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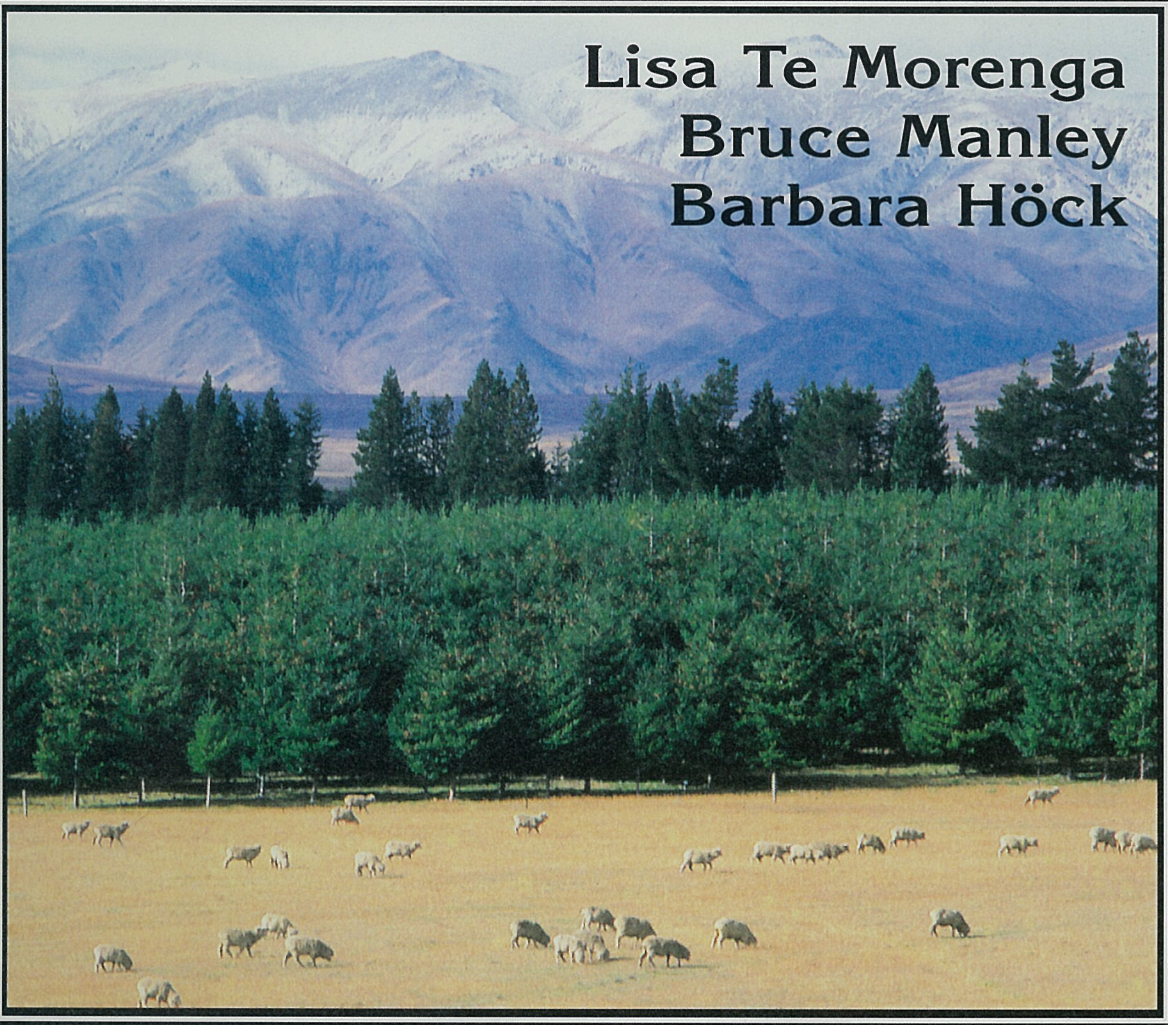
Model Inputs and Results



Lisa Te Morenga
Bruce Manley
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ABSTRACT

Potential economic impacts of five land-use scenarios for the Mackenzie/Waitaki Basin, New Zealand, were modelled using Forestry Oriented Linear Programming Interpreter (FOLPI) models. These scenarios ranged from a conservation-based (de-stocking) option through to combinations of forestry and agriculture. The impacts of each scenario on agricultural and forestry outputs, employment, and income were calculated, both for the Basin, and for administrative areas in which it falls (Mackenzie/Waitaki districts and Canterbury/Otago region).

Data sources and FOLPI problem formulations for the agricultural and forestry modelling are described. The FOLPI projections of agricultural production and wood volumes for different scenarios were combined with estimates of related employment and income to assess overall economic impacts, with and without new wood-processing facilities being established in the Basin. Processing assumptions allowed an evaluation of the change in employment and income resulting from hypothetical changes in new wood-processing in the Basin over a 90-year period.

FOLPI is typically used for forest estate planning. Its application to modelling combinations of forestry and agriculture, on a wide regional scale, is new and indicates the potential of FOLPI to be used as a tool for regional planning.

Keywords: FOLPI; land-use planning; estate modelling; Mackenzie Basin; Waitaki; high country; forestry; de-stocking; agriculture.

INTRODUCTION

This work was undertaken as part of a multi-disciplinary research study conducted by the New Zealand Forest Research Institute (Forest Research), Lincoln University, Landcare Research, and Butcher Partners. The study aimed to identify ways in which social and economic impacts of land-use change can be identified and evaluated, and made use of a variety of analytical techniques. It was designed to provide useful information for planners and administrative bodies charged with making decisions under the New Zealand Resource Management Act (Höck *et al.* 2001).

The research included a case study of the Mackenzie/Waitaki Basin in the South Island high country (Fig. 1). Farm incomes in the high country have been falling, due to land degradation, exacerbated by infestations of the weed *Hieracium* (hawkweed) and a rabbit problem (which at the time of the study was severe). The traditional land use, pastoral farming, is unsustainable in some parts of the Mackenzie/Waitaki Basin (Hughes 1991). Forestry has been seen as a possible alternative use for degraded farmland and one which could also improve income and employment levels. The study aimed to evaluate long-term social and economic effects on the Basin and wider region of such a change.

In the early part of the study, geophysical data on the Basin were compiled in a geographic

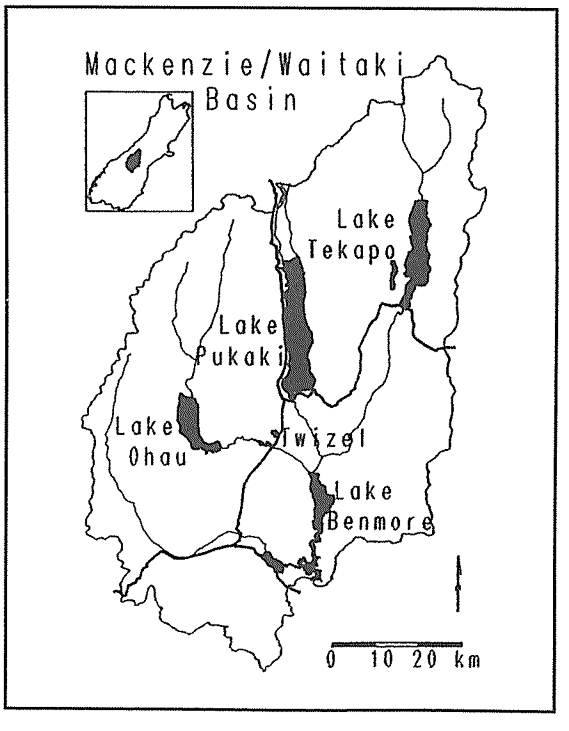


FIG. 1: The Mackenzie/Waitaki Basin

information system. In a structured survey, stakeholders were presented with a range of forestry options, together with computer visualisations of their effects on basin landforms (e.g., hills, flats). From their responses to this survey, and also to a follow-up survey, focusing on the basin as a whole, five potential land-use scenarios were developed (Fairweather and Swaffield 1996; Höck *et al.* 1995). Four of these involved forestry and one was a "conservation" option that did not include tree planting. Visual effects of each scenario on the Basin were simulated (Bennison and Swaffield 1994; Höck *et al.* 1995) and economic impacts (on employment and income) were modelled. The economic impacts of forestry regimes were modelled in two stages, firstly on a per hectare basis (Butcher 1997), and later for the Basin and the region as a whole. This Bulletin describes the data sources and modelling methodology used in the Basin-wide/regional economic evaluation.

