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Defining agricultural and forestry systems in econometric land use models: Some critical reflections

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Summary

The paper discusses the way pastoral and forestry systems are defined in econometric land use modelling on a national level. It briefly reviews the relevant data bases and modelling tools. Above all, it reflects on the questions asked and information needed in the work of the Ministry of Agriculture and Forestry (MAF) Policy. The paper presents the first results of a working group about the key policy questions related to land use and land use change and the adequacy of the related analyses and modelling approaches.

1 Introduction

1.1 Land use systems in New Zealand

Land is a finite resource. The allocation of an area to specific land use systems such as dairy, horticulture or forestry excludes other options of land use. "Farmers, growers and foresters have the ultimate responsibility for managing land." (MAF, 2002) Land use systems differ in their flexibility to change as a result of the local conditions, the farmer's skills, the phenomenon of path dependency in agriculture and long term investment strategies. The decisions on actual and future land use reflect the specific socio-economic, market and natural conditions. There are no legal or policy regulations which farmers have to consider when grassland is converted into plantation forests or arable land and vice versa. As a result, management decisions of a large number of individuals determine both, the actual land use type (dairy, forestry, sheep/beef etc), and the management system (intensive versus low intensity dairy) of New Zealand's land area. This is different to many countries such as the European Union member states, where farmers face restrictions regarding a conversion from permanent pasture into arable land (Council Regulation (EC) 1782/2003, Article 5). Afforestation requires permission from the local authority.

The work of government agencies such as the Ministry of Agriculture and Forestry (MAF) or the Ministry for the Environment (MfE) require quantitative and qualitative information about actual land use, as well as possible land-use changes. Sometimes these changes are a response to alterations in policy frameworks (e.g. MAF 2006).

Defining agricultural and forestry systems in terms of the land use in econometric models is challenging due to the complexity of the task. This paper reflects on pastoral land uses, especially dairy systems and highlights the importance of assumptions and limitations for the interpretation and the final use of modelling results.

1.2 Purpose of the analysis

The paper discusses the interrelation between farming and forestry reality, modelling approaches that reflect the reality in a simplified way and the leading policy questions on land use and land use changes on a national level. It will briefly review the relevant data bases and modelling approaches - mainly in relation to MAF Policy information needs.

The analysis will identify the key questions that agricultural administrations and policy makers are asking. These key questions need to inform the development of econometric models and specifically the elaboration of the land use modules they comprise.

Pastoral systems are inherently complex – in terms of their varied outputs (like milk, lamb, beef or venison), the external factors that influence the systems such as soil, water, climate and fertiliser and, even more challenging, feedback loops such as the impact of land use patterns and management practices impacts on the productivity of the land.

Transparency regarding assumptions and limitations is essential in the communication of modelling results. The paper discusses some critical assumptions that relate to the modelling of land use changes. A connection with the initially asked policy questions is to be made.

1.3 Methodology

The paper is based on a review of the available land use models that cover New Zealand's land use on a national level and a consultancy process within the teams of MAF Policy focussed on identifying key questions on land use and land use changes. The consultation also aims at illuminating the related understanding and exploring the common ground. The purpose of the process is to agree on the most relevant question(s) and, based on that, on the most appropriate quantitative and qualitative analytical tools. The working group is still ongoing.

1.4 Relevance of the conference contribution

The conference provides an opportunity to discuss (a) the key land use questions and (b) the implications for the related modelling activities with the scientific community of NZARES. The results of the discussion will contribute to the ongoing MAF Policy working group on land use issues and they will also feed into the further development of MAF Policy's strategy on national level land use modelling tools.

The following section summarises some key results of the MAF internal consultancy process on land use and land use changes in July and August 2010 (chapter 2). Chapter 3 gives a short overview of the available data series, data related problems and the modelling approaches that are available for the analysis of land use changes in New Zealand's farm land and forestry area. In chapter 4, the paper outlines some of the challenges researchers are facing when modelling agricultural and forestry land use.

2 MAF Policy working group on land use information

The MAF Policy working group ran over a ten week period. It was undertaken by the Monitoring and Evaluation team which provides data and analysis internally when the other MAF Policy teams address specific enquiries.

2.1 Concept of the process

MAF Policy is involved in several projects focussing on the current and potential future land use on a national level. The results of these projects tend to be ambiguous. Underlying assumptions and restriction in model based projects differ. Moreover, values of data series on land use are not standardised internally.

Land use and land use change issues relate to several work fields in MAF Policy:

- The team with responsibility for data, information and analysis does forecasting of agricultural and forestry production and contributes to the national GHG inventory
- Research projects that relate to Greenhouse Gas (GHG) emissions
- Diverse topics at a policy level such as
  - Implications of changing agricultural production systems as a result of changing price and cost structure (dairy intensification, dairy versus beef/sheep, tillable and non-tillable land, agriculture and afforestation)
  - Natural environment - water policy (and nexus with climate change, water, energy and its implications of food security)
  - International obligations – Kyoto process, ETS
  - Financial issues, e.g. indebtedness, land prices.

