/regions, by 18 agro-ecological zones, and by 10-year tree age classes;
5) Timberland marginal land rent data: 2004 US$ per hectare per year, of various management types in 124 countries/regions;
6) GTAP-compatible land rent (header 'VFM' in the GTAP input-output database) data: 2004 US$, of agriculture and forest sectors (totaling 13) in 87 regions, by 18 agro-ecological zones;

This data can be used in the GEMPACK software. The knowledge level for someone to apply this data into a general equilibrium model is very high, requiring skills to apply the data into the model. We will now discuss the dataset produced by Lee *et al* (2005) with references to the sources of data used.

Key procedures for MRF data
In order to supply the necessary data for this specification of GTAP, the spatially-explicit land use data sets from MRF has to be aggregated to match up with the format of the GTAP land use data. Two procedures are required:
(1) Mapping data to match GTAP crop sectors;
(2) Calculate productivity.

A third procedure is the segmentation of a parcel of land into smaller units according to agro-ecological characteristics, e.g. moisture and temperature regimes, soil type, landform etc. This has been carried out in the dataset but since AEZs (AEZ = Agro-Ecological Zone) have not been used in production of the test model. An explanation for this is shown in Appendix 1. AEZs are used in the database as the spatial unit within which data on the value added from forestry is displayed. For the test version, we have adjusted the data so that it shows value added by country.

Mapping data to match GTAP crop sectors
MRF has 175 crops and GTAP only has 8. Each of the 175 crops has been allocated to a GTAP group according to a common sense / expert opinion process.

Calculating productivity
These figures (in $US millions) were obtained by multiplying harvested area by yield and then that by the product price. This is done at the FAO 175 crop level and then condensed to the GTAP 8 crop level.

DGTM data (global timber land area)
The processes for adapting this dataset will now be summarized according to Lee *et al* (2005). This section concerns productive forest. Forest not in productive use has been determined from the MRF dataset. The intention was to produce estimates of land area for forestry by regions and countries and to obtain economic parameters to allow the land area to be modeled in general equilibrium. This was achieved by combining forest area data from Ramankuty and Foley (2008) with ecosystem types from the BIOME3 model (see Haxeltine, 2006 for an introduction) plus forestry area from FAOSTAT (2004). This produced the most accurate estimates of regional and country forestry area available. Economic data on the forestry was also taken from FAOSTAT (2004)

Harvested area vs. physically cultivated area
While it might seem, at first glance, that physically cultivated area is preferred to harvested area in building this global data base, this is not the case. In the GTAP economic accounts for each country, land rents are generated from the activity (or use) on a given parcel of land during the calendar year. Therefore, the interesting value is that of the land in production over the course of the entire year, not just one season. Consider the case of a farmer in Southern China who grows early double-crop rice from March to July, and then grows ‘catch crops’ (fast growing crops, e.g., vegetables) over the rest of the calendar year. The GTAP Input-Output data identify sectors in terms of crops (e.g., the paddy rice sector, the cereal grain sector, the oil seeds sector, etc.), not hectares of land, per se. So the land rents of the crop sectors should accrue to the harvested area, by crop. To illustrate this example, land rent due to the growing of paddy rice is allocated, to the GTAP paddy rice sector, while land rents generated by the growing of vegetables are allocated to the GTAP vegetables sector, both within the same AEZ. Thus, while the harvest-based land rents can be allocated to GTAP sectors within a given AEZ, the physically cultivated-based land rents cannot.

Crop harvested area by crop type is used in the IMAGE model (Tabeau *et al*, 2006), thus, this manner of data use is suitable for comparison with the IMAGE model.

Caveats
The data produced by this method also has three caveats which must be considered. There will be more timber price variation across countries in reality than reflected in this data. The reason for this is that the prices and quality adjustment factors for prices were originally developed for a global model that aggregates the world into just nine regions: North America, South and Central America, Europe, the Former Soviet Union, China, Asia-Pacific, India, Oceania (Australia and New Zealand), and Africa. Within each of these regions, there will surely be price differentials that are not reflected here. For modelers interested in global analyses, the price differentials contained in this data set are adequate for purposes of making broad comparisons across the major producing regions of the world. However, modelers seeking to use the data for more selected, national analyses involving countries within a particular region may consider adjusting the prices used for timber with more recent data from the FAOSTAT database (FAOSTAT, 2004).

A second, and analogous issue, is that there are surely larger differences in forest productivity across countries than are reflected in this data set. The reasons are similar to those described above for prices: The productivity (i.e. merchantable yield) of timber types was originally estimated so that it could be applied to large areas of timber in the nine regions of the model in Sohngen *et al*. (1999). The same parameters have been applied to all timber types in each country located in a particular region. Thus, the productivity estimates may fail to reflect important differences in specific countries. Unlike price data, however, there are no global databases with country specific parameters for the timber yield functions; hence it is not possible at this point to make further corrections to the data for specific countries.

2.2 Land rent data

The processes for producing land rent data varies between the land use. Each of these processes will be discussed. This is what Purdue University have already done with the data. We will end this section with a discussion of validation process for land rent.

For crops
There is no available, observed data on land rents in most countries. Where it is available, it is not grouped by land use or, obviously, AEZ. Furthermore, the multiproduct nature of most farms, and a general shortage of data in this area mean that land rents differentiated by use are not available. As such, the only relevant piece of data offered by GTAP is total land rents in agriculture at the national level. This is then split according to the following formula for crops.

$$L_{ca} = L_c \{ \sum_{i \in FAO=c} P_i Y_{ia} H_{ia} / \sum_{a \in AEZ} \sum_{i \in FAO=c} P_i Y_{ia} H_{ia} ,$$
$$\forall c \in crops, i \in FAO$$

where:
L_{ca} is the land rent accrued to GTAP crop sector c in AEZ a;
L_c is the total land rent of GTAP crop sector c, (no AEZ distinction: header VFM in GTAP);
P_i is the per-ton price of FAO crop i (invariant to AEZs, sourced from FAOSTAT)
Y_{ia} is the yield (ton/1000 ha) of FAO crop i in AEZ a, (sourced from MRF); and
H_{ia} is the harvested area of FAO crop i in AEZ a, (sourced from MRF).

For livestock
For livestock there are four primary livestock production sectors in the GTAP data base:ruminants (ctl = cattle, sheep and goats), dairy production (rmk), wool (wol) and non-ruminants (oap = pigs and poultry). In the case of non-ruminants, we assume that the sector does not use substantial amounts of land directly in production. By their very nature, what they consume has already been produced using land somewhere else in the system (e.g., feedgrains). As production intensifies, these animals are confined to a facility which is more nearly akin to a manufacturing sector than a land-using sector. Therefore, the technique used is to abstract from the direct competition for land between non-ruminant production, ruminant production, crops and forestry. Of course there is indirect competition, insofar as increased production of poultry, for example, will boost the feed requirements and hence increase the demand for land in feed grains. However, we capture this competition via the intermediate demand for feed in non-ruminant production in the CGE model.

For forest
This process focuses on the share of land rents in total costs (sales). This means that the data is portable across data sets as well as over time. The process began with total hectares of forestry minus inaccessible forest which gave the currently accessed land in forestry production. Accessible forest was then multiplied by land rent (which varies by management class). Land rents needed to be estimated as a share of total costs. As such, an estimate of total cost was required. In order to estimate total costs, zero-profit was assumed. In this way sales equaled total costs. Sales were estimated as production multiplied by quality adjusted timber price. As such, the following equation was implemented: (Product sales / forest land rent) * 100 = 38%. The result (38%) is the share of land rent in global forestry value added and the percentage of product sales accounted for by forest land rent.

There are two conditions which need to hold concerning forest land rent:
1. Land rents < total sales (for all AEZs and regions);
2. Land rental share in total costs < value-added share.

These conditions may not hold due to disequilibrium in reality and miss-estimation of land rents or other aspects of the data. In order to make the inequalities hold, some adjustments were made. Firstly, the share of land rents in value-added at a global level is calculated. The share of product sales accounted for by forest land rent (38%) is used to allocate these total land rents over forestry and agriculture.

Validation and improvement of land rent data
Validation is best made by comparing the inferred data to actual data. As of 2008, the only actual data available comes from the United States Department of Agriculture. The conclusions from validation are that the approach to estimating lands rents in agriculture is weak and that a more direct approach would clearly be preferable. While it is weak, it is still deemed satisfactory since globally the results are broadly as expected. However, if it is weak for agriculture, it is likely to be very weak for forests. Therefore, the uncertainty regarding these estimates needs to be taken into account during the interpretation of results.

The data could be improved by acquiring more observed land rent data (may be possible if new data is available since 2008).

2.3 Forest access cost functions

Access as an investment

Gouel and Hertel (2006) propose a forest access cost function for inclusion in GTAP style models. This long run function contains a short run quadratic component. In this section, the logic and process of constructing this cost function will now be explained.