FOLPI (Garcia 1984, 1990; Manley *et al.* 1991), a forest estate modelling system developed by Forest Research, was used to model the economic impacts of the five scenarios. Although FOLPI is used chiefly in forestry situations, it has the flexibility to model a wide variety of land uses (Forest Research Institute 1989). Agricultural and forestry outputs, and associated employment and income, were evaluated under each scenario for the Mackenzie/Waitaki Basin, its district, and the wider region over a 90-year period.

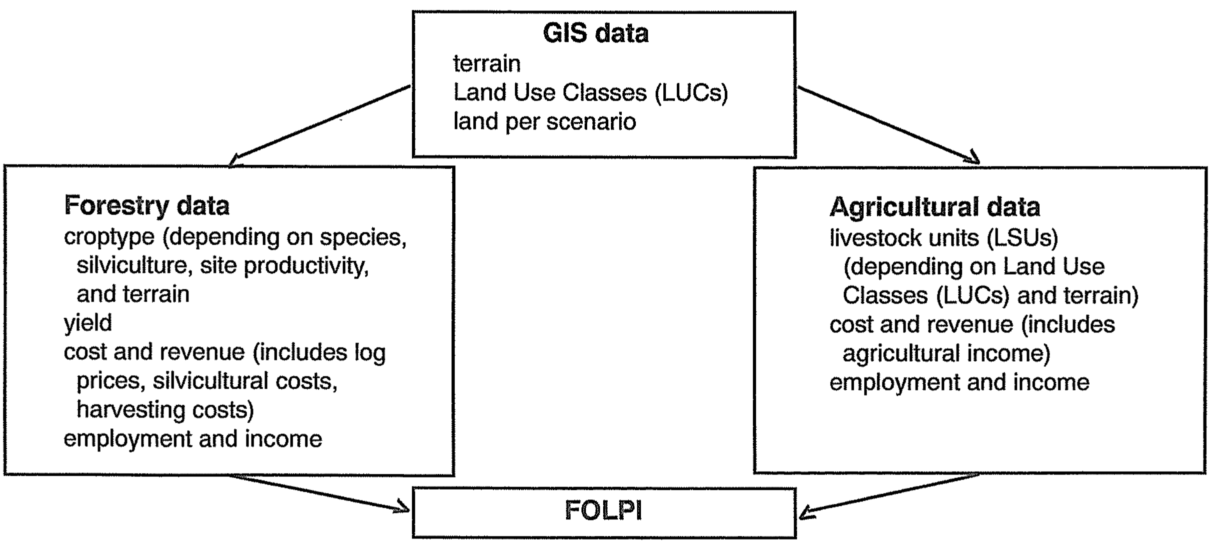
DATA REQUIREMENTS AND FOLPI PROBLEM FORMULATION

Data Requirements

FOLPI has been developed to assist estate planning ("estate" being a forest, several forests, or other productive land holdings) and data requirements include a current description of the land estate. In this instance, the estate included both a forestry component and an agricultural component. For the purpose of comparing scenarios, the forestry component was assumed to start at zero. In modelling of forest estates, forest stands are grouped into "croptypes" based on species, silviculture, site productivity, and terrain. For the Mackenzie /Waitaki Basin, agriculture was modelled in addition to forestry croptypes by treating grazing as a croptype that was harvested annually.

For each croptype included, the model requires a yield table; for forestry crops this gives the total merchantable volume produced at harvest, broken down into log grades, and for other crops it gives some similar measure of production. Yield tables were obtained for forestry modelling from the model STANDPAK (Whiteside 1990). Agricultural production was modelled as livestock units (LSU) per hectare. For financial evaluations, cost and revenue data (such as log prices, agricultural income, silvicultural costs, harvesting costs) are added to the datafile, while social evaluations require data on employment and income. A summary of the FOLPI data inputs used is given in Fig. 2.

FIG. 2: Summary of FOLPI data inputs used (some of the terminology is explained in the text)



Problem Formulation

The FOLPI model can be used in one of two ways: either to simulate and compare results of different land management strategies; or to find an optimum management strategy for a given objective and constraints. This was a simulation study in which the aim was to compare pre-set scenarios. It therefore used the simulation capabilities of FOLPI.

A data file was created for each land-use scenario. The basic data for these files were obtained from earlier parts of the research programme, as reported by Höck *et al.* (1995, 2001), Evison and Swaffield (1994), Fairweather and Swaffield (1996), and Butcher (1997). Forestry data included: thinnings volumes and revenues, volumes of log grades obtained at clearfelling, logging costs and revenues, silvicultural costs, and forestry employment factors. Agricultural data comprised livestock units per hectare and associated agricultural employment and income. Unique models were created for each scenario.

Earlier economic modelling carried out by Butcher (1997) had estimated direct and indirect (flow-on) employment and income impacts of the various forestry regimes, on a per hectare basis, and also scaling factors (multipliers) required to convert from Basin impacts to district and regional impacts. The FOLPI models were used to assess the overall impact of the scenarios, when these production figures and multipliers were applied to different areas and combinations of landforms in the Basin, as determined by the scenario constraints. Outputs of forestry and agricultural production produced by the models were used to calculate employment and income for the Basin, the district, and the wider region, for each scenario.

DESCRIPTION OF DATA INPUTS

Landform Classification of the Mackenzie/Waitaki Basin

Before modelling could begin it was necessary to identify those areas in the Mackenzie/Waitaki Basin where some form of forestry could be considered, and the type of forestry appropriate for them. From a total area of 772 700 ha within the Basin, 215 500 ha was considered to be available for possible conversion to forestry or mixed forestry and agriculture, and this was the area modelled under the five scenarios. Land in this area was classified into four broad landform classes (dry flats, wet flats, toe slopes, and hills) which related to slope and rainfall (Höck *et al.* 1995), in order to determine the amount of land available for the specific forestry regimes listed below.

Forestry Data

Five forestry regimes (Corsican pine sawlogs, Corsican pine poles, ponderosa pine sawlogs, Douglas-fir production-thinned, and Douglas-fir thinned to waste—*see* Ledgard 1994a, b) were selected as appropriate for the Basin. The regimes appropriate to each area were allocated, necessitating the landforms to be further subdivided by rainfall and aspect parameters. These combinations of landform, rainfall, and regime, together with the appropriate yields, gave a total of 12 unique combinations (or 12 croptypes in the FOLPI model). The landform class, rainfall, regime, and yield table for each crop type, and the area available for conversion to each crop type, are summarised in Table 1.

Calculation of yield tables

Growth model estimates based on high altitude data provided basal area, height, stocking, and volumes for the various forestry croptypes (Ledgard 1994a; Höck *et al.* 2001). STANDPAK (Whiteside 1990) was used to generate log assortment and log grade yield tables. The basal area, height, stocking, and volume estimates for ages 40, 45, and 50 for each species were used as direct inputs into STANDPAK. STANDPAK's inbuilt models for Douglas-fir, and for ponderosa pine and Corsican pine (if models existed), for all New Zealand or Southland, were used to achieve realistic log assortments (*see* Appendix 1). Douglas-fir models were used when there were no alternatives for ponderosa and

TABLE 1: Area and forestry regimes for each combination of landform and rainfall class.

Landform class	Rainfall range (mm/yr)	Regime	Yield table (*see* next section)	Area (ha)*
dry flat	<600	Corsican sawlog	CORS1-1	55 633
dry flat	600–800	ponderosa sawlog	PPON1_1	46 932
wet flat	800–1000	Corsican poles	CORS3_2	11 677
wet flat	>1200	ponderosa sawlog	PPON3_2	11 763
toe slope	<600	Corsican sawlog	CORS1_3	7 722
toe slope	600–800	ponderosa sawlog	PPON1_3	7 237
toe slope	800–1000	Douglas-fir prod. thin	DFIR5_3	4 031
toe slope	>1200	Douglas-fir prod. thin	DFIR7_3	8 617
hills	<600	Corsican sawlog	CORS1_4	31 759
hills	600–800	Corsican sawlog	CORS2_4	13 890
hills	600–800 (southerly aspect), and 800–1000	Douglas-fir waste	DFIR2_4	7 381
hills	>1200	Douglas-fir waste	DFIR4_4	8 833
TOTAL				215 500

* Areas are given to the nearest 1 ha; however, the GIS data used to calculate these were not necessarily so precise.