Purpose of the MAF Policy internal process:

- Enhancing transparency and understanding of the actual land use questions within MAF Policy and the related methodological approaches
- Identifying potential changes and areas of policy concern
- Informing the future strategy on data and information in terms of methodological tools (models, data series) and supporting the upcoming review and evaluation processes

Figure 1 shows the fields of interest of this analysis. The MAF internal consultancy process aimed to enhance understanding of the linkages between farming and forestry reality, data series and models on land use and the needs of the policy teams on data and model calculations.

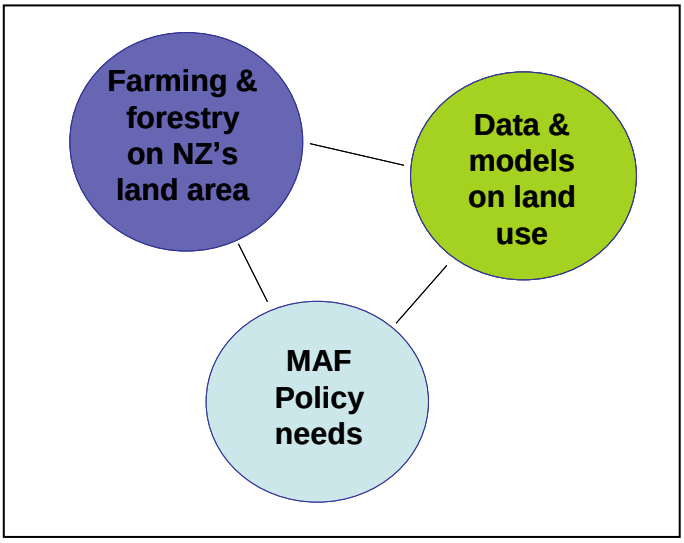


Figure 1: Related areas of concern in the consultancy process on land use questions

Results of the working group:

The information needs related to land use and land use changes as they are listed in the following section do not necessarily represent the author's perspective. MAF policy staff who contributed to the process, will be not cited individually either. The presentation of the results of the working group is intended to cover the wide range of perceptions on land use issues internally, and for that reason, they don't represent an elaborated strategy yet.

Three main areas of concern appeared to be highly relevant for the work in policy.

First, data and information on actual land use is available but the quality is often not good enough to answer specific enquiries appropriately. Therefore MAF Policy teams identified several needs related to land use data:

- Detailed information on land use and its different dimensions e.g. on the ownership of the land - policy interventions might impact differently on Maori and Non-Maori land
- Work towards better alignment between datasets and research activities
- Alignment of available data with international reporting requirements e.g. distinction between pre-1990 and post-1989 forest (Kyoto Protocol)

There are different options to classify land use data e.g. by land cover, state of environmental protection, ownership, ecological characteristics (biodiversity, carbon cycle) or by the supply of products and services.

Several agencies are actually working on an improvement of land use data for New Zealand (MfE, Landcare Research, MAF etc). In contrast to other data fields such as demography, health or transport, Statistics New Zealand is not responsible for land use data management. The process of GHG reporting has strengthened the position of MfE in this field of data collection.

Second, policy teams quite often face questions related to the most appropriate type of land use in a particular location or the relative benefits of a particular land use option. These are questions like "Where will afforestation impact positively on the environment and where negatively on the communities?" or "Where will future dairy farming be most efficient?" The latter question relates to potential public support of new irrigation schemes. If governmental agencies are asked to intervene, the need for information on land use dynamics becomes evident. Aspects of efficiency, good management practices on the farm level and overarching policy goals constitute this second area of concern.

The third aspect which MAF policy teams identified as important focuses on policy evaluation and the related internal mechanisms. The key question is: "Will our policy interventions drive the development in the direction we want?"

In terms of the practical aspects of land use and land use change issues, the teams mentioned that it is crucial to their work;

- to have direct access to data and the modelling tools
- to improve communication between different agencies and to link activities
- to have appropriate, credible and defensible data and analysis available (metadata and basic knowledge about the used systems and approaches must be available for everyone)
- to have the opportunity to tailor the programming of the model to what is needed in the specific case
- to ensure verification
- to have a clear commitment to the activity (funding, management etc).

During the process the teams identified several other constraints:

- A stocktaking of available data and analyses is missing.
- Linking spatial data and time series data would be helpful.
- The public sector is declining; reduced funding is available.
- Daily work is overwhelming; there is little space for strategic processes. Maybe, teams are too busy to avoid inconsistency in their engagement. The 'right' commitments in terms of work time investment might be different to the actual routines.
- Political environment was/is changing and work programmes are changing in it; sometimes without a sufficient strategic reorientation.

An engagement in land use data and modelling work should have a dedicated place in the work programmes; this position was broadly supported in a workshop.