Accessing a new forest presents the main features of an investment: money invested today leads to capital accumulation – in this case a larger stock of accessible land – which in turn permits production of a stream of future benefits. So introducing inaccessible land in GTAP means also introducing a new kind of investment. We don't observe the real cost of accessing new forests. Instead, we will hypothesize some key relationships which may be quantified in order to provide an acceptable access cost function for use in empirical modeling.

Gouel and Hertel (2006) structure their report around three steps. Firstly, they determine how the inaccessible forest is accessed and what the first period access cost is. Secondly, they choose a functional form for the access cost function so that they can predict future access costs. Thirdly, they calibrate the function so that it can be implemented in a CGE model.

Choosing the level of investment in inaccessible land

Firstly, Gouel and Hertel (2006) distinguish between those regions in which inaccessible forest land is present, and those in which it is not. Brent Sohngen's Global Timber Supply Model is followed in order to exclude the possibility of additional forest access in South Asia, High Income Asia and Western Europe. For those regions that do have inaccessible forests still available, they hypothesize that a part of the inaccessible forest is accessed during the first period in every region. This is a useful assumption for purposes of calibration, since it implies equality between the price of forest land and the marginal access cost, so we can infer the latter (unobserved) from the former (observed forestland price). For example, if a region experiences a lot of deforestation because of a low marginal cost of access, then the land rent must be small to reflect this fact. The link between forestland price and land rent is a simple economic rule. A forest landowner will access new land only if the access cost is less or equal to the expected benefits. And the expected benefits are summarized in the forestland price.

The owner will choose to access more land if the forestland price is higher than the access cost. The owner will not access new lands if the marginal access cost is higher than the forestland price. Hence the land accessed will be determined in equilibrium by the condition that the marginal access cost equals the forestland price.

The forestland price is determined as the net present value (NPV) of the flow of benefits from the forestland. The forest landowner benefits are defined in GTAP as the land rent. With static expectations (per usual in a recursive dynamic model) the NPV of future benefits can be expressed as follows:

$$P_t^{ForestLand} = Landrent_t \cdot \frac{1+ROR_t}{ROR_t} \qquad (1)$$

with $P^{ForestLand}$, the price of one hectare of forestland, *LandRent,* the land rent for one hectare and *ROR,* the net expected rate of return in the region where the access is occurring.

If we consider that the newly accessed land will bring benefits the period after its access, like an investment, the access cost will not equal the forestland price but the present value of the next period forestland price:

$$AccessCost_t = NPV\left(P_{t+1}^{ForestLand}\right)$$

$$AccessCost_t = \frac{P_{t+1}^{ForestLand}}{1 + ROR_t}$$

with static expectations: $$AccessCost_t = \frac{P_{t}^{ForestLand}}{1 + ROR_t}$$

substituting in for $P^{ForestLand}$ we get:

$$AccessCost_t = \frac{Landrent_t}{ROR_t} \qquad (2)$$

At each period, the possibilities are: either the access cost is bigger than the land rent divided by the expected rate of return and no new forest is accessed, or the access cost is smaller and new forest is accessed until access cost equals the NPV of land rents.

The land rents can now be calculated by combining GTAP forestry sector output values and Brent Sohngen's data on country-specific land rents and sectoral output values. Gouel and Hertel (2006) apply the world average share of land rents in product sale, 38% (see page 14), from Sohngen's data to the GTAP forestry sector output. After dividing this estimate of total forest land rents by the accessible forest area they get the average land rents per hectare for each region. The net expected rate of return comes from the version 5 GTAP-Dyn database for 1997. They calculate the access cost using equation (2), which involves simply dividing land rents by the rate of return.

Gouel and Hertel (2006) also required data on accessible and inaccessible forest areas. These have been obtained from Brent Sohngen's website and from calculations using the 16-region Global Timber Supply Model (Sohngen *et al*., 1999). Gouel and Hertel (2006) opt to follow Sohngen’s model in determining the regions without inaccessible forest because we are interested in an economic definition of inaccessible forest (e.g., there could be inaccessible forests in Germany, but no amount of increase in commercial land rents will bring it into production.) For the other regions, they use the country-level data from Sohngen’s website, as derived from the FAO. The results are shown in Table 1.

Table 1: Area of accessible and inaccessible forest (1000 ha)

Region	Accessible forest	Inaccessible forest	Share of accessible forest
North America	154,309	451,968	25%
China	81,904	49,775	62%
South Asia	52,147	-	100%
Rest of the world	169,898	121,501	58%
Australia & New Zealand	10,810	153,943	7%
High income Asia	30,312	-	100%
ASEAN	50,335	94,941	35%
Latin America	300,507	577,251	34%
Western European Union Europe	131,061	-	100%
Economies in transition	190,134	723,170	21%
Middle East and North Africa	15,263	1,854	89%

Choice of functional form of the long run access cost function

This section shows the functional form preferred by Gouel and Hertel (2006). As will be shown in Chapter 3, this is not the same function as we use in implementing the data into MAGNET. However, it is presented here because it will be useful information for considering future developments to the model.

Gouel and Hertel (2006) assume that the marginal access cost changes with the share of accessible forest. In particular, the access cost function is convex in accessed forest. Therefore, as the share of total forest that has been accessed increases, the cost of accessing an additional hectare rises. This makes sense, since we expect that the more readily accessible lands will be accessed first. In addition, Gouel and Hertel (2006) assume that access costs become infinite as we approach complete access (the last hectare of inaccessible land can't be economically accessed). Several functional forms can mimic these effects. Gouel and Hertel (2006) prefer the following form:

$$AccessCost(h) = -\alpha.\ln\left(\frac{\bar{h}-h}{\bar{h}}\right)+\beta \qquad (3)$$

with α and β two positive parameters, *h*bar the total forest area, and *h* the accessed forest area, *h*bar - *h* so is the remaining inaccessible forest land. Thus the term in brackets (.) is bounded between zero and one, so that ln(.) is bounded between –infinity and 0. The parameter alpha governs the elasticity of access costs with respect to cumulatively accessed forest land, σ(*h*)

$$\sigma(h) = \frac{\alpha}{AC(h)}\cdot\frac{1}{\bar{h}/h-1} \qquad (4)$$

where:

$$\frac{d\sigma}{dh} = \frac{\alpha\cdot\bar{h}}{AC(h)\cdot\left(\bar{h}-h\right)^2}\cdot\left(1-\frac{\alpha\cdot h}{AC(h)\cdot\bar{h}}\right)>0 \qquad (5)$$

In other words, the elasticity of access costs becomes larger as more hectares are accessed. Note also that β is the implied level of access costs for the first hectare of land being accessed (i.e., access costs evaluated at $h = 0$).

This functional form has one significant drawback in that it is not dynamic. There are several reasons why a dynamic element would be appropriate. Put simply, harvesting forest takes time. There may be planning regulations. Infrastructure for forestry takes time to produce. There will also be limited availability of capital and this will mean that investments must be staggered over time. This issue could be dealt with using an adjustment cost approach and this should be an element of future research into this topic.

Calibration of the cost function

The calibration problem consists of choosing α and β to match information on current access costs (land prices) as well as the elasticity of access costs with respect to accessed land. The parameter α is a slope parameter that can be calculated from the elasticity σ. Gouel and Hertel (2006) begin by calibrating to the elasticity of access costs with respect to accessible land, then they choose the intercept parameter β to reproduce the observed level of access costs (land prices). However, good information on the access cost elasticity was not available. Therefore, Gouel and Hertel (2006) adopt a simple approach that avoids introducing spurious variation across countries. Specifically, they postulate that each region will have the same access cost elasticity, were it to be evaluated at the same current share of accessible land. For this they simply choose an elasticity of 0.05 (very low) at 5% of accessible share – roughly the share currently exhibited in Australia/New Zealand. The variation in these elasticities across regions now depends solely on the currently observed accessible share (and the functional form). This produces access cost elasticities which match the expectations that elasticity should be higher as the amount of unaccessed forest decreases.

Figure 1 plots these access schedules for the eight regions with accessible forest lands. It is important to point out that this curve, in practice refers not only to deforestation but also to reforestation. Within the model, agricultural land can be taken out of production and then it will return to natural forest. Unfortunately, the system used here means that the agricultural area will immediately return to natural forest. In practice, this is clearly not the case. Therefore a suitable mechanism to deal with this would be to add an intermediate step by classing land which has recently been returned to forest as "shrub" land. This option will be explored in the production of the test version.

