Nature and Scale of Eligible Post-1989 Non-planted Forests

Final Report

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Landcare Research
Manaaki Whenua

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Part I. How much land is potentially available, where is it, and who owns it?

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Part II. How much of this land is likely to enter the ETS as indigenous reversion?

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Summary Final Report – 2008/09

Agreement Numbers and Title: PRO MAF POL_0809-21. Measurement of carbon sequestration in post-1989 compliant indigenous forests. Objective 1. Nature and scale of eligible post-1989 non-planted forest.

Businesses/Institutions: Landcare Research
Motu Economic and Public Policy Research

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Goal:
Determine the areas of indigenous forest/shrubland and exotic shrubland types that have regenerated since 1990, and that could potentially regenerate on marginal erosion-prone lands where economic returns tend to be low. Identify the broad ownership of these areas and predict the extent and likely location of indigenous reversion under an emission trading scheme.

Context of the project:
The Ministry of Agriculture and Forestry (MAF) is undertaking the design and implementation of a methodology for assessing the carbon content of forests established after 31 December 1989 that will become part of the New Zealand Emissions Trading Scheme (NZETS), including forests established under the Permanent Forest Sinks Initiative (PFSI). As part of this process Landcare Research was contracted to assess the nature and scale of eligible post-1989 indigenous forest land.

Approach:
Areas of forest and shrubland that regenerated on marginal grasslands between 1990 and 2000 were determined using data from the Land Use and Carbon Analysis System (LUCAS) 1990 baseline mapping project. The Corax Mobile data layer of New Zealand cadastral boundaries (derived from data held by Land Information New Zealand), and GIS shape files of Conservation land, other Crown land, and Māori land were intersected to give an 'ownership' shape file showing broad land-ownership information (Conservation land, other publically owned or covenanted land, Māori land, and privately owned land). This 'ownership' file was used to extract and tabulate the areas and types of regeneration in each land ownership category for both the North and South Island.

Grasslands marginal for agriculture but with the potential to undergo reversion to shrubland and indigenous forest were determined by intersecting areas mapped as Class 6 (with a moderate to severe erosion rating), 7 and 8 by the New Zealand Land Resources Inventory (NZLRI) with areas identified by the Vegetation Cover Map (Newsome 1987) as likely to have seed sources that would allow natural reversion to indigenous forest, indigenous broadleaved shrubland, mānuka/kānuka shrubland, or gorse.

The Land Use in Rural New Zealand (LURNZ) model was used to assess how much land is likely to enter the ETS as indigenous reversion. The model uses historical relationships between output prices and land uses (where all land uses depend on all prices) and projections of commodity prices, to predict shifts in land use at a national scale. Three scenarios were modelled: (1) business as usual without an ETS, (2) financial reward for shrubland carbon from 2008, and (3) cost of farm emissions plus financial reward for shrubland carbon from 2013.

Outcomes:
Analysis of land cover changes on marginal erosion-prone grasslands between 1990 and 2000 show a substantial increase in planted forests (319 200 ha) for several areas of both the North and South Island, and smaller changes towards mānuka/kānuka shrubland (18 200 ha), other indigenous shrubland (5500 ha), gorse/broom (8100 ha), other exotic shrubland (10 300 ha) and regenerating indigenous forest (30 100 ha). Most of this change occurred on privately owned land.

Extension of this analysis to include land that is potentially available for indigenous reversion identified a total of 1.55 m ha across both main islands where the proximity of woody seed sources makes it possible for marginal grasslands to revert to shrubland and eventually indigenous forest. As with the actual land cover changes on marginal erosion-prone grasslands, the majority of the land that is potentially available for indigenous reversion is in private ownership.