MAF Policy teams formulated their needs related to land use change modelling approaches:

- There is a need for a MAF Policy wide model that can deliver a simple projection of land use changes between forestry, sheep and beef, and dairy farming. This model would respond to a range of policy and carbon price scenarios and have the ability to be spatially linked.
- There is a need for a MAF Policy model that can deliver simulated projections of land use change between forestry and anything else (and vice-versa). It would be good if team members could anticipate on- and off-site effects to check that policies are in place or available, to maximise positive effects and/or minimise/mitigate negative effects.
- There is a need for information that will help MAF policy teams to understand the capacity, limitations and potential of the land in order to enable them to provide better informed advice about new and innovative land uses.
- There is a need for information which is 'fit for purpose' and therefore directly useable. Some of this information has to reflect the international definitions of forests, forestry and other land uses. The functionality and clarity of the information is the key determinant of success. A high degree of comprehension is most easily measured by the ability to communicate the information externally.

The results of the working group on land use data and modelling reflect that MAF Policy teams work mainly in two areas; the GHG reporting driven by international commitments resulting from the Kyoto process, and water allocation and water quality issues. Water topics are underrepresented because team members involved in natural resource topics were less involved in the working group.

In general, MAF's work programmes and its funding of external research projects relate mainly to climate change issues (MAF 2008).

3 Data series and the modelling approaches

3.1 Land use data

There are several data series available that relate to land use in New Zealand:

- Land use mapping (MfE)
- Land Cover Data Base, LCDB (satellite pictures from 1996/97 and 2001/2002, 42 land cover classes)
- Land Use NZ, LUNZ = LCDB + Agribase survey data (Landcare, Motu))
- Land Use Capability, LUC, class I to VIII
- Agricultural Production Survey, APS (StatsNZ)
- Agribase (Asure Quality)
- FarmsOnLine (MAF Biosecurity, in preparation)
- Farm Monitoring (MAF)
- International comparisons.

MfE is responsible for environmental reporting in New Zealand. Land use data is closely related to all areas of environmental reporting, in particular water, erosion and GHG emissions. Therefore, MfE is widely involved in data issues around land use and land use changes. MfE maintains the national level land use mapping dataset. It represents the basis of many analyses related to land use and land use change in NZ. The classifications are based on imagery from ~1990 Landsat and 2008 Spot. Since then, only the forest land use classes have been updated. All non-forest classes are taken from the Land Cover Data Base 2.

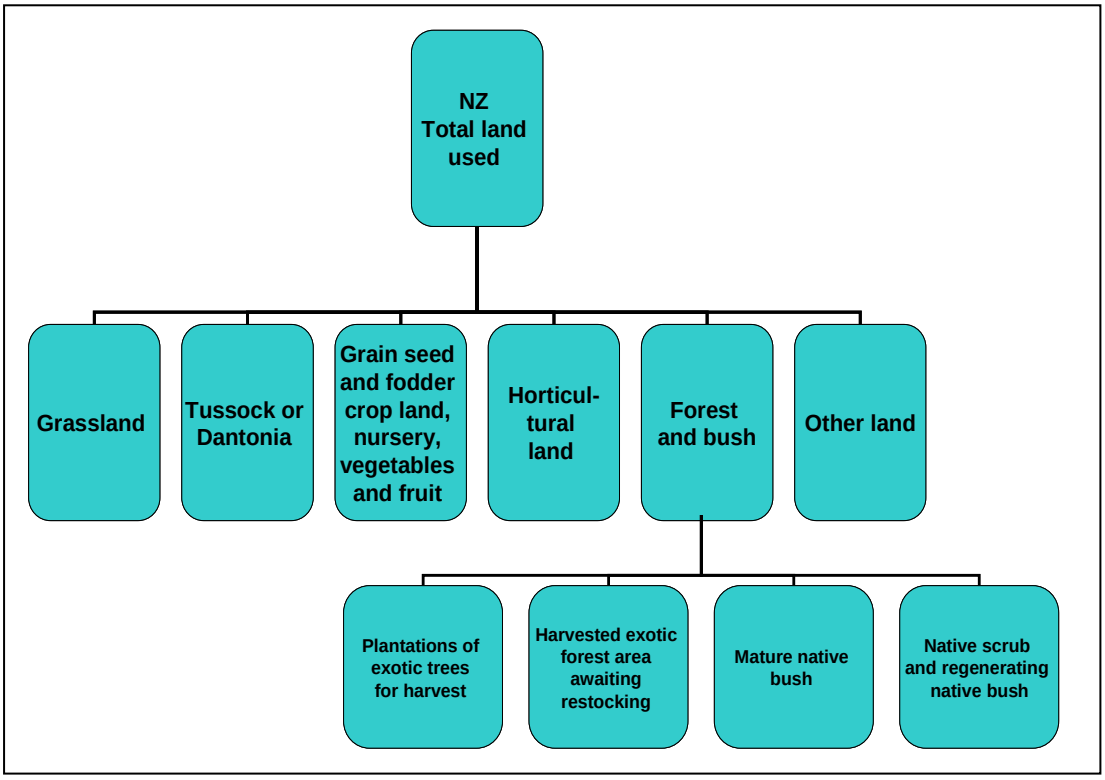
Land Cover Data Base (LCBD) is based on aerial photography. The entire area of New Zealand has been identified and classified into 43 types of land cover classes e.g. planted forest, indigenous forest, horticulture and pasture (Terralink International, 2010). Land cover information is different to the land use. A forestry area, for example, which has been harvested recently, is not covered with forest. Classified as land use type, this area would still be forest if the owner intents to replant. In New Zealand, there are two land cover data bases available. Due to financial restriction the third one was postponed in 2008.