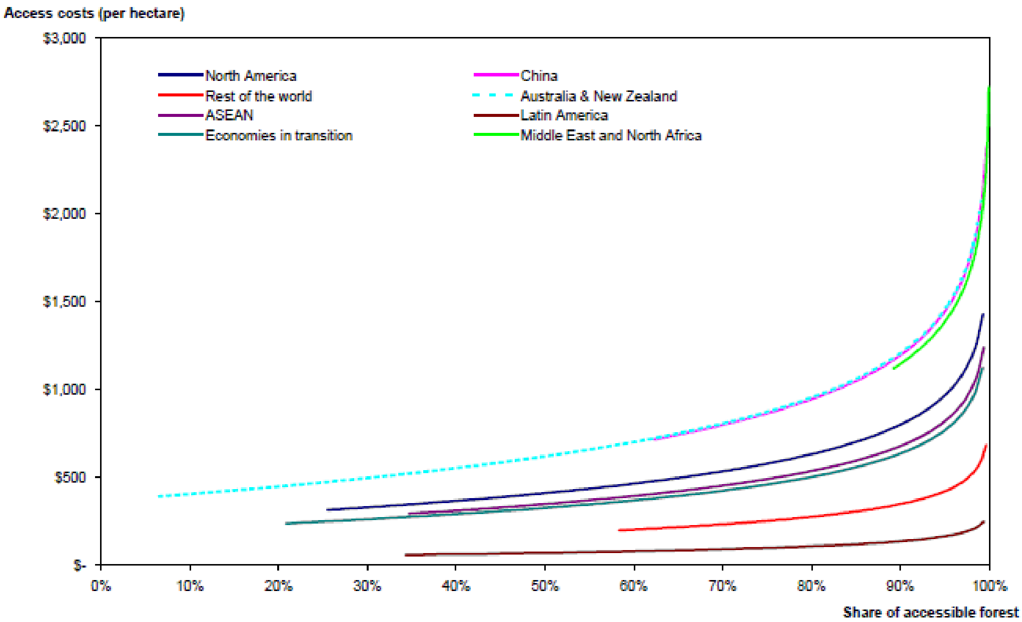

Figure 1. Access schedules for the eight regions with accessible forest lands

The need for a short run element

Gouel and Hertel (2006) use the access cost function (3) to calculate the total investment in forest access. Figure 1 is compared to actual data. This comparison showed that access cost function leads to too high a rate of access. This comes about due to the lack of short run constraints. Even if a large part of the forest is cheap to access, it can't be accessed in a single period. Some area must be accessed before we can reach the rest. Besides, the investment in inaccessible forest requires labor and capital, which can't be easily move from one sector to another. Yet these constraints on short run access are not embodied in our functional form. This suggests the need to modify this 'long run' access cost function.

Treating (3) as the long run access cost function, modify it to reflect the type of short-run considerations raised in the previous paragraph; specifically, we append a term that is quadratic in the annual rate of access, i.e. the change in *h* per annum, as in equation (6). As a further step in the calibration procedure, we can adjust this quadratic term to give the same rate of access in the first decade that is observed in the FAO data. This gives rise to the following equation:

$$ShortRunAccessCost(h_{t+1}) = -\alpha.\ln\left(\frac{\bar{h} - h_{t+1}}{\bar{h}}\right) + \beta + \gamma.\left(\frac{h_{t+1} - h_t}{h_t}\right)^2 \quad (6)$$

Assuming that the 4.2 million hectare deforestation in Latin America occurs for a small increase in land rent -- say 3% -- we would set γ equal to $ 450/ha. This figure can be adjusted in light of the predicted rate of increase in land rents in the general equilibrium model for the period in question.

Calibration of investment in accessed forests

Having calibrated the national access cost function, we now turn to the general equilibrium issue of providing the necessary resources to accomplish this investment activity. Ideally, forest access would already be included in the investment vector and the associated inputs could be extracted and treated separately for these purposes. However, in practice this activity will often not be included in gross national investment. And when it is, we do not know which inputs are used in this activity. Therefore, we propose a simpler approach. Specifically, we assume that the costs consist of variable labor and capital expenditures. In this way, the social accounting matrix can be expanded to include another investment activity (forest access), and labor and capital can be added as costs for this activity. This serves to augment income of (e.g., in GTAP) the regional household. As with normal investment, this activity is financed with savings, in general equilibrium, and the additional savings are exactly covered by the additional labor and capital income. In this way, we maintain Walras' Law.

2.4 Conclusion

GTAP version 7 Land Use Database (Avetisyan *et al*, 2010) is the first port of call for producing a test version. The data does not have to be modeled using AEZs and it has been decided that normal country boundaries are more appropriate at this stage. The methods suggested to improve the data provided in this data set and also the land rent data should be explored. This data can now be modeled into MAGNET and this will be the subject of the following chapter.

3 The implementation of forestry in the MAGNET model

This chapter deals with the second aim of this project which is to produce an initial implementation of forestry in MAGNET which will form a concrete starting point for improvements in modeling next year. Chapter 2 showed that Purdue already made very important steps in creating a database for forestry land use that is adapted to a general equilibrium context, and have made some estimations about land supply and land allocation that may be relevant in this context. But the model used is different from ours as is the way data and logistics are structured. For this reason, the information provided by Purdue have to be structured and implemented in a manner that is consistent with the modeling approach of LEI Wageningen UR and of the Netherlands Environmental Assessment Agency, PBL (IMAGE and MAGNET).

3.1 Implementation of the database

We implement the data from the GTAP land use database in MAGNET. In order to be consistent we decided to take all information from the GTAP land use database instead of using the information from IMAGE that was included till now in the MAGNET database. This also implies that procedures had to implemented to modify the land use database so that it can be used in the MAGNET model. In a later stage, it will be important to compare the GTAP land use database with the information in IMAGE and investigate to what extent the data have to be adjusted. Section 3.1 discusses the implementation and Section 3.2 discusses the results of tests which were designed to evaluate the success of the implementation.

Allocation of land rents to the forestry sector

In the standard GTAP database the forestry sector has no land, and some rents are allocated as natural resources. This rent on natural resources has to be transferred to land in order to be able to include competition between forestry and agricultural land use in the model. Furthermore, the information on rents in the natural resource sector is not consistent with the information that is available in the GTAP land use database about land rents. So, the land rents have to be adjusted accordingly.

The database consists first of a part that includes value added for land in forestry. Because the data supplied are consistent with an older database with data of insufficient quality for our purpose, the data have to be adapted to those of the database we use. We do this by keeping the value added consistent with the database we use, and adjusting the data from the forestry database to the value added in our database. Because of the low quality Myanmar is included in the rest of south east Asia in the database we use, we aggregate this country with the rest of south east Asia.

While land rents are accounted for in the forestry sector, land rents are taken out of the sector 'other animal products'. The sector 'other animal products', mainly consists of pigs and poultry, and can be assumed to use no agricultural land, because the production process is either more like industry, or it is just using the leftover space on the farms. The land rents that are taken out of the database, are distributed equally over the other value added categories, i.e. labor and capital. The last choice is made, because the GTAP database is constructed in this way. An alternative would be to say that land is part of capital, and therefore the land rent should be brought to capital only.

Land cover data

Land cover data are derived from SAGE. At this moment these land cover data are taken from the GTAP land use database, but we are working on our own mappings to be able to create and update the information ourselves based on the FAO database:

- Forest;
- Savannah / grassland;
- Shrub land;
- Cropland;
- Pastureland;
- Built up land.

As a first approximation, we assume that cropland, pastureland, forest, savannah, grassland and shrub land can potentially be used for agriculture and forestry. The 2004 dataset produced by the GTAP consortium assumes that all land that is abandoned after 2001 is forest in 2004. Because the creation of forest requires a long period of time, we bring this land in first instance into the shrub land category. This is only relevant in experiments where we decide to exclude all forest land to be transferred into agricultural land.

Agricultural land use data

Total cropland and pastureland use are included in the land cover database. But to distribute this land use over different sectors, only harvested areas are available, and only for cropland. To make the sum of the harvested areas of all commodities consistent with total land cover, all harvested areas per region are adjusted with the same percentage change. So, the proportions of land use are consistent with the harvested area information, while the total land use equals cropland land cover.

For pastureland no detailed land use information is available. Lacking more information, pastureland is distributed over the sectors according to the share in total land rents in the GTAP database. The sector 'other animal products', mainly consisting of pigs and poultry is assumed to use no agricultural land, because the production process is either more like industry, or it is just using leftovers in the farms.

Forestry land use data

DGTM timberland use data are in the GTAP database. These data are added to our agricultural land use database. The data are provided in a very aggregated manner, but as a first approximation all categories are added together. So, the DGTM timberland use data are aggregated to one category, and included as land use in the forestry sector.

Aggregation of AEZs into regions

The GTAP land use database did split out land cover and land use over AEZs per region. The MAGNET-IMAGE approach has always been that the AEZs are not fixed regions with jumps in productivity, but it is a more gradual adjustment. As a first step, we continue with this approach. This implies that we aggregated all AEZ-specific land use information to one production factor, land. This makes the database for land use smaller, and therefore allows for more detail in other parts of the model. With respect to the effect on the model dynamics, it increases flexibility to switch from one type of land to another, reduces the productivity effects from switching from one AEZ to another, but also implies a loss of the information about AEZs. Future implementation of the model to test different scenarios will define which approach is best.

3.2 Implementation of forestry in the model code

For the implementation in the model code it has been decided to change the code as little as possible. We assume that commercial forest land is just another land use category, that can be substituted with agricultural land with a relatively small elasticity of transformation. We use the same elasticity as Gouel and Hertel (2006) use. This means that if the price of forestry products and therefore also forestry land rents rises, the sector can rent or buy land from the agricultural sector, and increase its land use at the cost of agricultural land use.