Results from the modelling scenarios predict that without an ETS areas in shrubland and sheep/beef production will fall. The introduction of either of the ETS scenarios exacerbates the decline in the area of sheep/beef production and reduces the decline in shrubland. Most of the response comes from the reward for shrubland carbon rather than the cost of farm emissions, which only begins in 2013. Existing shrubland is predicted to shift to plantation forestry, and existing sheep/beef land is predicted to shift to shrubland. Although a price for carbon reverses the decline in shrubland, this is only temporary. Further increases (reductions in net decrease) would require that the carbon price continues to rise faster than the returns on sheep/beef land, and that shrubland is able to compete with plantation forestry for this very marginal land.

Summary:
Between 1990 and 2000 there was a substantial shift from marginal erosion-prone grasslands to planted forests, and smaller shifts towards shrubland and regenerating indigenous forest. Most of this change occurred on privately owned land. Further analysis identified a total of 1.55 m ha of marginal grasslands with the potential for indigenous reversion. Most of this land is also in private ownership. Modelled estimates predict that without an ETS areas in shrubland and sheep/beef production will fall, and that an ETS will exacerbate the decline in the area of sheep/beef production and reduce the decline in shrubland. Existing shrubland is predicted to shift to plantation forestry, and existing sheep/beef land is predicted to shift to shrubland.

1. Introduction

The Ministry of Agriculture and Forestry (MAF) is undertaking the design and implementation of a methodology for assessing the carbon content of forests established after 31 December 1989 that will become part of the New Zealand Emissions Trading System (NZETS), including forests established under the Permanent Forest Sinks Initiative (PFSI). As part of this task Landcare Research was contracted to assess the nature and scale of eligible post-1989 indigenous forest. This comprised two components: a biophysical and an economic element. The former looked at how much land is potentially available for indigenous (non-planted) regeneration, where it is, and who owns it. The latter addressed the question of who might participate.

2. Objectives

- Use existing datasets to determine the areas and dominant indigenous forest/ shrubland and exotic shrubland types that (a) have actually regenerated since 1990, by broad ownership category, and (b) could potentially regenerate on marginal erosion-prone lands[1], where economic return tends to be low and reversion is likely, by broad ownership category.
- Predict the extent and likely location of indigenous reversion using the LURNZ (Land Use in Rural New Zealand) model.

3. Methods

3.1 How much land has reverted to woody vegetation, or is potentially available for indigenous reversion, where is it, and who owns it?

To determine how much land has reverted to woody vegetation between 1990 and 2000

Areas where woody vegetation had regenerated on grassland between 1990 and 2000 were determined using data prepared during the MfE LUCAS mapping project[2] (these data are draft and currently under QA/QC procedures as part of MFE Contract 11418, 'Completion – 1990 Land Use Mapping').

[1] Land classified by the New Zealand Land Resources Inventory as Class 6 (with a moderate to severe erosion rating), 7 or 8.

[2] Uses satellite imagery from LANDSAT4 (1990) and LANDSAT7 (2000)

Regenerating woody vegetation was classified by intersecting these areas with a condensed set of the forest (planted forest, indigenous forest) and shrubland (mānuka/kānuka shrubland, other indigenous shrubland, gorse/broom shrubland, other exotic shrubland) classes from LCDB2.[3]

To determine how much land is potentially available for indigenous reversion

The area of marginal lands in grassland at c. 2000 was determined using the LCDB2 dataset, and the areas of erosion-prone land were identified using the NZLRI.[4] These were then split using the Vegetation Cover Map (Newsome 1987) into areas that are likely to have (or not to have) potential seed sources to allow natural reversion to indigenous forest, indigenous broadleaved shrubland, mānuka/kānuka, and gorse.

To determine the ownership of land that has reverted to woody vegetation, or that has potential for indigenous reversion

The Corax Mobile data layer of New Zealand cadastral boundaries (derived from data held by Land Information New Zealand), and GIS shape files of Conservation land, other Crown land, and Māori land were intersected to give an 'ownership' shape file showing broad land-ownership information (Conservation land, other publically owned or covenanted land, Māori land, and privately owned land). This 'ownership' file was used to extract and tabulate the areas and types of regeneration in each land ownership category for both the North and South Island.