Landcare Research created a dataset known as Land Use of New Zealand (LUNZ) which is based on a combination of Agribase farm boundaries and the information of the LCDB2. The intersection results in sub-farm shapes which identify land cover types within farm boundaries and link to land use information. (Todd & Kerr 2009)

The Land Use Capability data is a terrestrial approach. It has three main data themes; vegetation, land use capability and soil. Each area has a set of attributes relating to slope, soil pr rock type, erosion and the vegetation class. LUC data and maps are used mainly to determine the capability of the land. The higher the class, the wider the range of potential land use systems. Arable farming is only possible on the classes I to IV where dairy farming is also likely to be possible. Sheep and beef systems are more profitable on better land, but they are mainly in the weaker classes of land use capa-

bility (V to VII). The poorest land in terms of the production capacity is class VIII, which tends to be covered by native vegetation, tussock or bush (often DOC land) (Lynn IH et al., 2009). The resource inventory for soil and land, which is based on the Land Use Capability approach (LUC classes), is available on a national level and covers the country's farm areas very well. It is a very good data base for actual and potential land use analysis. However, the evaluation of the suitability of a specific location is influences by the subjective perspective of the valuating expert, as the expert might eventually not be able to take a completely different type of land use and its potential into account (e.g. wine or olive trees instead of low intensity grazing).

MAF is involved in the Agricultural Production Survey (APS) which is done by Statistics New Zealand (StatsNZ, 2010). Figure 2 shows the land use classification of the APS on a high level. Data on land use is available by region and by farm type following the ANSIC classification.



Source: StatsNZ 2010

Figure 2: New Zealand's land use classification in the Agricultural Production Survey

AgriBase™ is primarily survey data collected from farm owners by AsureQuality. The database contains attributes reported by the farmer such as primary land use, farm land area and stocking rates. It is based on the LCDB data set of 2001/02 and embeds real land use information within broad pastoral classes of the land cover database 2 (LCDB2) (AsureQuality, 2010). Agribase has only one land-use map which refers to the year 2002. There is no time series data and the data is relatively noisy. However, this source is useful as a comparison tool at certain levels.

MAF Biosecurity is preparing a new farm survey called FarmsOnLine. FarmsOnLine plans to be the authoritative source of rural property information for Biosecurity management. FarmsOnLine is developing a cohesive approach to the collection and maintenance of rural property information to support government and industry initiatives. FarmsOnLine aims to reduce fragmentation of data and duplication of effort while developing a consistent frame for analysing rural property information. (MAF Biosecurity 2010)

The Farm Monitoring data is the result of an annual survey of selected farms. MAF‘s Farm Monitoring programme models the production and financial status of farms, orchards and vineyards throughout New Zealand. Model calculations are used to derive key farm economic data such as; production, income, costs and product prices. Model data is available on a regional and a farm type level. The data is used by farmers, other agents of the sector, scientists, regional and central government organisations and non-governmental organisations. (MAF, 2010)

Moreover, national data is linked to international data systems from, for example, OECD, FAO or the UNFCCC. The Montreal Process and the Kyoto Protocol are international agreements that New Zealand has signed. Consequently, the country is liable to report on forestry and on greenhouse gas emissions. Information on land use and land use changes relates directly to both international agreements.

Quality of data sets

The quality of New Zealand’s data on land use and land use change is heterogeneous. MfE’s land cover maps are essential for national level land use or land cover analysis but the information has not been up dated in 2010. The resource inventory for soil and land is a valuable source of information on the actual and potential land use. There is limited information on driving forces of historic land use changes. Moreover, time series data is not sufficiently connected with spatial data.

Details on irrigation land and scrub land are fields of specific concern. Both types of land use are highly dynamic and can have a significant impact on New Zealand’s agricultural production or carbon sequestration. Both aspects are directly linked with the country’s international liabilities (Kyoto Protocol).

