New Zealand Agricultural and
Resource Economics Society (Inc.)

Projecting Livestock Numbers

Rod Forbes
Senior Policy Analyst, Ministry of Agriculture and Forestry (MAF), Wellington

Peter Gardiner
Manager Applied Primary Sector Statistics, MAF, Wellington, New Zealand

Paper presented at the 2004 NZARES Conference
Blenheim Country Hotel, Blenheim, New Zealand. June 25-26, 2004.

Projecting Livestock Numbers[1]

Rod Forbes and Peter Gardiner[2]
Ministry of Agriculture and Forestry
PO Box 2526
Wellington

ABSTRACT

The Ministry of Agriculture and Forestry (MAF) undertakes forecasts and projections of livestock numbers as part of the twice yearly contribution to The Treasury's economic and fiscal updates. MAF's Pastoral Supply Response Model (PSRM) was recently re-developed and used for the first time in the Budget Economic and Fiscal Update round of 2004. The PSRM projects annual inventory numbers as at 30 June, births and livestock numbers for slaughter. The paper discusses the PSRM, the post-model adjustments process, and the feed through to a simplistic assessment of land use changes within pasture areas.

Key words – Livestock numbers, forecasting, supply response

1. INTRODUCTION

The Ministry of Agriculture and Forestry (MAF) undertakes forecasts and projections of livestock numbers as part of the twice yearly contribution to The Treasury's economic and fiscal updates. The Treasury require from MAF projections of agricultural and forestry exports (quantities, prices and values) and the agriculture sector's contribution to GDP (for income tax derivation) over a three year outlook period.

During the forecasting round a considerable amount of data is derived with projections currently out to 2012/13. The data has a much wider use: to meet MAF's own needs, and to meet its obligations to international agencies such as the OECD and the FAO. We also provide longer term livestock number projections to derive Greenhouse Gas emissions as part of New Zealand's obligation to report annually on emissions and sinks to the United Nations Convention on Climate Change. Following each forecasting round MAF publishes Situation and Outlook for New Zealand Agriculture and Forestry in December and an update in May.

Underpinning forecasting activities are:
- the monitoring of prices, production and trade of key products and associated issues in the agricultural, horticultural and forestry industries, and
- the maintenance and development of models used in forecasting.

In projecting prices to New Zealand producers we endeavour to base these on forecasting frameworks using representative international markets. In some cases,

---

[1] The views expressed in this paper are those of the authors and not necessarily those of the New Zealand Ministry of Agriculture and Forestry.
[2] Peter Gardiner is Manager Applied Primary Sector Statistics (previously with the NZIER) and Rod Forbes is a Senior Policy Analyst with the main responsibility for coordinating forecasting activities.

FOB is the only international price proxy available. International price trends are adjusted by exchange rate assumptions provided by The Treasury. The forecasts of producer prices are then used to derive supply responses.

Key supply responses are for the various livestock industries – dairy cattle, beef cattle sheep and deer - and these are projected in a pastoral supply response model (PSRM), which was re-developed in 2003 and used for the first time in the recent Budget Economic and Fiscal Update round.

2. BACKGROUND TO THE PSRM

2.1 Model History

Laing and Zwart (1981) at Lincoln University originally developed the PSRM. The PSRM describes the structure of sheep, beef cattle and dairy cattle production in New Zealand. This econometric model was based on a theory of investment where a farmer is assumed to manage a portfolio of on-farm investments. Farm income, expenditure and capital investment were key components of their model. It was substantially reviewed by Laing (1982) and by Laing and Zwart (1983). A further revision was undertaken by Grundy et al (1988).

The PSRM was substantially redeveloped in MAF (SriRamaratnam and Reynolds, 1990) where the farm income, expenditure and capital investment aspects of the original model were de-emphasised. Instead a more pragmatic econometric approach was developed to provide forecasts of sheep, beef cattle and dairy cattle inventory and product supply.

A deer forecasting model was developed later using a combination of a spreadsheet based deer population model and econometric model which had an international trade emphasis (Pearse, SriRamaratnam and Dake, 1994).

A number of studies have subsequently been undertaken to investigate other modelling paradigms for improving the PSRM. Some examples are:
- Narayan, Dake and SriRamaratnam (1993) focused capital investment in the dairy farming,
- SriRamaratnam, Forbes, Narayan and Wallace (1995) explored the income, expenditure and investment aspects,
- Forbes and SriRamaratnam (1995) explored the impact of forestry on pastoral land.

In recent years, the PSRM has been reviewed extensively by econometric modellers in AgResearch (Dake and Vetharanian, 2000, and Dake, 2001). They reviewed the performance of equations in the PSRM (including the Deer model) and made suggestions for model reformulation. One recommendation was that an investment approach should be pursued, and a variable coefficient model using a Kalman Filter could be developed. Preliminary Kalman Filter models of the main livestock categories of sheep, beef cattle and dairy cattle were subsequently experimented with.