Corsican pine. Log grade specifications used as inputs in STANDPAK for each of the three species are given in Tables 2 and 3. The actual STANDPAK models used are provided in Appendix 1.

The yields produced in STANDPAK by log grade for clearfelled material and production thinnings for ages 40, 45, and 50 for each of the forestry croptypes in Table 1 are given below in Table 4. Yield tables for shelterbelts were created by adjusting the growth model estimates for stands (N.J.Ledgard, unpubl. data).

TABLE 2: Log grade specifications for Douglas-fir and ponderosa pine

Log grade	Log length (m)	Minimum s.e.d. (cm)
No1	12	30
No2	12	20
No1b	8	30
No2b	8	20
Dom1	4–6	30
Dom2	4–6	15
Pulp	4–6	8

TABLE 3: Log grade specifications for Corsican pine

Log grade	Log length (m)	Minimum s.e.d. (cm)
No2 (pole)	12	20
No2b (pole)	8	20
Dom2	4–6	15
Post	1.8	8
Pulp	4–6	8

The yields produced in STANDPAK are given for each regime in Table 4.

TABLE 4: Yield tables: clearfell and production thinning volumes by log grade for each forestry regime

Douglas-fir, waste thinned, hills, rainfall 800–1000 mm/yr (DFIR2_4)

Age	Recoverable clearfell volumes by log grades (m^3)							Total
	NO1	NO1B	NO2	NO2B	DOM1	DOM2	PULP	
40	13	52	34	95	52	134	42	420
45	55	183	37	40	30	136	43	524
50	178	130	41	45	71	125	47	635

Douglas-fir, waste thinned, hills, rainfall >1200 mm/yr (DFIR4_4)

Age	Recoverable clearfell volumes by log grades (m^3)							Total
	NO1	NO1B	NO2	NO2B	DOM1	DOM2	PULP	
40	261	139	18	22	104	126	48	718
45	350	149	13	45	156	120	52	885
50	549	101	8	63	199	89	59	1067

Douglas-fir, production thinned, toe slopes, rainfall 800–1000 mm/yr (DFIR5_3)

Age	Recoverable clearfell volumes by log grades (m^3)							Total
	NO1	NO1B	NO2	NO2B	DOM1	DOM2	PULP	
40	4	27	31	94	31	125	40	352
45	26	146	41	43	17	129	40	443
50	124	114	49	39	49	127	43	545
Age	Recoverable production thinning volumes by log grades (m^3)							Total
	NO1	NO1B	NO2	NO2B	DOM1	DOM2	PULP	
25	0	0	0	17.6	1.9	121	57.8	198.3

Douglas-fir, production thinned, toe slopes, rainfall >1200 mm/yr (DFIR7_3)

Age	Recoverable clearfell volumes by log grades (m^3)							Total
	NO1	NO1B	NO2	NO2B	DOM1	DOM2	PULP	
40	184	125	32	33	74	111	43	603
45	270	131	21	49	111	121	48	751
50	454	64	13	77	164	93	54	919
Age	Recoverable production thinning volumes by log grades (m^3)							Total
	NO1	NO1B	NO2	NO2B	DOM1	DOM2	PULP	
25	0	0	0	17.6	1.9	121	57.8	198.3

Ponderosa pine, sawlogs, dry flats and toe slopes, rainfall 600–800 mm/yr (PPON1_1 & PPON1_3)

Age	Recoverable clearfell volumes by log grades (m^3)							Total
	NO1	NO1B	NO2	NO2B	DOM1	DOM2	PULP	
40	0	9	12	126	51	84	30	313
45	0	113	33	45	67	106	34	398
50	20	147	22	55	94	112	37	486

Ponderosa pine, sawlogs, wet flats, rainfall >1200 mm/yr (PPON3_2)

Age	Recoverable clearfell volumes by log grades (m^3)							Total
	NO1	NO1B	NO2	NO2B	DOM1	DOM2	PULP	
40	14	171	27	37	101	103	35	487
45	197	128	23	29	101	101	38	617
50	289	189	6	22	122	95	46	768

TABLE 4: Yield tables (cont.)

Corsican pine, sawlog regimes on dry sites (rainfall <600 mm/yr) (CORS1_3 & CORS1_4)

Age	Recoverable clearfell volumes by log grades (m^3)					Total
	NO1	NO2	NO3	POST	PULP	
40	0	50	167	12	36	266
45	27	68	194	1	45	334
50	29	167	166	0	36	398

Corsican pine, sawlogs, hills, rainfall 600–800 mm/yr (CORS2_4)

Age	Recoverable clearfell volumes by log grades (m^3)					Total
	NO1	NO2	NO3	POST	PULP	
40	4	61	211	1	38	314
45	23	163	163	0	37	386
50	98	130	187	2	40	457

Corsican pine, poles, wet flats, rainfall 800–1000 mm/yr (CORS3_2)

Age	Recoverable clearfell volumes by log grades (m^3)					Total
	NO1	NO2	NO3	POST	PULP	
35	3	38	234	47	105	426
40	14	132	237	40	107	531
45	13	128	333	30	126	629
50	67	155	345	33	119	719

Calculation of costs and rates of return

Operational forestry costs for each of the crop types (Appendix 2) are given by Höck *et al.* (2001). For planting, it was assumed that mechanical operations were carried out on the flats and toe slopes, and that hand planting was done on the hills. Estimates of man-hours required for planting, releasing, thinning, and pruning operations were those used by Butcher (1997) to calculate the number of annual full-time equivalents (FTEs) for employment generated by each silvicultural operation on 1000 ha. Clearfell revenues were derived from the log grade prices given in Table 5. Costs for each forestry croptype, incurred in controlling wilding spread, were included as an annual overhead (given by Höck *et al.* 2001).

TABLE 5: Log prices by species and log grade for Mackenzie/Waitaki Basin

Species	Log length (m)	Minimum s.e.d. (cm)	Description	Value: $ / m^3 (at wharf / mill)
Douglas-fir	12	30	Export	240
	12	20	Export	200
	8	30	Export	180
	8	20	Export	160
	4–6	30	Domestic saw	150
	4–6	15	Domestic saw	120
	4–6	8	Domestic pulp	45
Ponderosa	12	30	Export	120
	12	20	Export	90
	8	20	Export	75
	4–6	30	Domestic saw	75
	4–6	15	Domestic saw	65
	4–6	8	Domestic pulp	40
Corsican	12	20	Export pole	150
	9	20	Export pole	150
	4–6	15	Domestic saw	90
	1.8	8	Post	80
	4–6	8	Domestic pulp	40

Based on the silvicultural costs and harvest revenues, internal rates of return (IRRs) were calculated for each of the croptypes for harvest at ages 40, 45, or 50 years (Table 6). Note that IRRs were not calculated for rotation lengths beyond 50 years (the longest rotation for which volume was estimated).

TABLE 6: Internal rates of return for Mackenzie Basin forestry regimes.