For the moment we have decided not the use the information of agro-ecological zones in the model, and this is consistent with previous conventions regarding MAGNET. The argument for excluding AEZs is that characteristics of land vary much more continuously with environmental variables than is assumed in the strict differentiation between agro-ecological zones. As long as changes in land use are not too big, there is not much risk that products will be grown in regions where this is not possible at all. When necessary restrictions on total land use for certain types could be restricted, but this has not been a problem to date.

For the moment we start with the land use and land cover data as supplied by the GTAP land use database. We are aware of the differences with land use database as used at PBL, but comparison of the two databases and the implementation of corrections is one of the explicit challenges for next year. When everything is implemented the correction of the data consistent with IMAGE will not be very difficult.

With respect to forestry, we will follow the approach in the GTAP land use database in which there is no difference between different types of forestry. We also assume that forestry harvests are so flexible that extra harvests are possible and that these extra harvests are compensated with extra new land use of the forestry sector. In other words, we avoid the problem of the long term nature of the decisions in the forestry sector for the moment. This issues requires attention next year.

With respect to land supply, the quadratic cost function they use is very similar to the land supply curve approach that is used in MAGNET. Therefore, the land supply curve approach of the old LEITAP model will behave roughly in the same way as the quadratic cost function used by Goual and Hertel (2006) (see Section 2.3). For this reason, we didn't implement the quadratic cost function, but used our standard land supply curve approach.

The available land for forestry and agriculture is based on current land cover, so it will not change when commercial forestry sector is included as a land using sector. The only change is in the total current land use which is used as the starting point of the calibration of the land supply curve.

The price elasticity of land supply (i.e. the percentage change of land supply divided by the percentage change in price that causes this change in land supply) that we use in a standard way is calculated as:

```
LANDELAST(r) = {[asymptoteL(r)/landsupplyL(r)]^2}
            * LANDPOW(r)*(asymptoteL(r)/landsupplyL(r)-1)              (7)
```

where:
LANDELAST   is the price elasticity of land supply

asymptoteL	is the amount of land that can be potentially used for agriculture respectively agriculture and forestry
landsupply	is the amount of land that is currently used for agriculture respectively agriculture and forestry
LANDPOW	is a coefficient that without extra knowledge is set at 1

Equation (7) implies that the price elasticity of land supply approaches zero when land supply approaches the asymptote, infinity when land supply approaches zero, and equals 4 * LANDPOW when land supply is half of the available land. Be aware that MAGNET is a general equilibrium model, so land supply always equals land demand and land use.

What will be the consequence of the extension of forestry land use in the model? It first implies that an increase in profitability of the forestry sector may generate a reduction in agricultural land. Second, when nothing is changed with the asymptotes, land use increases compared with the asymptote, and therefore the price elasticity of land supply is reduced. In order to keep the same price elasticity of land supply LANDPOW has to be increased with about a factor 4. In summary, the extension of the model with forestry creates the possibility of the interaction between forestry and agriculture, but has no implication for the fundamentals of the agricultural land market.

3.3 Some experiments with the current implementation

At this moment, the conversion process from the old LEITAP model towards the new MAGNET model is going on. We have decided to implement the forestry module in the new MAGNET model. Because MAGNET is still being constructed, there are a lot of elements of the old LEITAP model which have not yet been implemented. For example, the MAGNET model has only the standard GTAP consumption structure. As such, a baseline scenario has not yet been developed. We use that GTAP database version 8 data for 2004 for which we have done no tests on its suitability. Despite the fact that MAGENT is not yet entirely complete, it is complete enough to run tests at this stage and it does facilitate meaningful evaluation of the results of the tests. In any case, simulations in the future will be done with the new MAGNET modeling structure and as such, the tests carried out here provide more insight into how well the new data will work in future modeling exercises than we could get if we did tests on the old structure.

In running the simulation we have split out 16 world regions and 26 sectors, but for presentation purposes we have created some aggregates. To create an overview of the main effects, we have divided the regions in EU27, NAFTA (North American Free Trade Association), Brazil (bra) and the rest of the world, and have aggregated all primary agricultural products into a sector AGRI, the cropland products into a sector AGRI_CROP, the animal sectors into AGRI_GRASS, the forestry sector remains just Frs, and all land using sectors are AGRIPlusFor. Finally we split out the Wood and paper sectors into a WoodPaper aggregate, and we created an aggregate for all other sectors, OtherComm.

Four scenario-experiments have been run:
- Increase in demand for forestry products;
- Increase in demand for cereals;
- Increase in population;
- Increase in GDP per capita.

For each of these scenarios we show some indicative results to show that the model performs roughly in the right way.

Experiment 1. Worldwide increase of 10% of timber, paper and forestry private consumption (TimberDemandShock)

In order to see the effect of changes in demand for forestry products, we increased the private demand for timber, paper and forestry private consumption by 10%. This resulted in an increase in an increase in production of timber and paper with roughly 2% and of forestry products of about 2.7% (Table 2). The rest of demand is indirect demand through other sectors. The increase in forestry production is concentrated in Brazil. Land demand for forestry increases with roughly the same percentage as production (Table 3), but there are differences across regions in terms of how the demand is supplied. In EU27, NAFTA and brazil production increases more than land demand, so there is a slight intensification of forestry, while in the rest of the world there is some extensification, probably because forestry is expanded in regions where forestry productivity is relatively low.

The effect of an increase in forestry production on agricultural land use is very small. The model suggests that agricultural production is going from the EU27 and to a lesser extent Brazil to the test of the world, where animal production is only slightly reduced. Total land use in agriculture increases. This is the consequence of the use of the CET function used, where an increase in price for forestry implies a reduction in price for agriculture if the land price is not changing much. This is a topic for further research that is not only related with the implementation of forestry into the MAGNET model but also constitutes a long term problem with the LEITAP model.

Table 2. Production volume (% change) (TimberDemandShock)

	EU27	NAFTA	Brazil	ROW	World
AGRI	-0.142	0.007	-0.075	0.059	0.004
AGRI_CROP	-0.196	0.076	-0.102	0.071	0.021
AGRI_GRASS	-0.102	-0.033	-0.048	0.041	-0.016
AGRIPlusFor	0.006	0.213	-0.003	0.191	0.150
Frs	2.232	3.223	4.206	2.703	2.716
WoodPaper	2.541	2.214	2.622	1.356	2.061
OtherComm	-0.061	-0.056	-0.052	-0.029	-0.047

Table 3. Land Demand per sector (km^2) (% change) (TimberDemandShock)

	EU27	NAFTA	Brazil	ROW	World
AGRI	-0.061	0.543	0.424	0.993	0.856
AGRI_CROP	-0.084	0.482	0.271	0.62	0.526
AGRI_GRASS	-0.012	0.592	0.477	1.181	1.042
AGRIPlusFor	0.771	1.502	1.593	1.438	1.421
Frs	1.786	2.989	3.361	2.858	2.837

Experiment 2. Worldwide increase of 10% of cereal private consumption (CerealDemandShock)

In this scenario the private demand for cereals (excluding rice) is increased with 10%. As a consequence the production of cereals increases with 3.3%, where the other part is indirect demand (Table 4). Land demand for cereals increases only a little bit less than production, where for example the EU27 has a relatively large intensification (Table 5). The effect of the increase in cereal production on the production of other commodities is again a little bit counterintuitive, and requires further investigation.

Table 4. Production volume (% change) (CerealDemandShock)

	EU27	NAFTA	Brazil	ROW	World
AGRI	0.209	0.125	0.07	0.449	0.329
AGRI_CROP	0.478	0.34	0.113	0.69	0.594
AGRI_GRASS	0.008	0.003	0.026	0.065	0.034
AGRIPlusFor	0.197	0.111	0.067	0.437	0.316
frs	0.016	-0.095	-0.067	0.199	0.088
WoodPaper	0.01	-0.024	-0.073	-0.002	-0.006
OtherComm	-0.003	-0.001	0.001	-0.023	-0.01
Cereals	2.457	1.316	1.028	4.344	3.278

Table 5. Land Demand per sector (km^2) (% change) (CerealDemandShock)

	EU27	NAFTA	Brazil	ROW	World
AGRI	0.881	0.382	0.095	1.218	1.03
AGRI_CROP	1.247	0.778	0.254	2.067	1.716
AGRI_GRASS	0.119	0.06	0.039	0.79	0.644
AGRIPlusFor	0.556	0.22	0.045	1.06	0.834
Frs	0.16	-0.031	-0.03	0.556	0.341
Cereals	1.884	1.338	0.914	4.087	3.208

Experiment 3. Worldwide increase of 10% of world population and employment (PopulationInclCap)

An increase in population implies an increase in labor supply and we assume also that the capital stock grows with population. As a consequence private demand increases also with roughly 10%. Consumption growth is a little bit less (Table 6), because land and nature are scarce production factors that restrict production growth. In particular direct consumption of forestry products show a relatively large effect, probably because the price of forestry products increases while demand is relatively elastic. Production has more or less the same rise as consumption. Land demand also increases with roughly 10% (Table 7), but the increase is significantly less in the EU27 because of land scarcity. These effect seem relatively plausible, although a little bit more intensification may be expected. This last aspect as an issue for further research.