The PSRM was originally developed in the TSP econometric package with Microsoft Excel used as the data input and output interface. Some iterations of the PSRM over the forecast period are required to adjust dairy cows and dairy calf reared for beef production. A separate forecast of dairy cows in calf or in milk is undertaken to take into account factors not included in the specific PSRM equation. Some attempt has been made to include the impact of deer and forestry expansion on sheep numbers within the PSRM. The beef cattle aspects of the model have never performed very well. The results of the PSRM are adjusted in a spreadsheet, and in particular to ensure that the total livestock numbers, expressed in stock units do not exceed realistic pastoral capacity for New Zealand.

The task of forecasting has been made more difficult since 1997 because there has only been one national agriculture survey in 1999 since 1996. Livestock numbers in 1997, 1998, 2000, and 2001 are all estimates. A census as at June 2002 is the first of ongoing funding commitment for five yearly censuses with surveys in intervening years. Livestock numbers and land use data will be collected each year in future.

In early 2003, funding was made available for several model developments, the first priority being the re-development of the PSRM. The latter was put out to tender and the New Zealand Institute of Economic Research (NZIER) was the successful bidder.

2.2 Model Re-Development[3]

The broad objectives of the PSRM redevelopment project included:
- Improving forecast accuracy
- Reducing model complexity
- Including the impact of forestry (which has been a substitute land use on sheep and beef farming farms over the past two decades)
- Including deer industry.

The fundamental obligation of the redevelopment was to maintain the structures and assumption of the original model. Price and weather variables were to remain exogenous, and behavioural equations were to be based on similar fundamental explanatory factors and data (see Appendix A).

Despite these obligations, several advances have been made in the redevelopment process. The PSRM has been re-estimated in software, which has enhanced the models usability and general understanding of model dynamics. This software is EViews and replaces TSP which was used in the earlier PSRM. The PSRM has been reduced to a national livestock reconciliation model, which has improved transparency of model linkages. The removal of production weight equations has reduced model complexity and the removal of livestock identities has enhanced overall model performance. Many of the structural equations have been re-estimated using new data, although fundamental biological structures have been maintained. In many equations ARMA modelling techniques have been included.

---

[3] This section has been extracted from the NZIER's report. The report was prepared by Peter Gardiner (then) of the NZIER and Dr J.J. Su from Massey University, with consultations from Prof. Ralph Lattimore (then) of the NZIER and Prof. Allan Rae of Massey University.

Specific achievements of the PSRM re-development include:
- Separating bulls and steer forecasts in beef cattle industry. In the original model bulls and steers combined, and estimated in three age cohorts. Changes in the industry, and underlying data unreliability necessitated a change in modelling. This was a major advance.
- Reduce the structure of the sheep industry (previously over specified).
- Test forecast properties of additional weather variables of days of soil moisture deficit and air temperature (soil moisture deficit and air temperature at different times of the year influence livestock industries differently).
- Attempt to include forestry prices in key sheep and beef cattle equations (a competing land use).
- Include the deer industry.

Seasonal soil moisture deficit patterns showed no improvement over annual deficit data and seasonal and annual temperature data was found to be insignificant. Forestry prices were also found to be insignificant for sheep and beef inventory equations.

Female breeding livestock equations are presented in Appendices B.

2.3 Sheep Industry Module

In the original PSRM the structure of the sheep industry was over specified with surplus equations and identities. The key features of the re-development included: simplifying the structure and linking lambs born, slaughtered and total wool production equations to the breading stock forecasts. The latter anchors forecast variables to breeding livestock forecasts, and have enhanced forecasting performance. Figure 1 illustrates the PSRM representation of the sheep industry.

Figure 1: Sheep industry
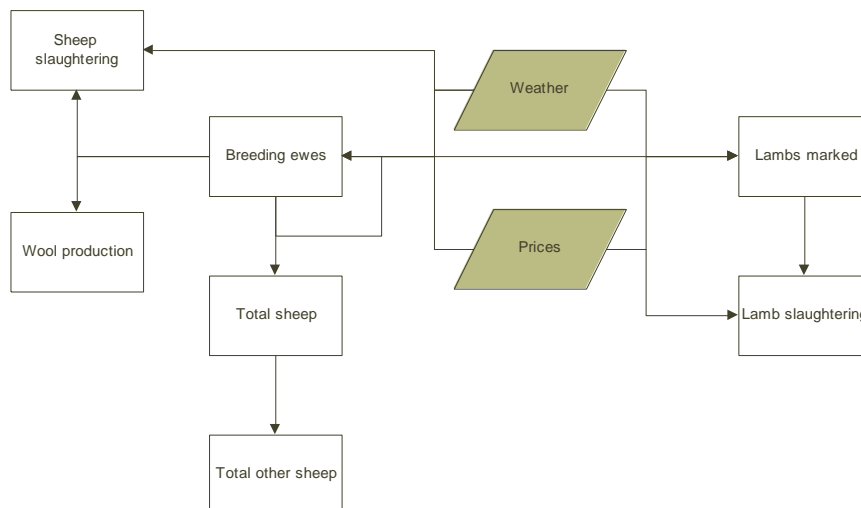
2.4 Dairy Cattle Industry Module

Despite significant changes in the dairy industry over recent years, the structure of dairy production has remained relatively unaltered. Figure 2 illustrates the PSRM representation of the dairy cattle industry with linkages to the beef cattle industry. Almost all bull beef now originates from the dairy herd. The dairy herd is also a major source of heifer and cows slaughtered.