The discussions on land use data highlighted the need for national and regional level information. Climate change reporting, one of the main drivers of land use data analysis, needs national data. Data on the spatial allocation of actual forestry land and potential future afforestation provides additional knowledge for GHG mitigation policies. In contrast, water policy issues and international agreements such as the Montreal Process have an essential need for spatial information on land use. In fact, the lack of good spatial land use data constrains evidence-based decisions.

Regional information has been identified as crucial if;

- the analysis focuses on the understanding of the actual land use,
- the projected total land use change will be ‘distributed’ to specific regions

Data sets that relate to a specific location exist but they are not accessible due to confidentiality issues. Therefore, analyses based on a small geographical unit like farms or catchments require additional (and cost intensive) data collection. Economic data such as prices or returns are available but only related to a small number of farming systems or products (Farm Monitoring, daily newspaper, online newsletters

etc.). Many data sets are based on average figures which are of limited suitability for various approaches.

Information on specific types of location or grazing systems such as stocking rates for beef finishing or dry dairy stock on high country pasture are not at hand. At the moment, information on the impacts of irrigation is particularly important for policy analysts. However, there is very little data available on the actual distribution of irrigation, its efficiency and impact on the productivity of different locations.

There are more problems related to data on land use and land use change which were identified during the process:

- Data or maps that refer to a specific year are often not suitable for land use change questions because the original concept of data collection did not focus on the creation of a time series. The interconnection of non-time series data often shows inconsistencies (noisy data).
- Available data often does not match (survey, aerial photography, terrestrial survey - LUC); problem of combining them.
- Existing data is partly not available due to confidentiality issues.
- Maintaining existing data or creating new data is expensive.
- Insufficiently harmonised data collection, underlying definitions differ, e.g. forest versus scrub, scrub versus pasture.
- Temporal and spatial data sets are misaligned.
- Data series often don't cover the needs of specific approaches (modelling).

Drivers of land use in the past are not identical with future drivers. Consequently it is often misleading if forecasting is only or mainly based on historical trends. Farmers' individual decisions determine the country's land use. Therefore, behavioural aspects impact on potential changes. However, the modelling approaches are based on the assumption that only economic incentives drive farmers' behaviour and so the land use change. It is crucial but very challenging to capture these other aspects.

Behavioural responses of farmers are captured in historic data; consequently no additional information is needed. This argument fosters the use of historic trends for projections. Another argument focuses on the changing economic and social frameworks. Those changes are likely to drive farmers' decision making processes as well. Individual or group specific behaviour can be captured by farmer surveys that include motivations of land owners. The aspect of farmers' behaviour is one of those areas that needs to be taken into critical reflection when a land use change model is developed. It is one of the specific and difficult aspects that can be either implemented or excluded into a model in respect of the initially asked questions.

3.2 Modelling approaches

The data series mentioned in section 3.1 feed into the land use models that have been developed to analysing New Zealand's land use changes. In this context, the term 'model' refers to any structured knowledge that reflects the linkages and mechanisms of a specific system. Models always provide a simplified description of reality.

This paper only focuses on national level modelling approaches. There are several models available with a regional or catchment focus. They are not part of the analysis even though they are in the process of 'growing' bigger from the regional to the national level, e.g. the CLUES model (NIWA 2007).

The modelling approaches available that focus on land use or that have an important land use dimension are listed below. During the consultancy process the different tools were analysed aiming to better understand advantages and limitations. The paper will not discuss each model with its underlying methodology. This would exceed the context of this contribution. Further information is easily accessible via the Internet page of the models' owner.

National level modelling approaches that relate to land use and land use changes:

- Land Use in Rural NZ (LURNZ) by Motu
- Pastoral Supply Response Modell (PSRM) by MAF Policy
- Computational General Equilibrium (CGE) models by e.g. NZIER
- Models focussing a specific sector e.g. forestry models (e.g. Alphametrics)
- Agent-based modelling (e.g. Scion, Landcare Research)
- Mediated modelling (e.g. Massey, Palmerston North)
- Pastoral production model (BIOME-BGC for pasture in NZ) by GNS

The LURNZ model, PSRM, CGE models and other sector specific models are based on econometric approaches. They require data series on historic trends and additionally several parameters to capture the interdependencies between driving factors and shifts in land use.

The Land Use in Rural New Zealand model (LURNZ) models land use changes based on an econometric approach. The model consists of several sub-tools such as the national level land use change tool, the land use allocation module and the land-use intensity module. Motu Economic and Public Policy Research developed the model. Most recent calculations focus on the effects of carbon prices on land use in New Zealand. (Kerr et al. 2010)

The PSRM model is used for economic forecasting of agricultural production in MAF Policy. Since 2009 the model has also contributed to the calculation of GHG on a national level. (Dake, Ch. 2009)

Computational General Equilibrium (CGE) models can be used to give an indication of the 'economy-wide' impacts of a policy or project. CGE models are based on the assumptions made earlier about optimising behaviour of consumers and producers. They attempt to represent the circular flow of goods and services in the economy. (UNESCAP 2010)