3.2 How much of this land is likely to enter the ETS as indigenous reversion?

Appropriate greenhouse charges and rewards were applied on an annualised basis to all land uses (dairy, sheep/beef, plantation forestry, scrub/indigenous forest). These were then translated into equivalent changes in prices received for output. Based on historical relationships between output prices and land uses (where all land uses depend on all prices) and projections of commodity prices (from MAF) the LURNZ model predicts the shifts in land use among the four uses at a national scale.

A series of rules were applied at a 25-ha-grid cell level based on the maps provided by Landcare Research of land that will be eligible for ETS rewards, current land use in the grid cell, land use capability classification, and a productivity index, to allocate the changes in national land use to specific grid cells. This process steps forward from the LCDB/Agribase land use map in 2002 based on actual changes in land use (as measured through Statistics New Zealand Agriculture Surveys and Censuses) as far the most recent year of data and then forecasts from then.

These data were used to generate a map of changes in shrubland in response to the ETS. This was used to provide predictions of which land is likely to enter the indigenous reversion sector of ETS (Forestry) to analyse their ownership.

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[3] Land Cover Data Base Version 2
[4] New Zealand Land Resources Inventory

4. Results

4.1 How much land is potentially available, where is it, and who owns it?

Actual change in area of post-1989 indigenous reversion and planted forests

Analysis of land cover changes between 1990 and 2000 on land that was primarily grassland showed a substantial increase in planted forests (319 200 ha) for several areas of both the North and South Islands, and smaller changes towards mānuka/kānuka shrubland (18 200 ha), other indigenous shrubland (5500 ha), gorse/broom shrubland (8100 ha), other exotic shrubland (10 300 ha) and indigenous forest (30 100 ha) (Tables 1 & 2, Figs 1 & 2). Most of this change occurred on privately owned land. The absence of data for several areas is caused by problems associated with cloud cover in the imagery being used to compile the 1990 baseline map which have yet to be resolved.

Table 1 Area and ownership of marginal grasslands in the North Island of New Zealand that changed to planted forest, indigenous forest, mānuka/kānuka shrubland, other indigenous shrubland, gorse/broom, or other exotic shrubland between 1990 and 2000

Vegetation class	Ownership	Area (ha)[1]
No data	Conservation	122 000
	Māori	111 000
	Other Public or Covenanted	339 000
	Private	1 429 200
	Uncertain	5 600
No reversion (> 5 ha)	Conservation	631 700
	Māori	626 000
	Other Public or Covenanted	1 893 000
	Private	5 994 700
	Uncertain	36 700
Planted forest	Conservation	4 400
	Māori	9 800
	Other Public or Covenanted	24 900
	Private	176 000
	Uncertain	0
Indigenous forest	Conservation	400
	Māori	1 400
	Other Public or Covenanted	1 100

	Private	13 100
	Uncertain	100
Mānuka/kānuka shrubland	Conservation	300
	Māori	1 500
	Other Public or Covenanted	400
	Private	9 200
	Uncertain	0
Other indigenous shrubland	Conservation	0
	Māori	200
	Other Public or Covenanted	600
	Private	1 600
	Uncertain	0
Gorse/broom shrubland	Conservation	0
	Māori	200
	Other Public or Covenanted	200
	Private	2 500
	Uncertain	0
Other exotic shrubland	Conservation	100
	Māori	300
	Other Public or Covenanted	300
	Private	5 700
	Uncertain	0

[1]Figures rounded to the nearest 100 ha

Table 2 Area and ownership of marginal grasslands in the South Island of New Zealand that changed to planted forest, indigenous forest, mānuka/kānuka shrubland, other indigenous shrubland, gorse/broom, or other exotic shrubland between 1990 and 2000

Vegetation class	Ownership	Area (ha)[1]
No data	Conservation	410 100
	Māori	1 700
	Other Public or Covenanted	1 212 700
	Private	558 100
	Uncertain	3 000
No reversion (> 5 ha)	Conservation	2 047 900
	Māori	400
	Other Public or Covenanted	5 488 800