Figure 2: Dairy cattle industry (including linkages to the beef cattle industry)
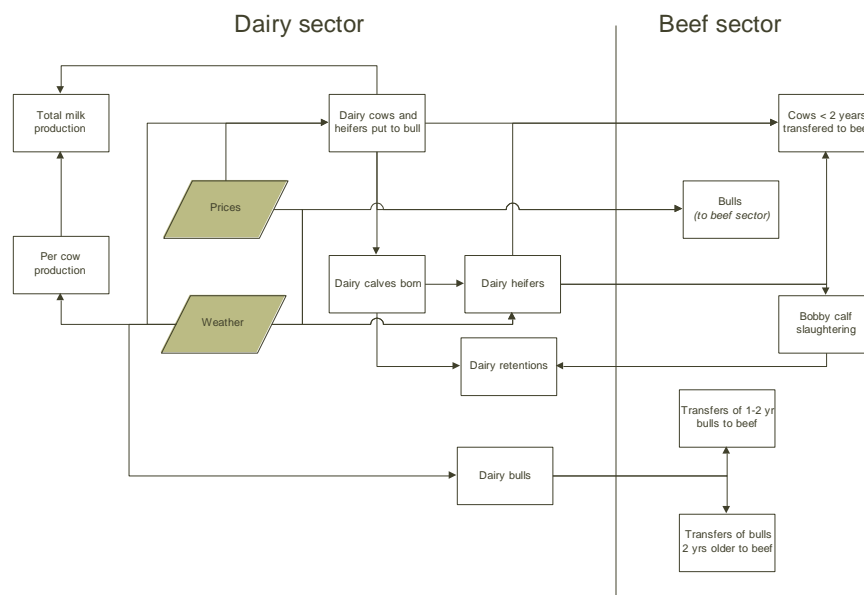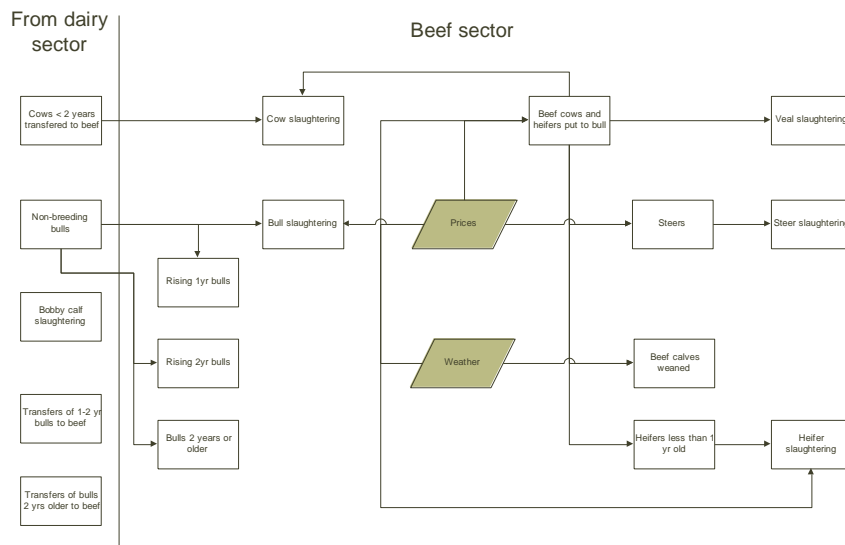

2.5 Beef Cattle Industry Module

The beef cattle industry module underwent the largest change during the PSRM redevelopment. All individual livestock and slaughtering equation were improved and updated with new data. Fundamental changes were made to male livestock and slaughtering estimation. New data on non-breeding bull livestock numbers have been incorporated into the beef cattle industry module and changes to the structure of the industry have been made.

In the original PSRM steer and bull livestock and slaughtering numbers were estimated in combination by age cohorts. But changes in farming practise since the 1980 has altered both steer and bull livestock linkages such that bull and steer livestock numbers are derived from different sources. Almost all bull beef is derived from the dairy herd, thus the number of dairy cows and heifers in calf each year are significant factors in determining bull beef live stock numbers. Similarly, steer livestock numbers are almost exclusively derived from the beef herd, where beef cows and heifer numbers are key drivers.

Figure 3: Beef cattle industry (including linkages from the dairy cattle industry)

2.6 Deer Industry Module

The deer industry is a new addition to the PSRM. The modelling structure of the deer industry is similar to the sheep and cattle industries in that the female livestock estimates and forecasts are the key driver of all livestock and production equations, either directly or indirectly. The number of total hinds is determined by real velvet, venison, and milksolids prices and the weather (days in soil moisture deficit). Figure 4 illustrates the PSRM representation of the deer industry.