Agent-based models represent a range of individuals and their decision making processes. They aim to identify tradeoffs between economic, social and environmental indicators that impact on the likelihood of innovation or policy adoption. (Landcare Research 2010) Scion has developed an agent-based model to simulate effects of the Emission Trading Scheme (ETS) with a focus on forestry. The agent based model is optimising decisions at landowner level, with the benefit of being able to aggregate up

to a national level. It assesses large-scale land use change for different carbon price scenarios. (Adams 2010)

Mediated modelling is a relatively new process-orientated tool that uses the computer-aided model-building process to create a shared understanding of complex problems. It is a process that focuses on the active involvement of stakeholders in the planning and decision-making processes. The process amalgamates computer modelling and public participation to better promote group learning and communal understanding of complex issues and conflicting goals. (Van den Belt 2004; Vicky & Richardson 2007)

Biome-BioGeochemical Cycles (BGC) models simulate plant growth. It is a computer programme that estimates fluxes and storage of energy, water, carbon, and nitrogen for the vegetation and soil components of terrestrial ecosystems. It is called a process model because its algorithms represent physical and biological processes that control fluxes of energy and mass. These processes include leaf growth, sunlight interception, precipitation, drainage and runoff of soil water, evaporation, nitrogen uptake etc. The model uses a daily time-step. This means that each flux is estimated for a one-day period. Between days, the program updates its memory of the mass stored in different components of the vegetation, litter, and soil (NTSG 2010). A Biome-BGC model for pastoral growth in different regions of New Zealand has been developed by GNS science in 2010, supported by MAF Policy.

4 Modelling agricultural and forestry land use

Models depict reality in a more or less precise way. When developing a model one has to decide which details will be essential to represent reality. These assumptions are crucial for the process of modelling as well as for the interpretation of the outcome.

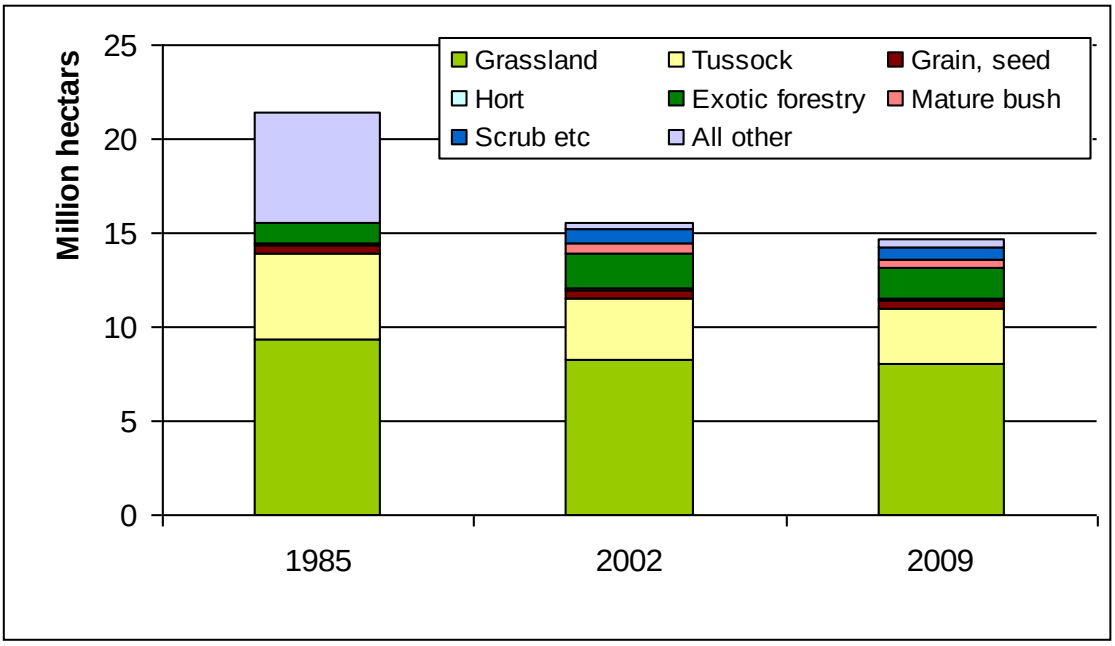
The following section focuses on the balance between depicting the driving forces of land use changes in farming and forestry reality and the necessary simplifications aiming to define a consistent and manageable mathematical system. Good model development is about getting the balance right between on farm reality and mathematical functions.

4.1 Driving factors of land use changes

In New Zealand, land use has been changing over time (see figure 3). Simultaneously, statistic methodologies have changed too (land use classification in 1985 in comparison to 2002 in figure 3). Modelling approaches attempt to replicate shifts in the reality by handling available data sets. The models, listed in chapter 3.2, mainly use historic trends of shifts in land use to test policy interventions in relation to their impact on land use. The analysis of the driving forces of these shifts is crucial to understand the historic changes and to simulate future developments.