Landform class	Rainfall class	Species	Regime	IRR @ age 40	IRR @ age 45	IRR @ age 50
dry flat	<600	Corsican	sawlog	5.3	5.5	5.8
dry flat	600–800	ponderosa	sawlog	3.9	4.4	4.5
wet flat	800–1000	Corsican	pole	7.3	6.7	6.5
wet flat	>1200	ponderosa	sawlog	6.1	6.6	3
toe slope	<600	Corsican	sawlog	5.3	5.5	5.8
3	>1200	Douglas-fir	production thin	12.6	12.0	11.5
3	800–1000	Douglas-fir	production thin	9.3	9.3	9.0
4	600–800 S. aspect; and 800–1000	Douglas-fir	waste thin	7.8	7.9	7.7
4	≥ 1200	Douglas-fir	waste thin	10.5	9.8	9.3
4	≤ 600	Corsican	sawlog	4.7	5.0	5.3
4	600–800	Corsican	sawlog	5.3	5.9	5.7

Agricultural Data

Land in the 215 500 ha study area was classified using agricultural Land Use Classes (LUCs) based on Land Resource Inventory data (Water and Soil Division 1979). Each landform and rainfall combination listed in Table 1 contained a number of agricultural LUCs, and an individual LUC could be present in a number of the combinations, or all of them. Each had an associated livestock carrying capacity or LSU (Live Stock Units) per hectare, which varied according to whether land was improved or unimproved. Information regarding the level of improvement of agricultural land and LSUs/ha for unimproved and improved land is given for each LUC in the Mackenzie/Waitaki Basin in Table 7.

Yield tables (LSU values) for agricultural land were created and built into the FOLPI datafile. For each agricultural LUC, the weighted average livestock carrying capacity (or LSU) based on the proportions of improved and unimproved land was calculated. LSU values were assumed to be constant for all model periods.

SCENARIO MODELLING

Total forestry and agricultural production in the Basin, plus related employment and income, were modelled under the five scenarios of land use formulated during the initial part of the study (Höck *et al.* 1995). The scenarios reflected the range of responses from stakeholders on their preferred forestry options, for particular landforms, and the Basin generally. The scenarios then determined the areas used for afforestation in the FOLPI models.

- Scenario A, Plantations: Commercial plantations on 70% of the available land on all four types of landform, with wild seedling management.
- Scenario B, Grazing/trees: Shelterbelts and improved pasture on 70% of higher rainfall flats and lower slopes, and plantations on 15% of hills, with wild seedling management.
- Scenario C, Conservation/destocking: Removing all livestock from the available land.
- Scenario D, Plantations on 15% of all landforms, without wild seedling management.
- Scenario E, Plantations on 15% of all landforms, with wild seedling management.

TABLE 7: Livestock units per hectare for agricultural land-use classes

Valley floor	LUC unit		Estimated carrying capacity (lsu/ha)						Gross margins ($/lsu)	Proportion		lsu/ha			Gross margin ($/ha)
	W.side (moist)	E.side (dry)	Present average			Top farmer				Unimproved	Improved	Unimproved	Improved	Wght av.	
			Unimpr.	Improved	Irrig.	Unimpr.	Improved	Irrig.							
Floodplains	4e8		2	4	na	2.5	5	na	17.69	0	100	2	4	4	70.76
	4s12		2	4	na	2.5	5	na	13.48	40	60	2	4	3.2	43.12
	6s11		0.5	1–2	na	1.5	2	na	31.47	20	80	0.5	1.5	1.3	40.91
		7s2	0.1	0.2	na	0.2	0.5	na	18.98	100	0	0.1	0.2	0.1	1.90
	7s3		0.1	0.2	na	0.2	0.5	na	13.48	100	0	0.1	0.2	0.1	1.35
		3c1	2	5–7	10	na	8	15	17.69	20	80	2	6	5.2	91.98
		4s6	0.5–1	4	10	2	8	15	23.14	20	80	0.75	4	3.35	77.51
		4s12	0.5–1.0	4	10	2	8	15	23.14	40	60	0.75	4	2.7	62.47
		6s11	0.5	1–2	5	1.5	2	12	17.69	20	80	0.5	1.5	1.3	23.00
		7s2	0.1	0.2	?	0.2	0.5	10	13.48	100	0	0.1	0.2	0.1	1.35
		7s3	0.1	0.2	6	0.5	1.5	10	13.48	100	0	0.1	0.2	0.1	1.35
Terraces	3e15		2	5	10		10	na	31.47	40	60	2	5	3.8	119.57
moraines	4e12		1	3–5	na		5	na	31.47	60	40	1	4	2.2	69.22
mainly flat	4e16		0.9	1.5	na	1	2	na	13.48	50	50	0.9	1.5	1.2	16.17
	6s12		0.5	1.5	na	1	2	na	13.48	90	10	0.5	1.5	0.6	8.09
	7c3		0.2	0.2	na	0.2	na	na	17.69	100	0	0.2	0.2	0.2	3.54
		3e11	2	5–7	10	3	8	15	20.90	20	80	2	6	5.2	108.68
		4s9	1	3	6	3	2	12	20.90	50	50	1	3	2	41.80
		5s3	0.3	1.5	na	0.5	3	na	22.37			0.3	1.5	0	0.00
		5s3	0.3	2	na	0.3	3	na	22.37	80	20	0.3	2	0.64	14.32
		6s7	0.1–0.2	0.5–1	6	0.2	2	12	20.90	90	10	0.15	0.75	0.21	4.39
		7s12	<0.1	na	na	0.1	na	10	20.90	100	0	0.1	0.1	0.1	2.09
Undulating	4e10		2	6	na	2	6	na	22.37	50	50	2	6	4	89.47
–rolling	6c1		1	2	na	1	2	na	20.90	80	20	1	2	1.2	25.08
	6e27		0.15	na	na	0.25	na	na	23.14	80	20	0.15	1.5	0.42	9.72
		4e9	2–3	4–5	10	3	6–7	15	17.69	50	50	2.5	4.5	3.5	61.91
		4e12	0.5–1	2–5	10	?	2.5–7	15	20.90	60	40	0.75	3.5	1.85	38.67
		6c3	0.2	2.5	na	0.5	3	na	0.00	80	20	0.2	2.5	0.66	0.00
		6e26	0.2	1.5–2	na	0.25	3	na	34.83	80	20	0.2	1.75	0.51	17.76
		6s9	0.2	1.5	na	0.5	2	na	34.83	90	10	0.2	1.5	0.33	11.49

TABLE 7: Livestock units per hectare (cont.)

Valley floor	LUC unit		Estimated carrying capacity (lsu/ha)						Gross margins ($/lsu)	Proportion		lsu/ha			Gross margin ($/ha)
	W.side (moist)	E.side (dry)	Present average			Top farmer				Unimproved	Improved	Unimproved	Improved	Wght av.	
			Unimpr.	Improved	Irrig.	Unimpr.	Improved	Irrig.							
Impeded	5w2		1–2.5	2–4	na	3	8	na	31.47	60	40	1.75	3	2.25	70.80
drainage	6w3		1	2	na	2	6	na	31.47	80	20	1	2	1.2	37.76
		3w1	3	6	na	4	10	na	28.32	80	20	3	6	3.6	101.94
		4w2	3–5	6	na	5	10	na	28.32	50	50	4	6	5	141.59
		5w1	1–2.5	2–4	na	?	8	na	28.32	50	50	1.75	3	2.375	67.25
		5w2	1–2.5	2–4	na	?	8	na	28.32	60	40	1.75	3	2.25	63.71
Steeplands														0	0.00
lower-mid	6e29		0.5	2	na	1	3	na	34.83	80	20	0.5	2	0.8	27.87
slopes	7e23		0.3	1	na	0.5	2	na	31.47	90	10	0.3	1	0.37	11.64
		6e14	0.5	2	na	0.7	3	na	28.32	80	20	0.5	2	0.8	22.65
		6e15	0.5	2	na	0.7	3	na	28.32	80	20	0.5	2	0.8	22.65
		6e19	0.3	1.5	na	0.5	2	na	28.32	80	20	0.3	1.5	0.54	15.29
		6e22	0.5	2	na	0.7	3	na	28.32	80	20	0.5	2	0.8	22.65
		6e23	0.5	2	na	1	3	na	28.32	80	20	0.5	2	0.8	22.65
		6c1	1	2	na	1.5	2.5	na	20.90	80	20	1	2	1.2	25.08
		7e12	0.1	0.5	na	0.5	1.5	na	18.98	90	10	0.1	0.5	0.14	2.66
		7e6	0.2	0.5	na	0.2	1	na	18.98	90	10	0.2	0.5	0.23	4.37
		7e24	0.1	na	na	o.15	na	na	23.14	100	0	0.1	0.1	0.1	2.31
Upper	7c4		0.2	na	na	0.2	na	na	18.98	100.0	0.2	0.2	0.2	3.80	
slopes	7e17		0.2	na	na	0.3	na	na	N/A	100	0	0.2	0.2	0.2	N/A
	7e18		0.15	na	na	0.2	na	na	N/A	100	0	0.15	0.15	0.15	N/A
	7e26		0.1	na	na	0.2	na	na	N/A	100	0	0.1	0.1	0.1	N/A
		7c4	0.15	na	na	0.2	na	na	28.32	100	0	0.15	0.15	0.15	4.25
		7e21	0.1–0.2	na	na	0.2	na	na	N/A	100	0	0.15	0.15	0.15	N/A
		7E26	0.1–0.2	NA	NA	0.2	NA	NA	N/A	100	0	0.15	0.15	0.15	N/A

The areas that would be planted in trees in the long term for each scenario are given in Table 8. (It was assumed that no forest or shelter trees previously existed on the 215 500 ha suitable for forestry in the study area).