Figure 4: Deer industry
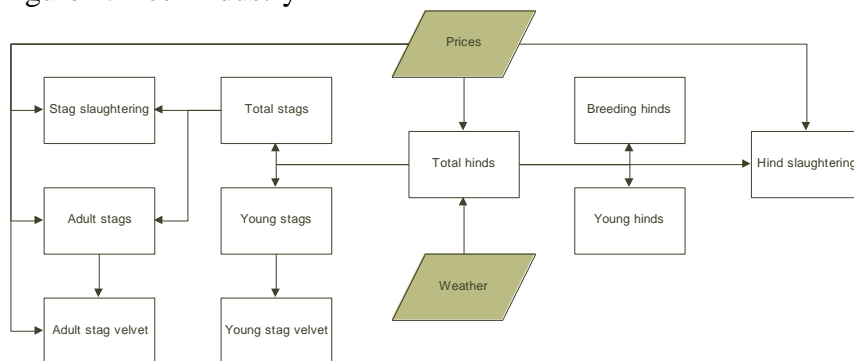
3. MODELLING CONSIDERATIONS

Throughout the PSRM, the least squares method – either linear or non-linear – is used. Given the price-taker assumption, the PSRM does not contain feedback mechanism across equations. Therefore, the least squares estimation is consistent and asymptotically efficient.

While the various modules have been explained separately, they are solved simultaneously in EViews because of links between some equations in different modules.

There are two important features in the redeveloped PSRM. The first factor looks at the formulation of key breeding livestock equations within each sector. Typically these equations include lagged dependent terms, and are generally referred to as distributed-lag models. The presence of lagged dependent variables in these breeding livestock equations imposes some constraints that need to be considered in more detail. The second issue that we address is the inclusion of auto-regressive and moving average terms.

3.1 Modelling Breeding Livestock

Nerlove (1958) developed an agricultural supply response system using an autoregressive model formulation. The underlying theoretical model that Nerlove considered was based on an accelerator model, which assumes that there is an optimal amount of capital stock needed to produce a given output under a given level of technology. In an agricultural sense, capital stock is breeding livestock. It was assumed that the optimal level of breeding livestock Y^*_t is a linear function of X:

$$Y^*_t = \beta_1 + \beta_2 X_t + u_t$$

However, the optimal level of capital stock is not directly observable, so Nerlove conceptualised what is known as the partial adjustment, or stock adjustment hypothesis:

$$Y_t - Y_{t-1} = \delta(Y^*_t - Y_{t-1})$$

Where δ is known as the coefficient of adjustment, and importantly $0 < \delta < 1$. The left hand side of the above model $(Y_t - Y_{t-1})$ is none other than investment (at t), which is some fraction δ of the optimal change in investment $(y^*_t - Y_{t-1})$ in that period. If $\delta = 1$, then the actual stock of capital is equal to the desired stock of capital. On the other hand, if $\delta = 0$, then actual stock (in t) is the same as the previous quarter. Typically, δ lies between 1 and 0 since the adjustment to the desired level of breeding stock is likely to be incomplete because of rigidities or constraints in the system. The following table presents the coefficient of adjustment for each of the breeding stock models in each industry.

Table 1: Coefficient of adjustment

Variable	KE	KCHPB	KCHMD	KTDH
Coeff. Of adjmt	0.9697	0.9276	0.8041	0.9126
t-statistic	19.3	13.7	10.8	20.6
Model R2	0.9954	0.9281	0.9899	0.9896
Est. period	1982-2002	1973-2002	1973-2002	1985-2002

Table 1 shows the importance of the lagged dependent variable in the key breeding female equations – mated ewes and ewe hoggets (KE), mated beef cows and heifers (KCHPB), dairy cows and heifers in calf/in milk, and total hinds (KTDH). It also suggests that mated ewes and ewe hoggets are very near optimal levels. In fact, if estimated over the entire data series available (1961 – 2002), the coefficient of adjustment δ is greater than 1, and in violation of the underlying equation specification.

The reason for this is in part due to non-price farming subsidies that were granted to sheep farmers during the late 1970s and early 1980s. These non-price subsidies created financial incentives for farmers to increase sheep numbers to levels that were greater than real price increases would indicate. In order to correct for this various non-price subsidy measures were added to the equation. But this in itself was not enough to reduce the coefficient below one. To remedy the problem a truncated time period was used.

3.2 Auto-Regressive and Moving Average Terms

In this redevelopment, the fundamental biological and investment structure of the original PSRM is mostly maintained as it accounts for the essential dynamic of pastoral supply. The modelling strategy goes as follows. Once the fundamental structure is set, the model is modified with a suitable autoregressive and moving-average (ARMA) feature to capture the extra dynamic. Basically, each behaviour equation in the PSRM is a special case of the following specification.

$$\Phi_p(L)y_t = c + f(X_t, \beta) + \Theta_q(L)\varepsilon_t$$

- c is an intercept.
- $\Phi_p(L) = 1 - \phi_1 L - \ldots - \phi_p L^p$ specifies the AR component in y while $\Theta_q(L) = 1 - \theta_1 L - \ldots - \theta_q L^q$ specifies its MA component.
- ε_t is white noise with zero mean and constant variance ($WN(0, \sigma^2)$).
- $f(X_t, \beta)$ is a function of a vector of exogenous variables (X_t) with β the corresponding parameter vector.