Table 6. Private consumption volume (% change) (PopulationInclCap)

	EU27	NAFTA	Brazil	ROW	World
AGRI	9.52	9.68	9.62	9.91	9.79
AGRI_CROP	9.85	9.89	9.66	9.79	9.8
AGRI_GRASS	9.29	9.59	9.61	10.09	9.770
AGRIPlusFor	9.42	9.62	9.6	9.88	9.74
Frs	3.63	7.56	8.9	8.75	7.83
WoodPaper	9.49	9.63	9.52	10.13	9.69
OtherComm	9.37	9.57	9.39	9.74	9.56
Cereals	9.78	9.86	9.65	10.24	10.16

Table 7. Land Demand per sector (km^2) (% change) (PopulationInclCap)

	EU27	NAFTA	Brazil	ROW	World
AGRI	6.64	10.96	10.33	9.44	9.57
AGRI_CROP	6.86	11.44	11.1	9.53	9.69
AGRI_GRASS	6.17	10.57	10.07	9.39	9.5
AGRIPlusFor	6.95	11.41	10.57	9.81	9.95
Frs	7.34	12.12	10.92	10.97	10.89

Experiment 4. Worldwide increase of 40% of GDP per capita (GDPperCap)

In order to achieve a 40% increase in GDP per capita, we shock general productivity by 10%. This leads to a rise in private consumption by less than 40% for crop products, for about 40% for animal products, and for more than 40% for other commodities (Table 8). Production increases less than private consumption, because it is assumed that the increase of GDP per capita is partly realized by more efficient use of intermediate inputs (Table 9). The total effect on land demand is very small (Table 10). The cause is the assumed correlation between general increases in productivity and increases in land productivity. This effect seems roughly consistent with history observations in which growth in GDP had only small effects on land demand.

Table 8. Private consumption volume (% change) (GDPperCAP)

	EU27	NAFTA	Brazil	ROW	World
AGRI	27.9	33.9	26.9	27.0	28.2
AGRI_CROP	3.7	4.1	17.8	19.5	15.6
AGRI_GRASS	44.4	47.2	30.8	38.5	41.7
AGRIPlusFor	28.8	34.9	27.5	27.7	29.0
Frs	80.9	70.0	47.6	54.7	61.0
WoodPaper	52.0	46.9	46.7	49.7	49.6
OtherComm	47.6	41.0	44.6	46.7	44.8
Cereals	5.5	5.7	16.7	20.8	18.2

Table 9. Production volume (% change) (GDPperCAP)

	EU27	NAFTA	Brazil	ROW	World
AGRI	13.44	15.02	4.04	15.47	14.6
AGRI_CROP	-0.79	1.65	-0.21	11.14	7.6
AGRI_GRASS	24.07	22.63	8.27	22.37	22.4
AGRIPlusFor	12.43	13.94	4.19	15.25	14.1
Frs	-2.88	-1.87	13.16	11.07	4.9
WoodPaper	7.61	4.48	3.45	12.30	7.9
OtherComm	20.31	19.93	19.83	21.14	20.5
Cereals	2.35	2.02	-2.49	11.36	7.4

Table 10. Land Demand per sector (km^2) (% change) (GDPperCAP)

	EU27	NAFTA	Brazil	ROW	World
AGRI	-5.69	-5.67	-4.07	4.77	2.44
AGRI_CROP	-8.81	-11.99	-9.60	0.76	-2.53
AGRI_GRASS	0.81	-0.54	-2.16	6.79	5.24
AGRIPlusFor	-9.56	-9.56	-4.36	3.03	-0.13
Frs	-14.28	-15.60	-4.80	-2.53	-6.59

Summary

The description of some simulation results above shows that the inclusion of the forestry is sector is roughly doing what is meant to do. The CET function to model the transformation between different land uses again seems to be problematic, and requires further research. The model shows small effects of extra demand on intensification. This may be partly caused by the amount of land that is assumed to be available, which is an issue to be tackled next year. But it is also something that in general comes out of this type of simulations. Further research in this topic may be needed.

3.4 What still has to be done?

The implementation of forestry in the MAGNET database and model is only the very first step into getting a reliable implementation in the model. It is a starting point for further improvements. Below we list some activities that are may be important for these further improvements.

Database check

The current version of the database is based on SAGE, while up to now, we worked with a database consistent with IMAGE. In order to coordinate activities between LEI Wageningen UR and PBL it is important to have a consistent land use and land availability database. Therefore, the differences between the two databases must be checked, and the SAGE database must be corrected for the information we get from PBL. In first instance it seems logic to scale the SAGE data towards the IMAGE data. We should get the IMAGE data at the lowest possible level so that it can be easily scaled. The scaling procedure used must be programmed, so it can be switched on or off.

Investigation of the CET function

The simulation results show again that the CET function to model substitution between different land uses generates perverse effects. This CET mechanism is used in most general equilibrium models, but a more realistic approach has to be found to deal with this problem.

Adding greenhouse gas information

The GTAP land use database also has greenhouse gasses included. In order to do sustainability analysis, this should be included in the MAGNET system, too. Again, the consistency between this database and the database used at PBL should be checked and made consistent.

Forestry harvests versus forests

At the moment forestry is handled in the same way as normal agriculture. But when a forest is planted, it requires a very long period before the forest can be harvested. The question is how to handle this discrepancy. First, it may be checked how they are doing this in Purdue. Then we may investigate to what extent differences in forest age can be seen as more or random, so not influencing the way it should be modeled, except for the moment profits emerge. The problem at least requires special attention.

A baseline

In order to investigate the plausibility of the implementation and to investigate the consequences of including forestry into the model, a baseline should be developed. This baseline should be consistent with the standard baseline at LEI Wageningen UR, but with the forestry sector explicitly included. Extra attention should be given to the demand for forestry products and how to model this.

3.5 Conclusion

A large part of the work done till now includes the understanding of the GTAP land use database, and the development of a simple modeling approach, including the programming of procedures to integrate forestry in an automatized way in both the MAGNET model implementation and the creation of the MAGNET database. The challenge was to influence the current implementation of the model as little as possible, and this has been successful. The next step will be to think over the fundamental mechanisms that are at hand with respect to the processes of deforestation, substitution between different land uses, and the intensification of land use, both in forestry and agriculture. This will be the challenge of the research in 2011.

4 Final conclusions

Chapter 2 has shown what data is available and how they have been constructed. Chapter 3 shows how the data has been implemented in the MAGNET model and has also shown that the data is behaving as expected. There are, throughout both chapters, many opportunities to improve both the data and the modelling of the data. To finish off this report, it is useful to consider what practical, policy issues can be addressed by the work which has already been carried out and where these issues cannot currently be addressed, what needs to be done in order to do so.

Initially, MAGNET needs to be fully implemented before it can be used for scenario analysis. Once this is complete, the updated MAGNET will be able to answer such questions as:

- How will the agricultural and forestry sector interact and compete for land?
- How will accounting for forestry change agricultural expansion and deforestation (with and with REDD (Reducing Emissions from Deforestation and Forest Degradation) measures)?
- To what extent will the demand for in different world regions be provided by their own production, or by international trade?

Further questions require the data that has been the topic of this report, but in addition, also require other information. These are shown in Table 10.

Table 10. Possible analyses and further requirements

Question	Requirement
How much land will be required in the future for forestry, to supply wood, paper and fuel wood for larger and wealthier world populations?	To make this reliable, it requires more detailed information about forest products to be fed into the consumption
How can plantation establishment play a role in increasing the land use efficiency of the forest sector?	Input from IMAGE is required. MAGNET can then be used to see what the effects of increasing land use efficiency are.
How much biodiversity can be maintained under different forestry development scenarios (with different contributions of silvicultural systems)?	MAGNET cannot provide information of biodiversity directly. Information about land use from MAGNET may be used in IMAGE and GLOBIO to shed light on this type of problem.
How much carbon will be stored will be stored in forests under different forestry development scenarios (with different contributions of silvicultural systems)?	When carbon information is implemented in MAGNET this can be partly dealt with, but probably it is best to calculate the carbon storage consequences by using the IMAGE model.

References

(All GTAP sources are available from https://www.gtap.agecon.purdue.edu/)

Avetisyan, M., Baldos, U. and Hertel, T.W. (2010). *Development of the GTAP Version 7 Land Use Data Base*. GTAP Research Memorandum No. 19.

FAOSTAT (2004). Data available at http://apps.fao.org.

Gouel, C. and Hertel, T.W. (2006). *Introducing Forest Access Cost Functions into a General Equilibrium Model.* GTAP Research Memorandum No. 8

Haxeltine, A. and Colin, P.I. (2006). 'BIOME3: An equilibrium terrestrial biosphere model based on ecophysiological constraints, resource availability, and competition among plant functional types.' *Global Biogeochemical Cycles*, Volume 10, Issue 4, p. 693-710.