Figure 3 shows that the underlying data base can cause significant problems when changes in the statistical methodology impact on the analysis. Before 2002, the structure of the Agricultural Production Survey changed after some years of weak data management. Based on that data source, it is difficult to interpret land use changes. The data of StatsNZ shows that total farm land contracted 6 percent between 2002 and 2008. Agricultural land was transferred into conservation land, managed by the Department of Conservation (DOC). This was mainly tussock, scrub land, and native

forest. Additionally, industrial and urban areas grew significantly, consuming mainly grassland and arable land. The data does not inform about the characteristics of the shifts between grassland and forestry or arable land. Shifts in land use from forestry to agriculture or within agriculture from sheep to dairy are basically caused by economic drivers in New Zealand. In contrast, afforestation can relate to both, changing economic drivers or policy interventions such as the Afforestation Scheme (MAF 2010b).



Source: StatsNZ 2010

Figure 3: Land use data of the Agricultural Production Survey for 1985, 2002, 2009

Forestry produces not only market goods but as well environmental goods and services such as high quality water bodies, carbon sequestration, habitats for biodiversity etc.

What has driven these changes? How might future land use change look like and how can we predict it?

Agriculture and forestry have some general drivers related to land use change in common:

- Economic framework such as product prices, land prices, input prices such as fuel, demand-supply mechanisms on the markets and a policy framework impacting on the different activities.
- Plant growth rates or carbon sequestration rates, each depending on species/variety and local conditions
- Expectations of the individual land owner

4.2 The challenge of the appropriate degree of simplification: dairy farming, an example

Some specific characteristics of real farming or forestry systems are especially challenging for the modelling process. Several drivers impact on harvesting, reforestation, afforestation or deforestation (MAF 2009). Challenging for the construction of forestry models is the long term perspective of the investment. In contrast, it is partly easier to built forestry products than animal husbandry based systems because forestry is characterised by a stable relationship between wood production/carbon sequestration and land use at a defined location.

In contrast, pastoral systems are less complex in terms of the long-term perspective but highly complex due to the flexibility and the variety of the particular pastoral systems and the related pasture requirements. Management decisions drive the level of intensity which, again, impacts on the productivity of the land.

To illustrate the ambiguity between simplification and representation of the real complexity, the following section will discuss the specific characteristics of dairy farming and land use.

Pastoral systems such as dairy farming in New Zealand are relatively responsive to changes in economic, social or policy frameworks, and they are inherently complex:.

- The level of dairy cow performance depends on the herd management and on the feed diet. The identical animal has a wide range of annual performance levels.
- The higher the nutrition energy in the lactation, the higher the performance level per cow if all dietary requirements are taken into account (maximum dry matter intake, mineral supply, proportion of well structured feed components etc).
- Since feed is a major cost factor in dairy systems, prices impact significantly on the management decision related to the feeding regime. (Hemme 2009)
- Pasture is the most cost efficient feed energy supply. In seasons with reduced pastoral growth, barn feeding regimes based on silage can contribute to the profitability of the system.

The stocking rate is one of the key determinants of pastoral systems.. Supplementary feed is a substantial part of the diet. Supplements are either grown on farm land or are purchased locally, regionally or internationally. There is no standardised parameter which represents the connection between the performance level per cow and the stocking rate.

Dairy herd management systems show a large variety on both a regional as well as on the national level. Some regions have systems that are fewer diverse than others. In general, dairy farming in New Zealand is represented by a range of systems (DairyNZ 2010). Optimised on farm performance levels, in terms of the profit maximisation principle, can differ significantly from the potential maximum level of dairy herd performance. Consequently, the intensification of land use as well as the reduction of inputs can raise efficiency on the farm level.

This example shows that when modelling dairy land use it is important to consider the mechanisms driving system changes in a rather detailed way. During the process of modelling, it will probably be evident that the latter considerations are too specific for a national level approach. The key question "how detailed does the specification of a modelling approach have to be?" is therefore critically important.

5 Conclusions

Land use change is a very complex issue. A holistic view on the topic is of crucial importance. Land use and land use changes are closely connected with water resource management, GHG emissions and economic development. All are high on the political and public agenda (see e.g. work programmes of MAF and MfE). Due to the complexity of land use and land use change, analyses have to focus on specific areas of concern while, at the same time, not neglecting cross-cutting questions and issues.

The results of the MAF internal consultation process show that not only land use and resource management questions are directly related to potential land use changes, but a large variety of policy questions associated with; climate change negotiations, dairy sector policy, farm surveys and economic forecasting are also linked to the changes.

Increases in dairy, horticultural and crop production are to contribute significantly to New Zealand's future economic growth (MAF 2008). Therefore, these sectors will either absorb more land or increase intensity of production. Land use data shows that the areas used for (e.g.) dairy farming and for arable farming have been increasing. The information on changes in land use intensities, however, is ambiguous. For example, some calculations show rising, some falling stocking rates in dairy farming.