Remarks:

- The model is the so-called ARMAX model which sees the usual ARMA model as a special case if $f(X_t, \beta)$ is excluded.
- $f(X_t, \beta)$ is assumed to be linear, that is, $f(X_t, \beta) = \sum_{i=1}^{K} \beta_i x_{it}$ if K exogenous variables are included.
- X_t may include time-trend (as a proxy for technological progress), weather condition and other current and lagged biological and market variables. The choice of exogenous variable is essentially based on the biological and market structure of pastoral supply.
- The selection of p and q is basically depended on the Box-Jenkins modelling methodology. The white noise property of the error term is checked by the Ljung-Box test.

The model is easily estimated by non linear least squares in EViews.

3.3 Subsequent Modelling Work

Since the completion of the contract a few equations have been re-specified. After the experience with the PSRM in the last forecasting round further refinements to both data and equations have become apparent, especially in the deer module. Deer

prices and supply responses have up to now, been projected in a separate model. A new deer price forecasting model is required and once completed the PSRM will handle deer supply responses.

4. POST-MODEL ADJUSTMENTS

The PSRM currently uses inventory data up to June 2002. After the PSRM was run for the last forecasting round, the projected livestock numbers were discussed with various MAF analysts. A number of post-model adjustments were carried out as follows:

- Increased dairy cattle and deer numbers with implications to sheep and beef cattle numbers
- Inclusion of Statistics New Zealand's provisional numbers as at June 2003 for sheep, beef cattle and deer
- Exclusion of Statistics New Zealand's provisional numbers as at June 2003 for dairy cows in milk/in calf which are considered to be too high
- Allowance for stock unit losses to sheep and beef as new planted forestry area is projected increase at between 15,000 and 19,000 ha per year (well down on the new plantings of the 1990's)
- Allowance for an estimated loss of 50,000 stock units[4] per year as South Island farm leaseholds are taken into the DOC conservation estate.

Finally, total stock units (including allowance for losses from forestry expansion) are assumed to remain constant at around 98.5 million over the outlook period. A downward adjustment to sheep numbers was required from 2008 onwards. In essence, this adjustment attempts to balance the aggregate feed demand and supply. Figure 5 reveals the pattern of adjustments by comparing the adjusted output with the EViews output.

It is considered that the new policy of annual surveys and five-year censuses of agricultural production, together with increasing experience by Statistics New Zealand in conducting these, should help reduce the need for post-model adjustments.

---

[4] A stock unit is a measure used to compare the nutritional requirements of different pastoral livestock. The standard stock unit is based on one breeding ewe of 55 kg liveweight producing one lamb.

Figure 5: livestock class comparisons post-model adjusted minus EViews output
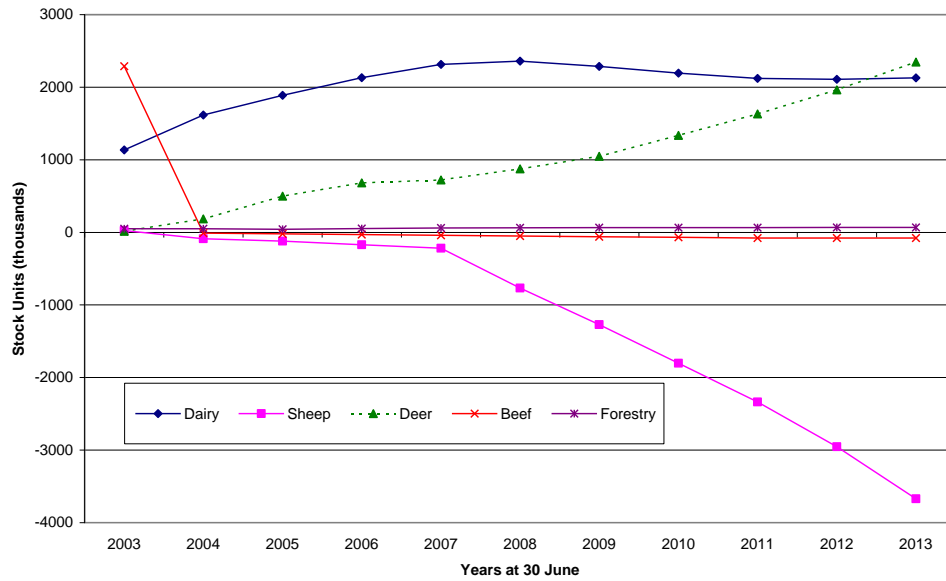
The stock unit trends over the past and outlook periods are shown in Figure 6 below.