Lee, H-L., Hertel, T.W., Rose, S. and Avetisyan, M. (2008). *An integrated global land use data base for GCE analysis of climate change policy options*. GTAP working paper No. 42.

Lee, H-L., Sohngen, B., Hertel, T., Ramankutty, N. (2005). *Towards an integrated land use data base for assessing the potential for Greenhouse Gas Mitigation.* GTAP Technical Paper, No. 25.

Monfreda, C., Ramankutty, N. and Foley, J.A. (2008). 'Farming the Planet 2: The Geographic Distribution of Crop Areas and Yields in the Year 2000.' *Global Biochemical Cycles.* Vol. 22(1).

OECD, The Netherlands Environmental Assessment Agency (2008). Background report to the OECD Environmental Outlook to 2030. http://www.rivm.nl/bibliotheek/rapporten/500113001.pdf

Ramankutty, N. and Foley, J.A., 1999. 'Estimating Historical Changes in Global Land Cover: Croplands from 1700 to 1992.' *Global Biochemical Cycles.* Vol. 11(5)

Sohngen, B., and Tennity, C., 2004. *Country Specific Global Forest Data Set V.1*. *memo.* Department of Agricultural, Environmental, and Development Economics, Ohio State University, Columbus, OH 43210, U.S.A.

Sohngen, B., Mendelsohn, R. and Sedjo, R., 1999. 'Forest Management, Conservation, and Global Timber Markets.' *American Journal of Agricultural Economics*. Vol. 81(1)

Appendix 1 Agro-Ecological Zones (AEZs)

AEZ refers to the segmentation of a parcel of land into smaller units according to agro-ecological characteristics, e.g. moisture and temperature regimes, soil type, landform etc. Accordingly, each zone has a similar combination of constraints and potentials for land use. The dataset of Lee *et al* (2005) defines AEZ according to Length of Growing Period (LGP) per year and climatic zones. There are 6 LGP categories, each of 60 days – thus, category 1 has a period of 0-59 days and so on. Overlapping areas defined on LGP with the 3 climatic zones (tropical, temperate and boreal) produces 18 AEZs. Within each AEZ there are consistent constraints and potentials for land use.

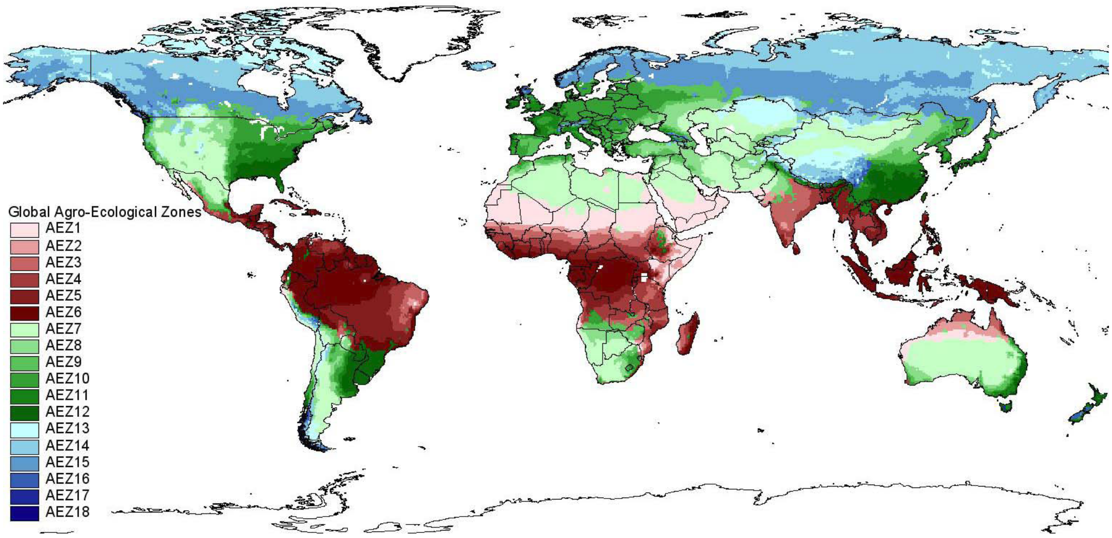

Figure 1: Global AEZs (Lee et al, 2005)

1. Working with AEZs requires different restrictions for different AEZs, creating less flexibility than there is in reality.
2. AEZs have jumps in productivity if you go from one AEZ to another; the real world is more gradual.
3. AEZs make calculations more complicated.

Verschenen documenten in de reeks Werkdocumenten van de Wettelijke Onderzoekstaken Natuur & Milieu vanaf 2009

Werkdocumenten zijn verkrijgbaar bij het secretariaat van Unit Wettelijke Onderzoekstaken Natuur & Milieu, te Wageningen. T 0317 – 48 54 71; F 0317 – 41 90 00; E info.wnm@wur.nl.
De werkdocumenten zijn ook te downloaden via de WOt-website www.wotnatuurenmilieu.wur.nl.

2009

126 *Kamphorst, D.A.* Keuzes in het internationale biodiversiteitsbeleid; Verkenning van de beleidstheorie achter de internationale aspecten van het Beleidsprogramma Biodiversiteit (2008-2011)
127 *Dirkx, G.H.P. & F.J.P. van den Bosch.* Quick scan gebruik Catalogus groenblauwe diensten
128 *Loeb, R. & P.F.M. Verdonschot.* Complexiteit van nutriëntenlimitaties in oppervlaktewateren
129 *Kruit, J. & P.M. Veer.* Herfotografie van landschappen; Landschapsfoto's van de 'Collectie de Boer' als uitgangspunt voor het in beeld brengen van ontwikkelingen in het landschap in de periode 1976-2008
130 *Oenema, O., A. Smit & J.W.H. van der Kolk.* Indicatoren Landelijk Gebied; werkwijze en eerste resultaten
131 *Agricola, H.J.A.J. van Strien, J.A. Boone, M.A. Dolman, C.M. Goossen, S. de Vries, N.Y. van der Wulp, L.M.G. Groenemeijer, W.F. Lukey & R.J. van Til.* Achtergrond-document Nulmeting Effectindicatoren Monitor Agenda Vitaal Platteland
132 *Jaarrapportage 2008.* WOT-04-001 – Koepel
133 *Jaarrapportage 2008.* WOT-04-002 – Onderbouwend Onderzoek
134 *Jaarrapportage 2008.* WOT-04-003 – Advisering Natuur & Milieu
135 *Jaarrapportage 2008.* WOT-04-005 – M-AVP
136 *Jaarrapportage 2008.* WOT-04-006 – Natuurplanbureaufunctie
137 *Jaarrapportage 2008.* WOT-04-007 – Milieuplanbureaufunctie
138 *Jong de, J.J., J. van Os & R.A. Smidt.* Inventarisatie en beheerskosten van landschapselementen
139 *Dirkx, G.H.P., R.W. Verburg & P. van der Wielen.* Tegenkrachten Natuur. Korte verkenning van de weerstand tegen aankopen van landbouwgrond voor natuur
140 *Annual reports for 2008; Programme WOT-04*
141 *Vullings, L.A.E., C. Blok, G. Vonk, M. van Heusden, A. Huisman, J.M. van Linge, S. Keijzer, J. Oldengarm & J.D. Bulens.* Omgaan met digitale nationale beleidskaarten
142 *Vreke, J.,A.L. Gerritsen, R.P. Kranendonk, M. Pleijte, P.H. Kersten & F.J.P. van den Bosch.* Maatlat Government – Governance
143 *Gerritsen, A.L., R.P. Kranendonk, J. Vreke, F.J.P. van den Bosch & M. Pleijte.* Verdrogingsbestrijding in het tijdperk van het Investeringsbudget Landelijk Gebied. Een verslag van casusonderzoek in de provincies Drenthe, Noord-Brabant en Noord-Holland.
144 *Luesink, H.H., P.W. Blokland, M.W. Hoogeveen & J.H. Wisman.* Ammoniakemissie uit de landbouw in 2006 en 2007
145 *Bakker de, H.C.M. & C.S.A. van Koppen.* Draagvlakonderzoek in de steigers. Een voorstudie naar indicatoren om maatschappelijk draagvlak voor natuur en landschap te meten
146 *Goossen, C.M.,* Monitoring recreatiegedrag van Nederlanders in landelijke gebieden. Jaar 2006/2007
147 *Hoefs, R.M.A., J. van Os & T.J.A. Gies.* Kavelruil en Landschap. Een korte verkenning naar ruimtelijke effecten van kavelruil.
148 *Klok, T.L., R. Hille Ris Lambers, P. de Vries, J.E. Tamis & J.W.M. Wijsman.* Quick scan model instruments for marine biodiversity policy.
149 *Spruijt, J., P. Spoorenberg & R. Schreuder.* Milieueffectiviteit en kosten van maatregelen gewasbescherming.
150 *Ehlert, P.A.I. (rapporteur)*. Advies Bemonstering bodem voor differentiatie van fosfaatgebruiksnormen.
151 *Wulp van der, N.Y.* Storende elementen in het landschap: welke, waar en voor wie? Bijlage bij WOt-paper 1 – Krassen op het landschap
152 *Oltmer, K., K.H.M. van Bommel, J. Clement, J.J. de Jong, D.P. Rudrum & E.P.A.G. Schouwenberg.* Kosten voor habitattypen in Natura 2000-gebieden. Toepassing van de methode Kosteneffectiviteit natuurbeleid.
153 *Adrichem van, M.H.C., F.G. Wortelboer & G.W.W. Wamelink* ***(2010).*** MOVE. Model for terrestrial Vegetation. Version 4.0
154 *Wamelink, G.W.W., R.M. Winkler & F.G. Wortelboer.* User documentation MOVE4 v 1.0
155 *Gies de, T.J.A., L.J.J. Jeurissen, I. Staritsky & A. Bleeker.* Leefomgevingsindicatoren Landelijk gebied. Inventarisatie naar stand van zaken over geurhinder, lichthinder en fijn stof.
156 *Tamminga, S., A.W. Jongbloed, P. Bikker, L. Sebek, C. van Bruggen & O. Oenema.* Actualisatie excretiecijfers landbouwhuisdieren voor forfaits regeling Meststoffenwet
157 *Van der Salm, C., L. .M. Boumans, G.B.M. Heuvelink & T.C. van Leeuwen.* Protocol voor validatie van het nutriëntenemissiemodel STONE op meetgegevens uit het Landelijk Meetnet effecten Mestbeleid
158 *Bouwma, I.M.* Quickscan Natura 2000 en Programma Beheer. Een vergelijking van Programma Beheer met de soorten en habitats van Natura 2000
159 *Gerritsen, A.L., D.A. Kamphorst, T.A. Selnes, M. van Veen, F.J.P.van den Bosch, L. van den Broek, M.E.A. Broekmeyer, J.L.M. Donders, R.J. Fontein, S. van Tol, G.W.W. Wamelink & P. van der Wielen.* Dilemma's en barrières in de praktijk van het natuur- en landschapsbeleid; Achtergronddocument bij Natuurbalans 2009.
160 *Fontein R.J, T.A. de Boer, B. Breman, C.M. Goossen, R.J.H.G. Henkens, J. Luttik & S. de Vries.* Relatie recreatie en natuur; Achtergronddocument bij Natuurbalans 2009
161 *Deneer, J.W. & R. Kruijne.* ***(2010).*** Atmosferische depositie van gewasbeschermingsmiddelen. Een verkenning van de literatuur verschenen na 2003.
162 *Verburg, R.W., M.E. Sanders, G.H.P. Dirkx, B. de Knegt & J.W. Kuhlman.* Natuur, landschap en landelijk gebied. Achtergronddocument bij Natuurbalans 2009.
163 *Doorn van, A.M. & M.P.C.P. Paulissen.* Natuurgericht milieubeleid voor Natura 2000-gebieden in Europees perspectief: een verkenning.
164 *Smidt, R.A., J. van Os & I. Staritsky.* Samenstellen