TABLE 8 – Area planted with trees under different land-use scenarios

Land-use scenario	Areas planted (total ha)	Wilding spread
Scenario A—plantations (70%)	150 853	
Scenario B—mixed grazing and trees	116 828	
Scenario C—conservation	0	
Scenario D—plantations (15%), no wilding control	32 326 plus wilding spread of:	1698 ha/yr from 2040 6422 ha/yr from 2065 9766 ha/yr from 2084
Scenario E—plantations (15%), + wilding control	32 326	

Scenario Representations in FOLPI

Scenarios A (plantations 70%) and E (plantations 15%)

For Scenario A, 70% of the land available in each landform and rainfall-class combination was afforested in equal amounts annually for 45 years. Scenario E was identical except that only 15% of the total available land in each landform and rainfall-class combination was planted. At the beginning of the modelling period, all land available for forestry was held in the agricultural croptypes. The model planted land on the basis of the worst agricultural land (based on LSUs) first. Wilding control was undertaken to prevent forest spread. Trees were harvested at age 45 years.

Scenario B (shelterbelts and improved pasture 70%, plantations 15%)

Under Scenario B, 70% of flat and toe slope areas were converted to improved pasture and shelterbelts and 15% of the hill slopes were converted to plantations over 45 years. Land on the flat and on toe slopes was classified as having either improved or unimproved pasture. Land from the same LUC but with different improvement status had a different LSU per hectare. Conversion to improved pasture with shelterbelts was done by first converting all the improved pasture in the initial area database into improved pasture with shelterbelts, in equal total annual amounts. As the already improved pasture did not constitute 70% of the land available for planting, the balance was converted from the unimproved pasture. Conversion to improved pasture with shelterbelts was done on the basis of maximising the livestock carrying capacity—that is, the land-use classes that gave the highest rates of improvement were converted first.

For each flat and toe slope LUC, a new "improved with shelter" croptype was derived, with the shelter component covering 3.5% of each hectare. Land within each LUC was found on a variety of landform and rainfall sites. The landform and rainfall class of the majority of stands in each LUC determined what type of shelter regime would be applied in the "improved with shelter" croptype. In the FOLPI datafile, agricultural products were combined with the forestry products, using LSU values for improved pasture in the shelter croptypes. A cost reflecting the annual costs of trimming shelterbelts was added.

As with Scenarios A and E, this land was planted up over 45 years so that the four rainfall zones were planted in equal annual amounts. The unimproved land was planted in the same way as the improved land—over 45 years with equal annual amounts for each shelterbelt regime.

Fifteen percent of the land available for each of the five hill landform and rainfall combinations was planted up over 45 years in equal annual amounts. All trees (forests and shelterbelts) were harvested at age 45 years and wilding control was undertaken.

Scenario C (conservation—destocking)

In Scenario C, the total study area (215 504 ha) was destocked over 10 years in equal annual amounts, on the basis of least productive land first. No wilding control was modelled; to be consistent with the other scenarios it was assumed that no trees existed previously. The FOLPI datafile consisted only of yield tables for each agricultural croptype (including a de-stocked croptype).

Scenario D (plantations 15 % without wilding management)

This scenario was similar to Scenario E. However, wilding control was not undertaken, leading to forest spread. By Year 12 new stands began to emerge, and were assumed to have final wood volume yields identical to those of the parent forest regime. All trees were harvested at age 45 and the land from the wilding trees was replanted into the parent regime. The wilding spread process is described by Höck *et al.* (2001).

New croptypes imitating parent forest croptypes were created for wilding spread. These new croptypes varied from the parent croptypes only in that the costs of establishment were nil and that all wilding croptypes were thinned at age 10 (thus incurring a higher cost of thinning because stockings were higher than in the planted stands). Wilding croptypes resulting from production thinning regimes were also production thinned, but no other silvicultural operations were undertaken. The annual overhead cost incurred in the other scenarios for wilding control was not included in this model. Wildings were modelled as an echo of the initial planting after 26 years. Wildings eventually formed new, entire plantations of a size 5–10% of the original plantation. The echo effect repeated after another 20 years, and 20 years after that. However, for simplicity, no ripple was assumed to arise from the plantations which originated as wildings.

Economic Impact of Agricultural and Forestry Operations

Multiplying factors, calculated by Butcher (1997), were applied to the FOLPI-derived woodflows and LSU flows to give estimates of total income, gross household income, and employment generated by the scenarios—for the Basin, the administrative districts in which it falls (combined Waitaki and Mackenzie districts), and the wider region (combined Canterbury and Otago regions). Separate calculations were made for agriculture and forestry. For forestry, employment and income were further broken down into operational categories of nursery work, planting and silviculture, roading, logging, transport, management, and royalties. In calculating agricultural impacts, the total LSU for the Basin was used, together with factors that translated this figure into jobs and income for a given area. The multipliers for agriculture that were used to generate employment levels, total revenue, and household income are listed in Table 9. The multipliers were applied to the total number of stock units in each year of the modelling exercise.

TABLE 9: Agricultural multipliers

EMPLOYMENT (FTE/LSU)	
Direct	0.000332
Basin	0.000384
District	0.000582
Region	0.000958
OUTPUT ($/LSU)	
Direct	34.474
Basin	40.263
District	54.211
Region	87.632
INCOME (Gross household $/LSU)	
Direct	8.421
Basin	10.000
District	14.737
Region	26.579

The forestry multipliers used, and how they were applied to various FOLPI outputs to give levels of employment, total revenue, and household income, are listed in Table 10.

TABLE 10: Impacts and multipliers for forestry employment, output, and income resulting from land use change in the Mackenzie Basin, the district, and the Canterbury region.

	Direct	Applied to:	Basin	District	Region	Applied to:
EMPLOYMENT						
Nursery	0		0	0.010	0.011261	Ha established
Plant/Silv.	1		1.06	1.130	1.31	All silv. & estab. costs
Roading	0.005	Ha clearfell	1.2	1.480	1.96	Direct
Logging	0.09	Ha clearfell+0.2 × ha thinnings	1.09	1.230	1.54	Direct
Transport	0.072	Ha clearfell+0.2 × ha thinnings	1.21	1.590	1.94	Direct
Management	0.0009		0.0009	0.001100	0.0016	Total estate at time
Royalty (/ha)	0		0.0135	0.030	0.071	Ha clearfell
OUTPUT						
Nursery						
Plant/Silv.	1	All silviculture & establ.costs	1.22	1.430	1.99	Direct
Roading	1	2 × volume clearfell	1.21	1.460	1.95	Direct
Logging	1	20 × volume clearfell+25 × volume thinnings	1.15	1.340	1.78	Direct
Transport	1	20 × volume clearfell+20 × volume thinnings	1.21	1.440	1.86	Direct
Management	1	25 × forestry estate ha	1.25	1.590	2.17	Direct
Royalty (/ha)	1	Clearfell and thinnings revenues	1.07	1.130	1.28	Direct
INCOME—Gross household income						
Nursery						
Plant/Silv.	0.8	Plant/silv. direct impact for Output	1.07	1.150	1.37	Direct
Roading	0.18	Roading direct impact for Output	1.15	1.340	1.73	Direct
Logging	0.5	Logging direct imapct for Output	1.06	1.170	1.41	Direct
Transport	0.33	Transport direct impact for Output	1.16	1.370	1.68	Direct
Management	0.4	Management direct impact for Output	1.1	1.480	1.99	Direct
Royalty (/ha)	0.3	Royalty direct impact for Output	1.05	1.100	1.26	Direct

Economic Impact of Processing In the Basin

Based on wood volumes resulting from the four forestry scenarios, four processing scenarios were developed for the Mackenzie Basin by *Forest Research* (Butcher 1997). Although many different scenarios are possible, these represented processing that could reasonably be expected to become established within the Basin area. They were modelled by Butcher (1997) to indicate likely income and employment impacts for the Basin, district, and region. The impacts were "net" in that they took account of reductions in employment and income resulting from reduced transport of logs from the region. The employment and income effects of establishing new forest processing industries, for each scenario, are summarised in Table 11.