Figure 6: Trends in stock units over time
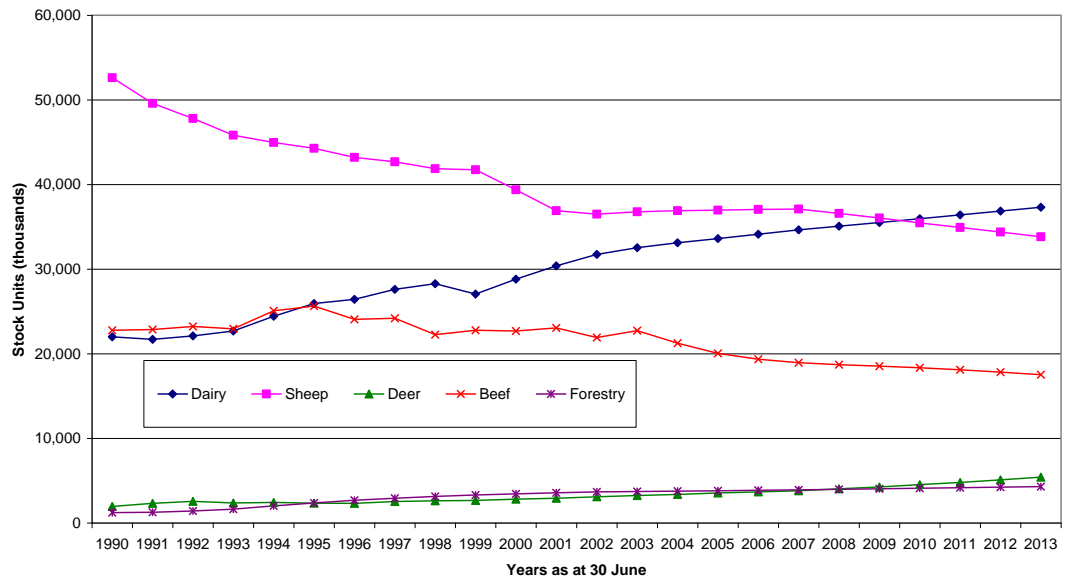
5. LAND USE IMPLICATIONS

Several years ago a simple framework to explore land use change was devised. Data from Statistics New Zealand's annual censuses and surveys up to 1996 was analysed to provide a more complete picture of grazing area (predominantly pasture) by dairy cattle, beef cattle, sheep and deer. There were no surveys in 1997, 1998, 2000 and 2001 and data from the 1999 survey and 2002 census have not as yet been

11

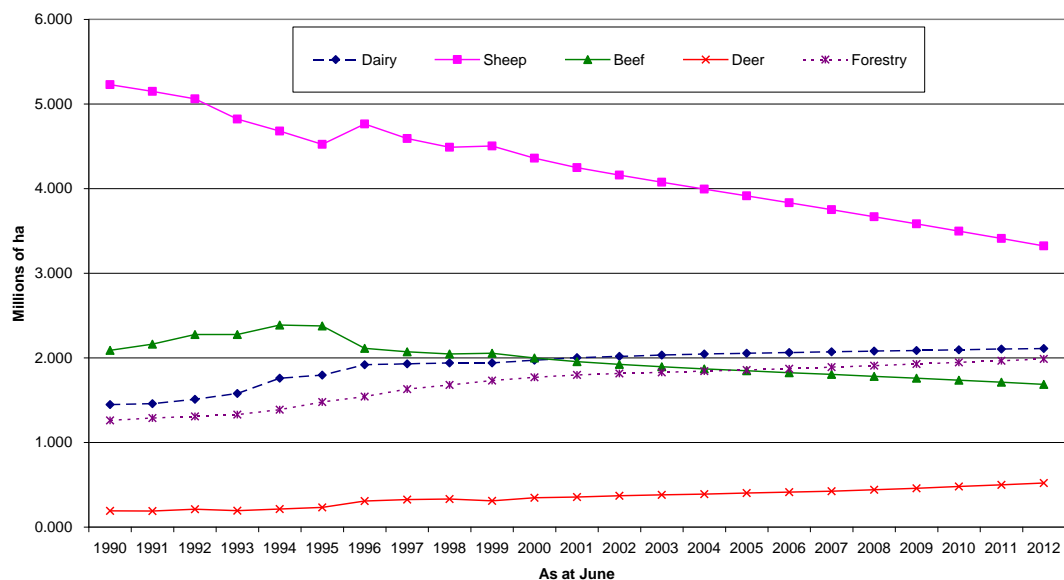incorporated. Using the forecast trends in terms of stock units, grazing areas over time are approximated. Figure 7 shows the results along with the forestry areas.

Figure 7: Trends in grazing and forestry areas

The total grazing area fell from 8.96 million ha at June 1990 to an estimated 8.30 million ha June 2004 and forestry area went from 1.26 million ha to an estimated 1.84 million ha over the same period. Increases in forestry area and dairy and deer grazing areas have been at the expense of declining sheep grazing areas. While dairy cattle numbers are expected to rise significantly over the outlook period, the carrying capacity is also increasing, leading to a more moderate increase in dairy grazing area.

6. SUMMARY

The concept of a PSRM has had a long history, with its use for forecasting in MAF starting in the early 1990s. Various attempts at improving the PSRM were made since then. The model was re-developed under contract with the NZIER in 2003 and used in the recent Budget forecasting round for the first time. While further work is still required, MAF is pleased with the outcome. Post-model adjustments are still likely to be necessary for factors not able to be adequately internalised into the model. The new policy of annual surveys and five-yearly censuses by Statistics New Zealand, together with further equation refinements, should help reduce the extent of post-model adjustments.