	Private	5 385 600
	Uncertain	40 800
Planted forest	Conservation	500
	Māori	0
	Other Public or Covenanted	12 200
	Private	90 500
	Uncertain	800
Indigenous forest	Conservation	500
	Māori	0
	Other Public or Covenanted	3 300
	Private	10 000
	Uncertain	300
Mānuka/kānuka shrubland	Conservation	500
	Māori	0
	Other Public or Covenanted	1 500
	Private	4 800
	Uncertain	0
Other Indigenous Shrubland	Conservation	200
	Māori	0
	Other Public or Covenanted	1 000
	Private	1 900
	Uncertain	0
Gorse/broom shrubland	Conservation	300
	Māori	0
	Other Public or Covenanted	900
	Private	4 000
	Uncertain	0
Other exotic shrubland	Conservation	100
	Māori	0
	Other Public or Covenanted	700
	Private	3 800
	Uncertain	0

[1]Figures rounded to the nearest 100 ha

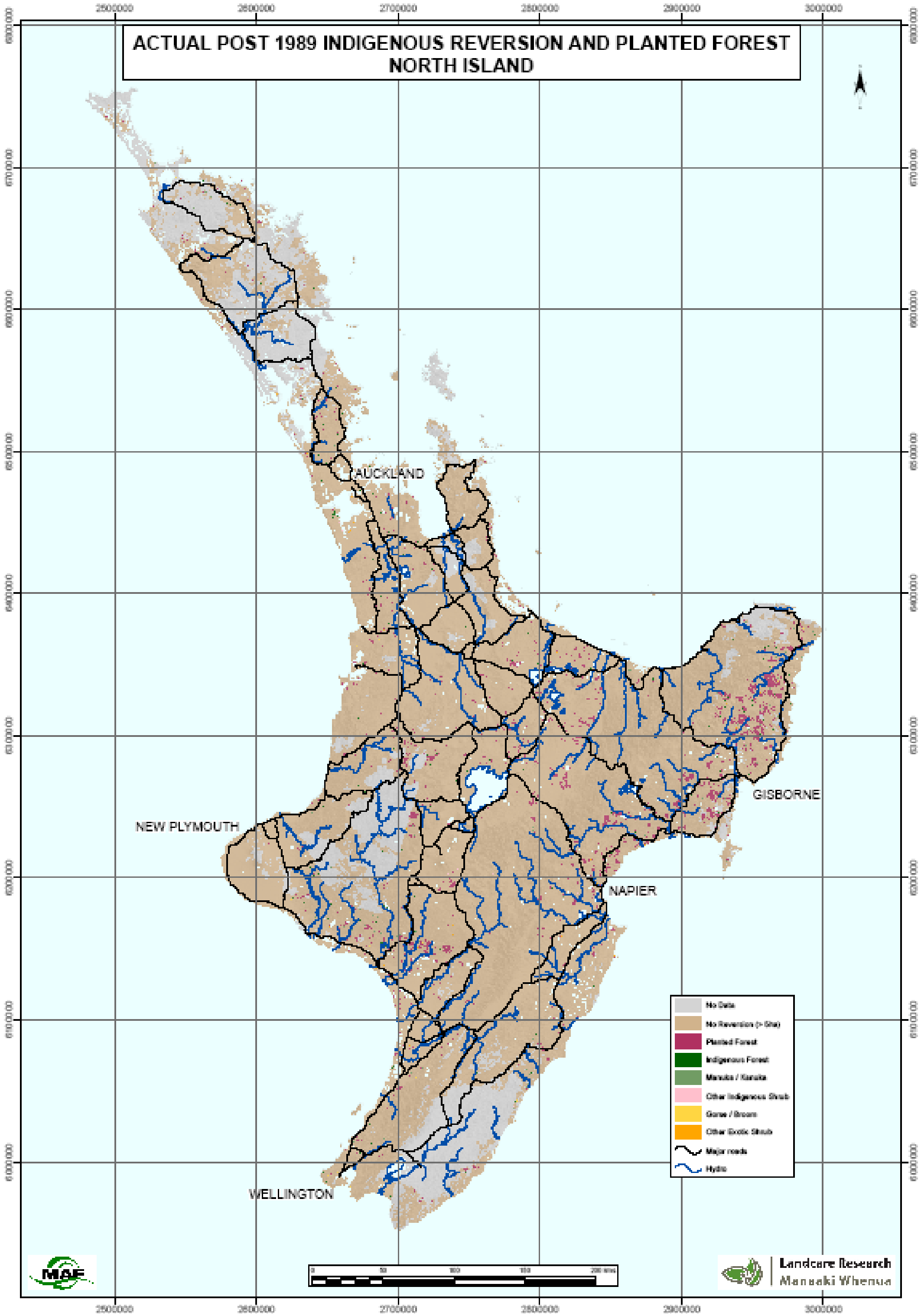

Fig. 1 Change from marginal grassland to planted forest, regenerating indigenous forest, mānuka/kānuka shrubland, other indigenous shrubland, gorse/broom, and other exotic shrubland between 1990 and 2000, in the North Island of New Zealand.