The impacts of meat and wool processing per $1 million of farm output are shown in Table 12.

Employment and income from processing were estimated for each scenario based on the "steady state" number of LSUs in the Basin study area, found after modelling each scenario. Steady state occurred once forestry was completely established, i.e., at the end of the first rotation (45 years), except where there was no control of wildings.

*TABLE 11: Processing impacts from forestry**

Scenario	Direct	Basin	District	Region
Income ($ million)				
A	25.1	23.6	28.3	44
B	3.8	1.9	4.5	6.8
C	0	0	0	0
D	5.8	2.5	6.7	10.2
E	5.8	2.5	6.7	10.2
Employment (FTEs)				
A	725	719	916	1430
B	104	48	131	202
C	0	0	0	0
D	166	73	204	317
E	166	73	204	317

* from Butcher (1997).

*TABLE 12: Impacts of agriculture**

Farm output	Multipliers for $ 1 million of "output"		
Employment			
Wool scouring	Region	Direct	1.2
		Total	3.3
Meat	Region	Direct	3.8
		Total	8.7
	District	Total	6.2
Income			
Wool scouring	Region	Direct	0.03
		Total	0.1
Meat	Region	Direct	0.14
		Total	0.29
	District	Total	0.22

* from Butcher (1997

RESULTS

The FOLPI forecasts for the five scenarios, as applied in the Mackenzie/Waitaki Basin, have been graphed for employment (Fig. 3), income (Fig. 4), livestock units (Fig. 5), and wood volume harvested (Fig. 6). Only the results of the forestry and farming activities are shown in the graphs; the impacts of any processing are additional.

All scenarios modelled, except conservation (not producing direct outputs), had a positive impact on employment and income. Scenario A gave by far the biggest impact but would require the development of plantations over a significant area of the available land. The next best was Scenario B which, in addition to providing income from forestry, allowed an increase in the region's livestock numbers through pasture improvement.

The effects of the scenarios on stock numbers, employment, and household income after 45 years (at steady state), with and without new processing, are shown in Tables 13–17. Increases in income and employment in the Mackenzie Basin, district, and region due to forestry and processing are summarised in Tables 18 and 19, and total values of employment and income generated from processing for each scenario at steady state (2040) are given in Table 20.

The potential impact of processing (Tables 18–20) is very significant in terms of increasing employment and income