REFERENCES

Gardiner P and Su J J (2003). Re-development of the Pastoral Supply Response Model: A report to the Ministry of Agriculture and Forestry, NZIER, 2003.

Laing M T and Zwart A C (1981). The New Zealand Pastoral Livestock Sector: A Preliminary Econometric Model. AERU Discussion Paper No 54, Lincoln College, 1981.

Laing M T (1982). The New Zealand Pastoral Livestock Sector: An Econometric Model (2). AERU Research Report No 127, Lincoln College, 1982.

Laing M T and Zwart A C (1983). Investment and Supply Response in the New Zealand Pastoral Sector: An Econometric Model. Version 3, AERU Research Report No 137, Lincoln College, 1983.

Grundy T P, Lattimore R G, Zwart A C (1988). New Zealand Livestock Sector Model, Version 4. AERU Research Report No 192, Lincoln College, 1988.

SriRamaratnam S, and Reynolds R (1990). The New Zealand Pastoral Sector Supply Responses. Contributed Paper at the 34th Annual Conference of the Australian Agricultural Economics Society, University of Queensland, Australia, 13-15 February 1990.

Narayan P, Dake C and SriRamaratnam R (1993). Determinants of Capital Investment in New Zealand Dairy Farming. Contributed Paper to the 37th Annual Conference of the Australian Agricultural Economic Society, Sydney University, Australia, 8-11 Feb 1993.

Nerlove M. (1958). Distributed lags and Demand Analysis for Agricultural and other Commodities. United States Department of Agriculture, Handbook No. 141, Ann Arbor, Michigan, USA, June 1958.

Pearse E, SriRamaratnam R and Dake C (1994). Dynamics of Supply and Demand for the New Zealand Deer Industry. Contributed Paper to the 38thAnnual Conference of the Australian Agricultural Economics Society, Victoria University, New Zealand, 7-11 February, 1994.

SriRamaratnam R, Forbes R, Narayan P, Wallace R (1995). Pastoral Sector Farm Income, Expenditure and Investment Model: Preliminary Modelling Results. Contributed Paper to the Annual Conference of the New Zealand Agricultural Economics Society, Blenheim, New Zealand, July 1995.

Forbes R and SriRamaratnam R (1995). Exotic Forestry Areas in New Zealand: Towards and Econometric Model. Contributed Paper to the Annual Conference of the New Zealand Agricultural Economics Society, Blenheim, New Zealand, July 1995.

Dake C K and Vetharaniam I (2000). Performance Review of MAF Policy Pastoral Supply Response Model, MAF Policy Kiwifruit Supply Model, MAF Policy Apple Supply Model. Report to MAF Policy, 2000.

Dake, C K (2001) MAF Deer supply and demand model review, testing for unit roots and cointegration relationships. Report to MAFPolicy, 2001.

Appendix A: Data Series for the Majority of Variables

Not all of the data series are listed below. Absent are some total values and variables that were tried but not used in the current model. In addition real price values are not listed. These are derived by dividing nominal prices by the relevant deflators. For example, the real price of lamb, RPLPP = PL/PPIS.

Sheep Industry

Mated ewes & ewe hoggets	KE
Total sheep	KS
Other sheep	KOS
Sheep stock units	SSU
Lambs marked	LM

Slaughtering of adult sheep	SLAS
Slaughtering of lambs	SLL
Wool production	WOOL

Beef Cattle Industry

Beef cows and heifers	KCHPB
Beef heifers < 1 year	KYHB
Beef calves born	CVWB

Steers 2+ year	KTS2UP
Steers R2 year	KTSR2
Steers R1 year	KTSR1
Non-brdg bulls 2+ years	KNB2UP
Non-brdg bulls R2 years	KNBR2
Non-brdg bulls R1 years	KNBR1
Total beef cattle	TOT_BEEF
Beef cattle stock units	BSU

Slaughtering of bulls	SLBULLS
Slaughtering of cows	SLCT
Slaughtering of heifers	SLHT
Slaughtering of steers	SLSTEERS
Slaughtering of veal	SLV

Dairy Cattle Industry

Dairy cows and heifers	KCHMD
Dairy bulls < 1 yr	KYBD
Dairy heifers <1 yr	KYHD
Total dairy cattle	TOT_DAIRY
Dairy cattle stock units	DSU
Dairy calves born	CVBD

Slaughtering of bobby calves	SLCV

Deer Industry

Adult stags	KADS
Breeding hinds	KBDH
Total hinds	KTDH
Total stags	KTDS
young hinds	KYDH
Young stags	KYDS
Total deer	TOT_DEER
Deer stock units	DRSU
Velvet production	QAVEL
Hind venison production	QHVEN
Adult stag venison production	QSVEN
Young stag venison production	QYVEL