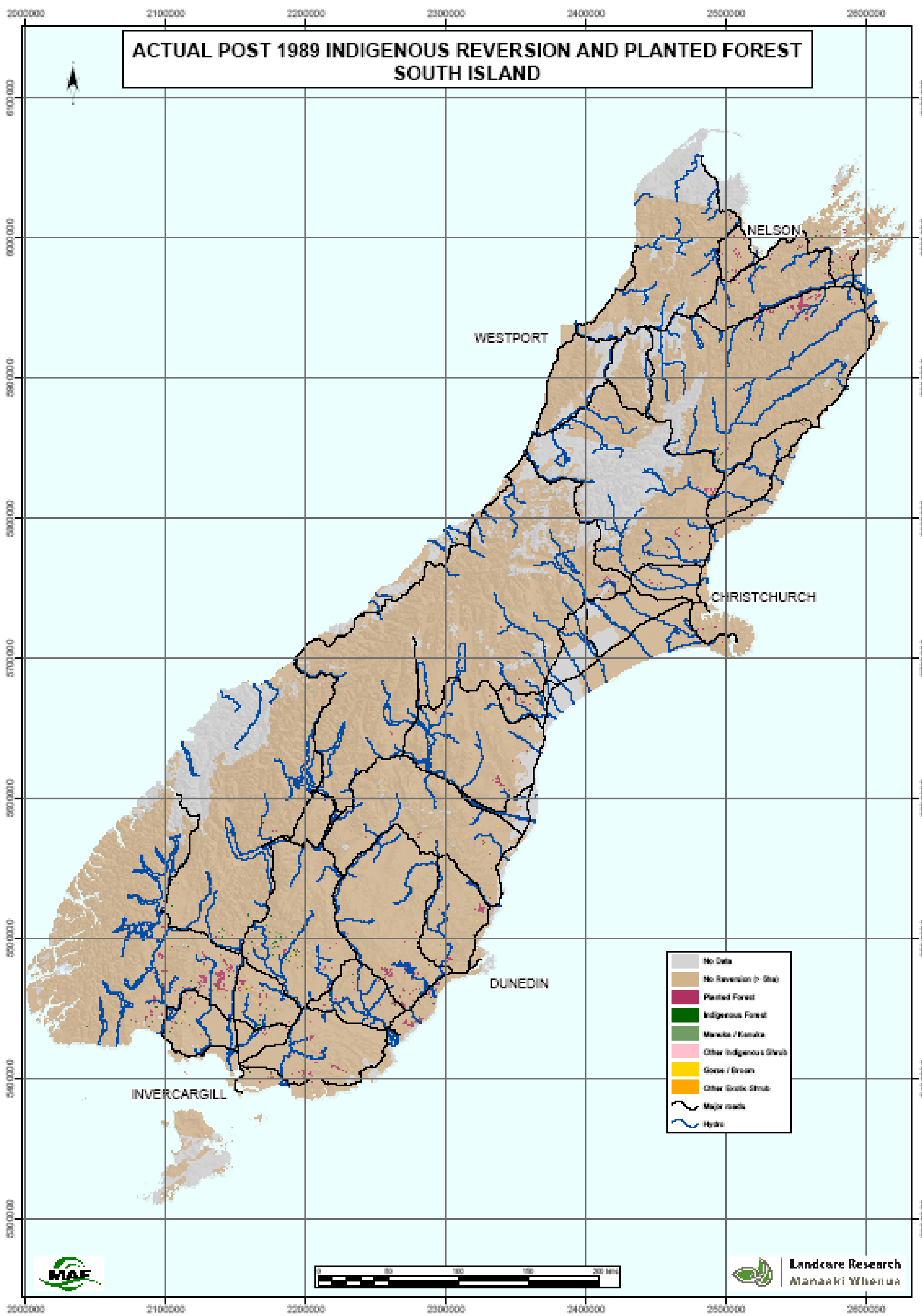

Fig. 2 Change from marginal grassland to planted forest, regenerating indigenous forest, mānuka/kānuka shrubland, other indigenous shrubland, gorse/broom, and other exotic shrubland between 1990 and 2000, in the South Island of New Zealand.

Marginal, erosion-prone lands potentially available for indigenous reversion

Extension of this analysis to include land that is potentially available for indigenous reversion identified a total of 1.55 M ha across both main islands where the proximity of woody seed sources makes it possible for marginal grasslands to revert to shrubland and eventually indigenous forest (Tables 3 & 4, Figs 3 & 4). As for actual change, the majority of the land that is potentially available for indigenous reversion is in private ownership.

Table 3 Area and ownership of North Island marginal grasslands potentially available for indigenous reversion

Seed sources available for	Ownership	Area (ha)[1]
Indigenous forest	Conservation	2 400
	Māori	7 900
	Other Public or Covenanted	5 200
	Private	167 000
	Uncertain	400
Indigenous broadleaved shrubland	Conservation	3 100
	Māori	12 300
	Other Public or Covenanted	7 800
	Private	214 800
	Uncertain	400