van landelijke kaarten met landschapselementen, grondeigendom en beheer. Technisch achtergronddocument bij de opgeleverde bestanden.

165 *Pouwels, R., R.P.B. Foppen, M.F. Wallis de Vries, R. Jochem, M.J.S.M. Reijnen & A. van Kleunen,* Verkenning LARCH: omgaan met kwaliteit binnen ecologische netwerken.

166 *Born van den, G.J., H.H. Luesink, H.A.C. Verkerk, H.J. Mulder, J.N. Bosma, M.J.C. de Bode & O. Oenema,* Protocol voor monitoring landelijke mestmarkt onder een stelsel van gebruiksnormen, versie 2009.

167 *Dijk, T.A. van, J.J.M. Driessen, P.A.I. Ehlert, P.H. Hotsma, M.H.M.M. Montforts, S.F. Plessius & O. Oenema.* Protocol beoordeling stoffen Meststoffenwet- Versie 2.1

168 *Smits, M.J., M.J. Bogaardt, D. Eaton, A. Karbauskas & P. Roza.* De vermaatschappelijking van het Gemeenschappelijk Landbouwbeleid. Een inventarisatie van visies in Brussel en diverse EU-lidstaten.

169 *Vreke, J. & I.E. Salverda.* Kwaliteit leefomgeving en stedelijk groen.

170 *Hengsdijk, H. & J.W.A. Langeveld.* Yield trends and yield gap analysis of major crops in the World.

171 *Horst, M.M.S. ter & J.G. Groenwold.* Tool to determine the coefficient of variation of DegT50 values of plant protection products in water-sediment systems for different values of the sorption coefficient

172 *Boons-Prins, E., P. Leffelaar, L. Bouman & E. Stehfest (2010)* Grassland simulation with the LPJmL model

173 *Smit, A., O. Oenema & J.W.H. van der Kolk.* Indicatoren Kwaliteit Landelijk Gebied

2010

174 *Boer de, S., M.J. Bogaardt, P.H. Kersten, F.H. Kistenkas, M.G.G. Neven & M. van der Zouwen.* Zoektocht naar nationale beleidsruimte in de EU-richtlijnen voor het milieu- en natuurbeleid. Een vergelijking van de implementatie van de Vogel- en Habitatrichtlijn, de Kaderrichtlijn Water en de Nitraatrichtlijn in Nederland, Engeland en Noordrijn-Westfalen

175 *Jaarrapportage 2009.* WOT-04-001 – Koepel

176 *Jaarrapportage 2009.* WOT-04-002 – Onderbouwend Onderzoek

177 *Jaarrapportage 2009.* WOT-04-003 – Advisering Natuur & Milieu

178 *Jaarrapportage 2009.* WOT-04-005 – M-AVP

179 *Jaarrapportage 2009.* WOT-04-006 – Natuurplanbureaufunctie

180 *Jaarrapportage 2009.* WOT-04-007 – Milieuplanbureaufunctie

181 *Annual reports for 2009; Programme WOT-04*

182 Oenema, O., *P. Bikker, J. van Harn, E.A.A. Smolders, L.B. Sebek, M. van den Berg, E. Stehfest & H. Westhoek.* Quickscan opbrengsten en efficiëntie in de gangbare en biologische akkerbouw, melkveehouderij, varkenshouderij en pluimveehouderij. Deelstudie van project 'Duurzame Eiwitvoorziening'.

183 *Smits, M.J.W., N.B.P. Polman & J. Westerink*. Uitbreidingsmogelijkheden voor groene en blauwe diensten in Nederland; Ervaringen uit het buitenland

184 *Dirkx, G.H.P. (red.).* Quick responsefunctie 2009. Verslag van de werkzaamheden.

185 *Kuhlman, J.W., J. Luijt, J. van Dijk, A.D. Schouten & M.J. Voskuilen.* Grondprijskaarten 1998-2008

186 *Slangen, L.H.G., R.A. Jongeneel, N.B.P. Polman, E. Lianouridis, H. Leneman & M.P.W. Sonneveld.* Rol en betekenis van commissies voor gebiedsgericht beleid.

187 *Temme, A.J.A.M. & P.H. Verburg.* Modelling of intensive and extensive farming in CLUE

188 *Vreke, J.* Financieringsconstructies voor landschap

189 *Slangen, L.H.G.* Economische concepten voor beleidsanalyse van milieu, natuur en landschap

190 *Knotters, M., G.B.M. Heuvelink, T. Hoogland & D.J.J. Walvoort.* A disposition of interpolation techniques

191 *Hoogeveen, M.W., P.W. Blokland, H. van Kernebeek, H.H. Luesink & J.H. Wisman.* Ammoniakemissie uit de landbouw in 1990 en 2005-2008

192 *Beekman, V., A. Pronk & A. de Smet.* De consumptie van dierlijke producten. Ontwikkeling, determinanten, actoren en interventies.

193 *Polman, N.B.P., L.H.G. Slangen, A.T. de Blaeij, J. Vader & J. van Dijk.* Baten van de EHS; De locatie van recreatiebedrijven

194 *Veeneklaas, F.R. & J. Vader.* Demografie in de Natuurverkenning 2011; Bijlage bij WOt-paper 3

195 *Wascher, D.M., M. van Eupen, C.A. Mücher & I.R. Geijzendorffer,* Biodiversity of European Agricultural landscapes. Enhancing a High Nature Value Farmland Indicator

196 *Apeldoorn van, R.C., I.M. Bouwma, A.M. van Doorn, H.S.D. Naeff, R.M.A. Hoefs, B.S. Elbersen & B.J.R. van Rooij.* Natuurgebieden in Europa: bescherming en financiering

197 *Brus, D.J.,, R. Vasat, G. B. M. Heuvelink, M. Knotters, F. de Vries & D. J. J. Walvoort.* Towards a Soil Information System with quantified accuracy; A prototype for mapping continuous soil properties

198 *Groot, A.M.E.& A.L. Gerritsen, m.m.v. M.H. Borgstein, E.J. Bos & P. van der Wielen.* Verantwoording van de methodiek Achtergronddocument bij 'Kwalitatieve monitor Systeeminnovaties verduurzaming landbouw'

199 *Bos, E.J. & M.H. Borgstein.* Monitoring Gesloten voer-mest kringlopen. Achtergronddocument bij 'Kwalitatieve monitor Systeeminnovaties verduurzaming landbouw'

200 *Kennismarkt 27 april 2010;* Van onderbouwend onderzoek Wageningen UR naar producten Planbureau voor de Leefomgeving.