Exogenous variables

Milksolids per kg	PD
Price of hind venison	PHVEN
Price of mutton	PM
Price of lamb	PL
Price of manufacturing beef	PMB
Price of prime beef	PPB
Beef industry price deflator	PPIB
Dairy industry price deflator	PPID
Sheep industry price deflator	PPIS
Price of stag venison	PSVEN
Price of velvet	PVEL
Wool price	PW
Sheep - days in soil moisture deficit	WS
Beef - days in soil moisture deficit	WB
Dairy - days in soil moisture deficit	WD
Deer - days in soil moisture deficit	WDR
Fonterra share price dummy	SHARE_DUMB

Appendix B: Female Breeding Livestock Equations

Mated ewe and ewe hoggets

Dependent Variable: KE
Method: Least Squares
Date: 11/28/03   Time: 18:11
Sample: 1985 2002
Included observations: 18
Convergence achieved after 106 iterations
Backcast: 1983 1984

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1022.573	2569.497	0.397966	0.6983
KE(-1)	0.969671	0.050358	19.25557	0.0000
RPLPP	1970.363	915.1821	2.152973	0.0544
RPDPP	-1405.658	514.3253	-2.733013	0.0195
RPPBPP	-1234.816	969.9911	-1.273018	0.2293
WS	5.404476	8.810838	0.613390	0.5521
MA(2)	0.901822	0.110596	8.154174	0.0000
R-squared	0.995402	Mean dependent var		38197.95
Adjusted R-squared	0.992893	S.D. dependent var		6881.127
S.E. of regression	580.0897	Akaike info criterion		15.84954
Sum squared resid	3701544.	Schwarz criterion		16.19580
Log likelihood	-135.6459	F-statistic		396.8486
Durbin-Watson stat	2.709525	Prob(F-statistic)		0.000000

Mated beef cows and heifers

Dependent Variable: KCHPB
Method: Least Squares
Date: 12/01/03   Time: 22:24
Sample(adjusted): 1974 2002
Included observations: 29 after adjusting endpoints
Convergence achieved after 14 iterations
Backcast: 1972 1973

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	46.92849	177.1502	0.264908	0.7935
KCHPB(-1)	0.927626	0.067706	13.70089	0.0000
RPPBPP(-1)	149.8310	58.30111	2.569952	0.0175
RPDPP	-14.57780	96.59071	-0.150923	0.8814
RPLPP	-57.44346	66.52398	-0.863500	0.3972
WB	-0.999492	1.325480	-0.754060	0.4588
MA(2)	0.009749	0.301506	0.032335	0.9745
R-squared	0.928063	Mean dependent var		1629.804
Adjusted R-squared	0.908443	S.D. dependent var		289.1659
S.E. of regression	87.49686	Akaike info criterion		11.98759
Sum squared resid	168425.4	Schwarz criterion		12.31763
Log likelihood	-166.8200	F-statistic		47.30351
Durbin-Watson stat	1.619314	Prob(F-statistic)		0.000000

Dairy cows and heifers in calf/in milk

Dependent Variable: KCHMD
Method: Least Squares
Date: 12/01/03   Time: 22:28
Sample(adjusted): 1974 2002
Included observations: 29 after adjusting endpoints
Convergence achieved after 16 iterations
Backcast: 1972 1973

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-178.4912	122.3223	-1.459188	0.1586
@TREND	14.09793	3.044940	4.629954	0.0001
KCHMD(-1)	0.804088	0.074173	10.84074	0.0000
RPDPP	200.5731	67.81798	2.957521	0.0073
RPPBPP(-1)	23.07260	40.45451	0.570334	0.5742
SHARE_DUMB	18.79242	43.28931	0.434112	0.6684
MA(2)	-0.421303	0.201140	-2.094574	0.0479
R-squared	0.989895	Mean dependent var		2760.472
Adjusted R-squared	0.987139	S.D. dependent var		475.7290
S.E. of regression	53.95010	Akaike info criterion		11.02050
Sum squared resid	64033.48	Schwarz criterion		11.35054
Log likelihood	-152.7973	F-statistic		359.1954
Durbin-Watson stat	2.177243	Prob(F-statistic)		0.000000
Inverted MA Roots	.65	-.65		

Total deer hinds

Dependent Variable: LOG(KTDH)
Method: Least Squares
Date: 12/01/03   Time: 22:52
Sample: 1986 2002
Included observations: 17
Convergence achieved after 17 iterations
Backcast: 1985

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.572358	0.308779	1.853616	0.0908
LOG(KTDH(-1))	0.912882	0.044338	20.58926	0.0000
LOG(RPHVEN(-1))	0.230580	0.086024	2.680407	0.0214
LOG(RPVEL)	0.084436	0.047476	1.778515	0.1029
LOG(RPPBPP(-1))	-0.127974	0.087953	-1.455035	0.1736
MA(1)	0.570173	0.250241	2.278498	0.0437
R-squared	0.989581	Mean dependent var		6.664147
Adjusted R-squared	0.984845	S.D. dependent var		0.471245
S.E. of regression	0.058013	Akaike info criterion		-2.585736
Sum squared resid	0.037021	Schwarz criterion		-2.291661
Log likelihood	27.97876	F-statistic		208.9513
Durbin-Watson stat	1.966978	Prob(F-statistic)		0.000000
Inverted MA Roots	-.57			