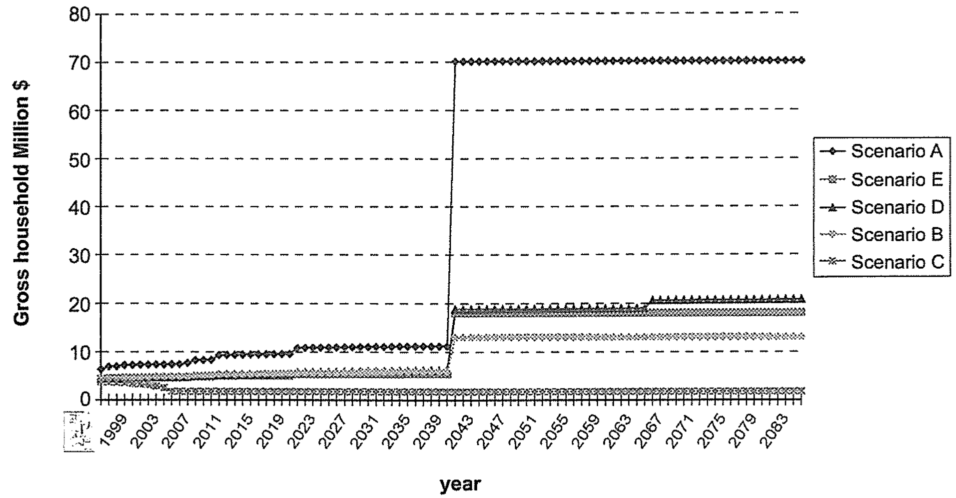


FIG. 3: Basin total employment, by scenario

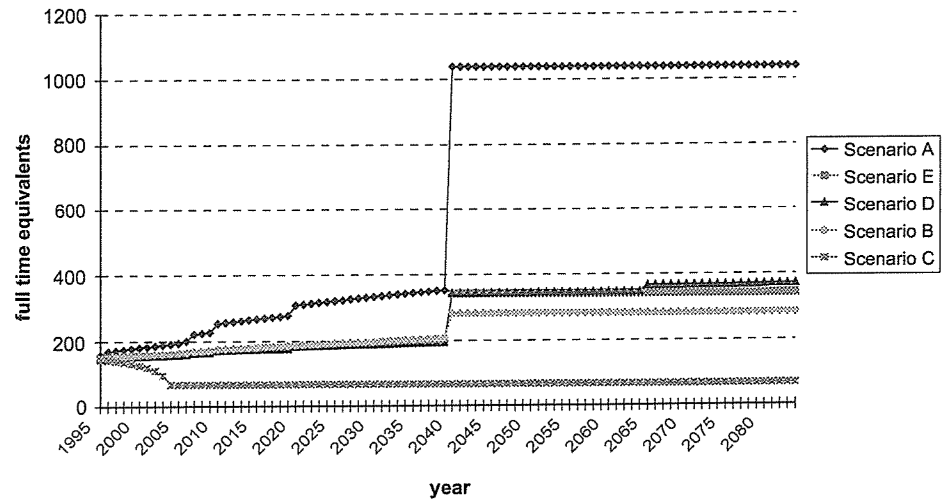


FIG. 4: Basin total stock units, by scenario

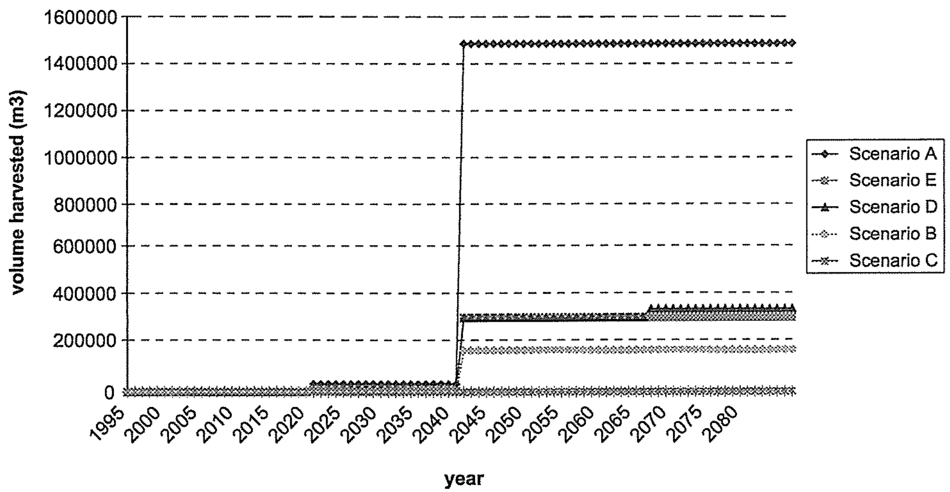


FIG. 5: Basin total income, by scenario

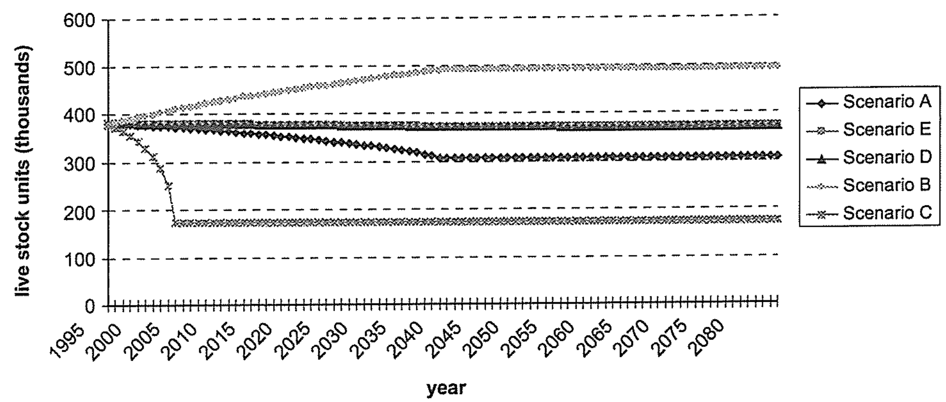


FIG. 6: Basin total harvested wood volume, by scenario

TABLE 13: Scenario A—Plantations across 70% of all landforms; wilding control

Area	Measure		Current	Steady state	Change (%)
Basin	Stock units		379 906	306 717	–19
Basin	Gross household income	*($)*	$3,799,060	$70,122,979	1746
	Employment	*(FTE)*			
Direct	Farm		126	102	–19
Direct	Forestry		0	786	na
Basin	Total		146	1 038	611
District	Gross household income	*($)*	$5,598,615	$77,926,556	1292
District	Employment	*(FTE)*	221	1369	519
Region	Gross household income	*($)*	$10,097,502	$95,205,799	843
Region	Employment	*(FTE)*	364	1905	423
Net processing impacts					
Basin	Employment	*(FTE)*	0.0	719	na
Basin	Income	*($)*	$0	$23,600,000	na
District	Employment	*(FTE)*	128	1019	698
District	Income	*($)*	$4,530,879	$31,958,004	605
Region	Employment	*(FTE)*	400	1753	339
Region	Income	*($)*	$12,983,787	$54,482,457	320

TABLE 14: Scenario B—Improved pasture and shelter-belts on 70% of flats and toe slopes, plantations on 15% of hills; wilding control

Area	Measure		Current	Steady state	Change (%)
Basin	Stock units		379 906	491 245	29
Basin	Gross household income	*($)*	$3,799,060	$13,107,648	245
	Employment	*(FTE)*			
Direct	Farm		126	163	29
Direct	Forestry		0	53	na
Basin	Total		146	283	94
District	Gross household income	*($)*	$5,598,615	$16,188,733	189
District	Employment	*(FTE)*	221	460	108
Region	Gross household income	*($)*	$10,097,502	$23,664,576	134
Region	Employment	*(FTE)*	364	772	112
Net processing impacts					
Basin	Employment	*(FTE)*	0.0	48	na
Basin	Income	*($)*	$0	$1,900,000	na
District	Employment	*(FTE)*	128	296	132
District	Income	*($)*	$4,530,879	$10,358,739	129
Region	Employment	*(FTE)*	400	719	80
Region	Income	*($)*	$12,983,787	$23,588,933	82

TABLE 15: Scenario C—Destocking 215 504 ha over 10 years

Area	Measure		Current	Steady state	Change (%)
Basin	Stock units		379 906	174 488	–54
Basin	Gross household income	($)	$3,799,060	$1,744,879	–54
	Employment	(FTE)			
Direct	Farm		126	58	–54
Direct	Forestry		0	0	na
Basin	Total		146	67	–54
District	Gross household income	($)	$5,598,615	$2,571,401	–54
District	Employment	(FTE)	221	101	–54
Region	Gross household income	($)	$10,097,502	$4,637,705	–54
Region	Employment	(FTE)	364	167	–54
Net processing impacts					
Basin	Employment	(FTE)	0.0	0	na
Basin	Income	($)	$0	$0	na
District	Employment	(FTE)	128	59	–54
District	Income	($)	$4,530,879	$2,080,999	–54
Region	Employment	(FTE)	400	183	–54
Region	Income	($)	$12,983,787	$5,963,357	–54

TABLE 16: Scenario D—Plantations across 15% of all landforms with no wilding control, increasing planted area by approximately 15%

Area	Measure		Current	Steady state	Change (%)
Basin	Stock units		379 906	369 229	–3
Basin	Gross household income	($)	$3,799,060	$19,692,380	418
	Employment	(FTE)			
Direct	Farm		126	122	–3
Direct	Forestry		0	183	na
Basin	Total		146	355	144
District	Gross household income	($)	$5,598,615	$22,949,983	310
District	Employment	(FTE)	221	492	123
Region	Gross household income	($)	$10,097,502	$30,590,448	203
Region	Employment	(FTE)	364	728	100
Net processing impacts					
Basin	Employment	(FTE)	0.0	73	na
Basin	Income	($)	$0	$2,500,000	na
District	Employment	(FTE)	128	328	157
District	Income	($)	$4,530,879	$11,103,542	145
Region	Employment	(FTE)	400	705	77
Region	Income	($)	$12,983,787	$22,818,887	76

TABLE 17: Scenario E—Plantations across 15% of all landforms; wilding control

Area	Measure		Current	Steady state	Change (%)
Basin	Stock units		379 906	371 712	–2
Basin	Gross household income	($)	$3,799,060	$18,063,977	375
	Employment	(FTE)			0
Direct	Farm		126	123	–2
Direct	Forestry		0	170	na
Basin	Total		146	341	134
District	Gross household income	($)	$5,598,615	$21,183,643	278
District	Employment	(FTE)	221	472	114
Region	Gross household income	($)	$10,097,502	$28,505,352	182
Region	Employment	(FTE)	364	703	93
Net processing impacts					
Basin	Employment	(FTE)	0.0	73	na
Basin	Income	($)	$0	$2,500,000	na
District	Employment	(FTE)	128	328	158
District	Income	($)	$4,530,879	$11,133,155	146
Region	Employment	(FTE)	400	708	77
Region	Income	($)	$12,983,787	$22,903,747	76

TABLE 18: Increases in gross household income ($ million) for each scenario

Income	Direct (growing)	Net processing	Total
Scenario A			
Basin	66.32	23.6	89.92
District	72.33	27.43	99.76
Region	85.11	41.5	126.61
Scenario B			
Basin	9.31	1.9	11.21
District	10.59	5.83	16.42
Region	13.57	10.61	21.17
Scenario C			
Basin	-2.05	0.0	-2.05
District	-3.03	-2.45	-5.48
Region	-5.46	-7.02	-12.48
Scenario D			
Basin	15.89	2.50	18.39
District	17.35	6.57	23.92
Region	20.49	9.84	30.33
Scenario E			
Basin	14.26	2.50	16.76
District	15.59	6.60	22.19
Region	18.41	9.92	28.33

TABLE 19: Increases in employment (FTEs) for each scenario

Employment	Direct (growing)	Net processing	Total
Scenario A			
Basin	892	719	1611
District	1148	891	2039
Region	1541	1353	2894
Scenario B			
Basin	137	48	185
District	240	168	408
Region	408	319	727
Scenario C			
Basin	–79	0	–79
District	–119	–69	–189
Region	–197	–216	–413
Scenario D			
Basin	210	73	283
District	271	200	471
Region	364	306	670
Scenario E			
Basin	195	73	268
District	251	201	453
Region	339	308	647

TABLE 20: Steady state (from 2040 on) income and employment from processing in forestry and agriculture