When land becomes a scarce input factor for agricultural production, a substitution of land by capital becomes an alternative. This can be observed in countries with higher land prices (e.g. much of Europe). This phenomenon might be of future relevance for New Zealand's (irrigated) cultivatable land as well.

Dealing with the diversity of production and management systems is constrained by the data available. During the process many discussions focused on data problems emphasising that data quality and availability is a major concern for policy and research work related to land use and land use change.

Data issues

The limitations of data sets on land use constrain policy analyses and decision making processes. Data on land use and land use change is based on insufficiently harmonised data collection. The underlying definitions differ so that comparative approaches are impossible. Project outcomes are ambiguous which might be due to either the underlying data sets or to the structure of the approach. Participants in the land use working group identified data problems as a major issue.

Good data is costly; budgetary restrictions limit maintenance and improvement of time series data. The frameworks of the agencies involved such as the Regional Councils, NIWA, research agencies etc. could be integrated to a certain degree aiming to improve the available information on land use and land use change (vertical and horizontal integration in data systems). The close cooperation between governmental and non-governmental bodies could be an opportunity to improve data quality, availability and eventually even the access to the most adequate data source.

Moreover, the process showed that the aspects which are discussed with policy teams appear often insufficiently aligned to external researchers. If members of governmental bodies could develop strategies on specific needs and questions internally, the communication and cooperation between an agency like MAF Policy and research institutes could be more efficient (e.g. quick, fit for purpose). It could even help to overcome some limitations related to land use data and modelling approaches.

The implementation of integrative concepts or the coordination of data collection would require clear leadership on land use statistics. Statistics New Zealand has no mandate to produce good quality data on land use. In the past, no other agency was responsible to set clearly defined standards ensuring usable information for land use and land use change analyses. MfE are leading a process to collate a range of data sets. The need for land use data in MfE is mainly related to climate change related projects. Participants of the modelling workshop agreed that an engagement of MAF Policy could improve the situation significantly.

Historic and actual data on land use change is lacking and hampers the identification of the driving forces of land use change. This gap in information impacts on model development, sound analysis and evidence-based policy advice.

The most important source of economic farm level data is MAF's Farm Monitoring data. It mainly refers to one system per region such as dairy, sheep/beef, horticulture (MAF 2010). Farm Monitoring data is widely used by scientists, stakeholders, governmental and non-governmental organisations. The data is crucial to many work programmes or research projects; although the increasing significance of the data set hasn't yet been reflected financially within MAF Policy.

The working group on land use and land use changes focussed mainly on national level modelling approaches. In the beginning of the process data issues were perceived as one part of the modelling work. However, essential needs and problems around data became more important as the process developed.

Modelling issues

Modelling approaches ought to relate directly to the work of the policy teams. Key questions of policy feed into the development of econometric models and specifically the elaboration of the land use modules they comprise.

The working group showed that policy needs and the work of modelling teams are perceived as often not to be sufficiently connected. It is of crucial importance that model developers (scientists) and model users (policy analysts) establish ongoing communication processes. For example, the implementation of the ETS has been in a constant process of detailed specifications in 2009 and 2010. Changing facts impacts on the models' applicability.

When modelling, it is important to tailor the models to the scale of the key questions. If models are too complex the user will be unable to oversee the underlying assumptions and constraints. In this case, the model output can be weakly interpreted as a result of a lack in transparency. On the other side, the complexity of real systems is often insufficiently covered by the model. Policy questions are specific and models have often been developed for slightly different issues. It is essential to review the suitability of the model; is it fit for purpose?

Transparency regarding assumptions and limitations is essential in the communication of modelling results. Model users have to take into account that agricultural and forestry models depict reality 'insufficiently'; therefore the results need a critical interpretation.

If the economic or the policy framework changes, models need to be adjusted. These adjustments require certain flexibility in terms of data, parameters as well as systematic linkages. It is an advantage if models are user friendly in terms of potential modifications. This requirement is closely linked to the aspect of transparency.

The combination of models or model tools is an option which was discussed by the working group ('building block system'). Depending on the question, it could be the forestry sector model, with a limited pastoral land use module, which produces first level results. These intermediate results would feed into another model which calculates carbon sequestration or the impact on rising land prices on sheep and beef systems.

Farmers' individual decisions do not necessarily respond only to the economic framework. The aspect of farmers' behaviour is a specific and difficult aspect of land use changes. When a model is developed, it can be either implemented or excluded in respect of the key policy needs. It is part of the transparency requirements of models that the model user is aware of the underlying assumptions.

A final remark
Participants of the process, external researchers as well as MAF Policy staff, agreed that the review and consultancy process on land use and land use change questions was helpful. It helped to enhance transparency on the provenience of data and analysis. Moreover, it encouraged a critical reflection on the actual engagement in the different areas of concern related to land use.

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