201 *Wielen van der, P.* Monitoring Integrale duurzame stallen. Achtergronddocument bij 'Kwalitatieve monitor Systeeminnovaties verduurzaming landbouw'

202 *Groot, A.M.E.& A.L. Gerritsen.* Monitoring Functionele agrobiodiversiteit. Achtergronddocument bij 'Kwalitatieve monitor Systeeminnovaties verduurzaming landbouw'

203 *Jongeneel, R.A. & L. Ge.* Farmers' behavior and the provision of public goods: Towards an analytical framework.

204 *Vries, S. de, M.H.G. Custers & J. Boers.* Storende elementen in beeld; de impact van menselijke artefacten op de landschapsbeleving nader onderzocht.

205 *Vader, J. J.L.M. Donders & H.W.B. Bredenoord*. Zicht op natuur- en landschapsorganisaties; Achtergronddocument bij Natuurverkenning 2011.

206 *Jongeneel, R.A., L.H.G. Slangen & N.B.P. Polman.* Groene en Blauwe Diensten; Een raamwerk voor de analyse van doelen, maatregelen en instrumenten

207 *Letourneau, A.P, P.H. Verburg & E. Stehfest.* Global change of land use systems; IMAGE: a new land allocation module

208 *Heer, M. de.* Het Park van de Toekomst. Achtergronddocument bij Natuurverkenning 2011

209 *Knotters, M., J. Lahr, A.M. van Oosten-Siedlecka & P.F.M. Verdonschot.* Aggregation of ecological indicators for mapping aquatic nature quality. Overview of existing methods and case studies.

210 *Verdonschot, P.F.M. & A.M. van Oosten-Siedlecka Graadmeters Aquatische natuur. Analyse gegevenskwaliteit Limnodata*

211 *Linderhof, V.G.M. & Hans Lenema. Quickscan kosteneffectiviteitsanalyse aquatische natuur*

212 *Leneman, H. V.G.M. Linderhof & R. Michels. Mogelijkheden voor het inbrengen van informatie uit de 'KRW database' in de 'KE database'*

213 *Schrijver, R.A.M., A. Corporaal, W.A. Ozinga & D. Rudrum. Kosteneffectieve natuur in landbouwgebieden; Methode om effecten van maatregelen voor de verhoging van biodiversiteit in landbouwgebieden te bepalen, een test in twee gebieden in Noordoost-Twente en West-Zeeuws-Vlaanderen*

214 *Hoogland, T., R.H. Kemmers, D.G. Cirkel & J. Hunink.* Standplaatsfactoren afgeleid van hydrologische model uitkomsten; Methode-ontwikkeling en toetsing in het Drentse Aa-gebied.

215 *Agricola, H.J., R.M.A. Hoefs, A.M. van Doorn, R.A. Smidt & J. van Os.* Landschappelijke effecten van ontwikkelingen in de landbouw

216 *Kramer, H., J. Oldengarm en L.F.S. Roupioz.* Nederland is groener dan kaarten laten zien; Mogelijkheden om 'groen' beter te inventariseren en monitoren met de automatische classificatie van digitale luchtfoto's

217 *Raffe, J.K. van, J.J. de Jong & G.W.W. Wamelink **(2011).*** Scenario's voor de kosten van natuurbeheer en stikstofdepositie; Kostenmodule v 1.0 voor de Natuurplanner.

218 *Hazeu, G.W., Kramer, H., J. Clement & W.P. Daamen (2011).* Basiskaart Natuur 1990rev

219 *Boer, T.A. de.* Waardering en recreatief gebruik van Nationale Landschappen door haar bewoners

220 *Leneman, H., A.D. Schouten & R.W. Verburg.* Varianten van natuurbeleid: voorbereidende kostenberekeningen; Achtergronddocument bij Natuurverkenning 2011

221 *Knegt, B. de, J. Clement, P.W. Goedhart, H. Sierdsema, Chr. van Swaay & P. Wiersma.* Natuurkwaliteit van het agrarisch gebied

2011

222 *Kamphorst, D.A. en M.M.P. van Oorschot*. Kansen en barrières voor verduurzaming van houtketens

223 *Salm, C. van der en O.F. Schoumans.* Langetermijneffecten van verminderde fosfaatgiften

224 *Bikker, P., M.M. van Krimpen & G.J. Remmelink.* Stikstof-verteerbaarheid in voeders voor landbouwhuisdieren; Berekeningen voor de TAN-excretie

225 *M.E. Sanders & A.L. Gerritsen (red.). Het biodiversiteitsbeleid in Nederland werkt;* Achtergronddocument bij Balans van de Leefomgeving 2010

226 *Bogaart, P.W., G.A.K. van Voorn & L.M.W. Akkermans.* Evenwichtsanalyse modelcomplexiteit; een verkennende studie

227 *Kleunen A. van, K. Koffijberg, P. de Boer, J. Nienhuis, C.J. Camphuysen, H. Schekkerman, K.H. Oosterbeek, M.L. de Jong, B. Ens & C.J. Smit **(2010).*** Broedsucces van kustbroedvogels in de Waddenzee in 2007 en 2008

228 *Salm, C. van der, L.J.M. Boumans, D.J. Brus, B. Kempen & T.C van Leeuwen.* Validatie van het nutriëntenemissiemodel STONE met meetgegevens uit het Landelijk Meetnet effecten Mestbeleid (LMM) en de Landelijke Steekproef Kaarteenheden (LSK).

229 *Dijkema, K.S., W.E. van Duin, E.M. Dijkman, A. Nicolai, H. Jongerius, H. Keegstra, L. van Egmond, H.J. Venema en J.J. Jongsma*. Vijftig jaar monitoring en beheer van de Friese en Groninger kwelderwerken: 1960-2009.

230 *Jaarrapportage 2010.* WOT-04-001 – Koepel

231 *Jaarrapportage 2010.* WOT-04-002 – Onderbouwend Onderzoek

232 *Jaarrapportage 2010.* WOT-04-003 – Advisering Natuur & Milieu

233 *Jaarrapportage 2010.* WOT-04-005 – M-AVP

234 *Jaarrapportage 2010.* WOT-04-006 – Natuurplanbureaufunctie

235 *Jaarrapportage 2010.* WOT-04-007 – Milieuplanbureaufunctie

236 *Arnouts, R.C.M. & F.H. Kistenkas*. Nederland op slot door Natura 2000: de discussie ontrafeld; Bijlage bij WOt-paper 7 – De deur klemt

237 *Harms, B. & M.M.M. Overbeek*. Bedrijven aan de slag met natuur en landschap; relaties tussen bedrijven en natuurorganisaties. Achtergrond-document bij Natuurverkenning 2011

238 *Agricola, H.J. & L.A.E. Vullings.* De stand van het platteland 2010. Monitor Agenda Vitaal Platteland; Rapportage Midterm meting Effectindicatoren

239 *Klijn, J.A.* Wisselend getij. Omgang met en beleid voor natuur en landschap in verleden en heden; een essayistische beschouwing. Achtergronddocument bij Natuurverkenning 2011

240 *Corporaal, A., T. Denters, H.F. van Dobben, S.M. Hennekens, A. Klimkowska, W.A.Ozinga, J.H.J.Schamineé en R.A.M. Schrijve*). Stenoeciteit van de Nederlandse flora. Een nieuwe parameter op grond van amplitudo's van de Nederlandse plantensoorten en toepassingsmogelijkheden

241 *Wamelink, G.W.W., R. Jochem, J. van der Greft, C. Grashof-Bokdam, R.M.A. Wegman, G.J. Franke & A.H. Prins.* Het plantendispersiemodel DIMO ter verbetering van de modellering in de Natuurplanner.

242 *Klimkowska, A., M.H.C. van Adrichem, J.A.M. Jansen & G.W.W. Wamelink.* Bruikbaarheid van WNK-monitoringgegevens voor EC-rapportage voor Natura 2000-gebieden. Eerste fase.

243 *Goossen, C.M., R.J. Fontein, J.L.M. Donders & R.C.M. Arnouts.* Mass Movement naar recreatieve gebieden; Overzicht van methoden om bezoekersaantallen te meten.

244 *Spruijt, J., P.M. Spoorenberg, J.A.J.M. Rovers, J.J. Slabbekoorn, S.A.M. de Kool, M.E.T. Vlaswinkel, B. Heijne, J.A. Hiemstra, F. Nouwens, B.J. van der Sluis.* Milieueffecten van maatregelen gewasbescherming

245 *Walker, A.N. & G.B. Woltjer.* Forestry in the Magnet model.

246 *Hoefnagel, E.W.J., F.C. Buisman, J.A.E. van Oostenbrugge & B.I. de Vos.* Een duurzame toekomst voor de Nederlandse visserij. Toekomstscenario's 2040.