Scenario			**Direct**	**Basin**	**District**	**Region**
A	Forestry income	*($ million)*	25.1	23.6	28.3	44
	Forestry employment	*(FTE)*	725	719	916	1430
	Agric. income	*($ million)*	1.8	0.0	3.7	10.5
	Agric. employment	*(FTE)*	0	0	103	323
B	Forestry income	*($ million)*	3.8	1.9	4.5	6.8
	Forestry employment	*(FTE)*	104	48	131	202
	Agric. income	*($ million)*	2.9	0.0	5.9	16.8
	Agric. employment	*(FTE)*	0	0	165	517
C	Forestry income	*($ million)*	0	0	0	0
	Forestry employment	*(FTE)*	0	0	0	0
	Agric. income	*($ million)*	1.0	0.0	2.1	6.0
	Agric. employment	*(FTE)*	65	0	128	400
D	Forestry income	*($ million)*	5.8	2.5	6.7	10.2
	Forestry employment	*(FTE)*	166	73	204	317
	Agric. income	*($ million)*	2.2	0.0	4.4	12.6
	Agric. employment	*(FTE)*	0	0	124	388
E	Forestry income	*($ million)*	5.8	2.5	6.7	10.2
	Forestry employment	*(FTE)*	166	73	204	317
	Agric. income	*($ million)*	2.2	0.0	4.4	12.7
	Agric. employment	*(FTE)*	0	0	125	391

DISCUSSION AND CONCLUSIONS

FOLPI was used successfully to model the impact of a variety of potential land-use scenarios in the Mackenzie/Waitaki Basin. Some of these scenarios examined an increase in plantation forestry while others looked at combinations of agriculture and small-scale forestry, such as woodlots and shelterbelts. Agricultural land use can be simulated in the FOLPI model by including livestock units per hectare as a product within agricultural "croptypes". As land is converted to forestry, the total number of livestock units dwindles. Multipliers can be attached to wood supply or livestock units per hectare to give direct employment and income, and employment and income derived secondarily through processing. This allows the economics of very different land uses to be compared.

Modelling of five scenarios for the Mackenzie/Waitaki Basin showed that, after a time delay for trees to reach harvestable age, forestry would be economically advantageous for the Basin as a whole, with impacts on the surrounding districts and region. When scenarios were compared, economic benefit went up with increasing afforestation. Conversion of 70% of available land to plantations, the highest level of forestry modelled, was forecast to produce a more than tenfold increase in Basin gross household income and a 500% increase in employment after the first clearfell (at age 45 years), with potential for further increases due to new processing industry. But clearly this level of forestry would change the landscape and potentially could alter social structure.

A number of assumptions were made in constructing the FOLPI models, particularly in formulating growth models. Changes in log prices and production costs, and refinement of growth models used to provide input data to the FOLPI models, are likely and will change the actual FOLPI forecasts, but the economic ranking of the scenarios would be unlikely to change. The results and conclusions drawn from the entire study are discussed by Höck *et al.* (2001).

Although FOLPI is normally used for forest estate planning involving stands of trees, it can be extended to other planning situations and crops and is a useful tool for simplifying complex data and for predicting results of different management strategies. The model has the flexibility to provide information at various geographic scales. Pre-set requirements (such as replanting) can be built in as constraints. Although the FOLPI models that were derived in this study were complex in some scenarios, FOLPI was able to easily address many regional planning issues. It was readily integrated with both the economic input/output analysis conducted by Butcher (1997) and information from the GIS survey and visualisation modelling. The most complicated part of the FOLPI modelling was in the data building and model organisation stages.

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APPENDIX 1: STANDPAK MODELS USED TO DEVELOP YIELD TABLES

Douglas-fir

initial models — SIDFIR (South Island Douglas-fir) and defaults, medium basal area

Weibull models — 2 PSMENS all New Zealand

tree vol. model — 136 PSMENS all New Zealand

taper model — 136 PSMENS all New Zealand

Site and regime variables set to medium defaults with the exception of sweep set to low.

Ponderosa pine

initial models — SIDFIR (South Island Douglas-fir) and defaults, medium basal area

Weibull models — 2 PSMENS all New Zealand (Southland PSMENS fell down at larger diams)

tree vol. model — 18 P.POND all New Zealand

taper model — 114 P.POND all New Zealand

Site and regime variables set to medium defaults with the exception of sweep set to low.

Corsican pine

initial models — SIDFIR (South Island Douglas-fir) and defaults, medium basal area

Weibull models — 2 PSMENS all New Zealand (Southland PSMENS fell down at larger diams)

tree vol. model — 139 P.LCO all New Zealand

taper model — 139 P.LCO all New Zealand

Site and regime variables set to medium defaults with the exception of sweep set to low.

APPENDIX 2: OPERATIONAL FORESTRY COSTS USED FOR THE MACKENZIE/WAITAKI BASIN

	Hill D-fir waste	Toe D-fir waste	Hill D-fir prod	Toe D-fir prod	Hill Cors. s'logs	Toe Cors. s'logs	Flat Cors. s'logs	Flat Cors. poles	Toe Pond. s'logs	Flat Pond. s'logs	T/Fl $/km Cors./Pond. sh'belt	Data Srce *
Stems/ha (year 1)	1250	1250	1250	1250	1250	1250	1250	1670	1250	1250	2 rows	
Stems/ha (final crop)	500	500	450	450	500	500	500	NA	400	400	3 × 2 m 1000/m	
Capital												
Fencing (1)	25	20	25	20	25	20	18	18	20	18	6000 (1 side)	1
Tracking (1)	25	NA	25	NA	25	NA	NA	NA	NA	NA	NA	1
Silvics												
Seedlings (1.5)	565	565	565	565	525	525	525	700	525	525	420	2
Seedling transport	30	30	30	30	30	30	30	40	30	30	25	3
Annual control (1)	30	30	30	30	30	30	30	30	30	30	21	1
Planting Hand (1.5)	440 (35c)	375 (30c)	440 (35c)	315 (25c)	440 (35c)	315 (25c)	290 (23c)	385 (23c)	315 (25c)	290 (23c)	315 (25c)	4
Planting Machine (+ labour)	NA	190 (15c/tree)	NA	190 (15c)	NA	190 (15c)	190 (15c)	250 (15c)	190 (15c)	190 (15c)	150 (15c)	5
Planting Machine (– labour)		115 (9c)		115 (9c)		115 (9c)	115 (9c)	150 (9c)	115 (9c)	115 (9c)	90 (9c)	5
Herbicide hand (1.5)	225 (18c/tree)	190 (15c)	225 (18c)	190 (15c)	225 (18c)	190 (15c)	175 (14c)	235 (14c)	190 (15c)	175 (14c)	150 (15c)	4
Herbicide tractor	NA	175 (14c)	NA	175 (14c)	NA	175 (14c)	150 (12c)	200 (12c)	175 (14c)	150 (12c)	130 (13c)	5
Boron (3)	85	85	85	85	85	85	85	85	85	85	60	6
Thin	250 yr12	230 yr12	250 yr12	230 yr12	250 yr15	230 yr15	230 yr15	NA	250 yr11	250 yr11	NA	1, 4
Stem prune to 2 m	600 yr12	500 yr12	NA	NA	600 yr15	500 yr15	500 yr15	NA	400 yr12	400 yr12	500 (1 row)	4
Side trim (sh'belts only)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	$25/ha/yr yr 12–21; $50/ha/yr 21+	7
Harvesting												
Roads ($/m^3)	3	2	3	2	3	2	1	1	2	1	1	8
Logging ($/m^3)	22 yr 45	20 yr 45	22 yr 45	20 yr 45	22 yr 45	20 yr 45	18 yr 45	22(?) yr 25+	20 yr 45	18 yr 45	15 yr 45	3
Transport ($/m^3)	20	20	20	20	20	20	20	20	20	20	20	3
Management of sale (%)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	1
Annual overheads (Rates, rentals, insurance, pest levies, weed control, project management)	25	25	25	25	25	25	25	25	25	25	18	

* Data sources for Appendix 2

1 M. C. Belton, New Zealand Ministry of Forestry (unpubl. data)
2 Seedling price list, Rangiora Nursery, 1994
3 G. V. Butcher, Butcher Associates (pers. comm.)
4 Ministry of Forestry 1994: "Canterbury Forest Operation Costs". New Zealand Ministry of Forestry, Christchurch.
5 Belton, M. C. 1991: "Land Use Options with Trees and Forests in the Mackenzie Basin Rabbit and Land Management Area". New Zealand Ministry of Forestry, Christchurch.
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