Mānuka/kānuka shrubland	Conservation	8 400
	Māori	35 800
	Other Public or Covenanted	26 000
	Private	549 700
	Uncertain	100
Gorse/broom shrubland	Conservation	100
	Māori	600
	Other Public or Covenanted	500
	Private	12 600
	Uncertain	0
No seed source for above classes	Conservation	25 500
	Māori	79 000
	Other Public or Covenanted	124 700
	Private	1 392 900
	Uncertain	3 200

[1]Figures rounded to the nearest 100 ha

Table 4 Area and ownership of South Island marginal grasslands potentially available for indigenous reversion

Seed sources available for	Ownership	Area (ha)[1]
Indigenous forest	Conservation	900
	Māori	0
	Other Public or Covenanted	4 200
	Private	10 600
	Uncertain	0
Indigenous broadleaved shrubland	Conservation	1 800
	Māori	0
	Other Public or Covenanted	28 800
	Private	93 800
	Uncertain	400
Mānuka/kānuka shrubland	Conservation	5 300
	Māori	0
	Other Public or Covenanted	66 400
	Private	237 200
	Uncertain	500
Gorse/broom shrubland	Conservation	200
	Māori	0
	Other Public or Covenanted	2 100
	Private	43 300
	Uncertain	100
No seed source for above classes	Conservation	134 200
	Māori	0
	Other Public or Covenanted	854 800
	Private	1 110 800
	Uncertain	2 600

[1]Figures rounded to the nearest 100 ha

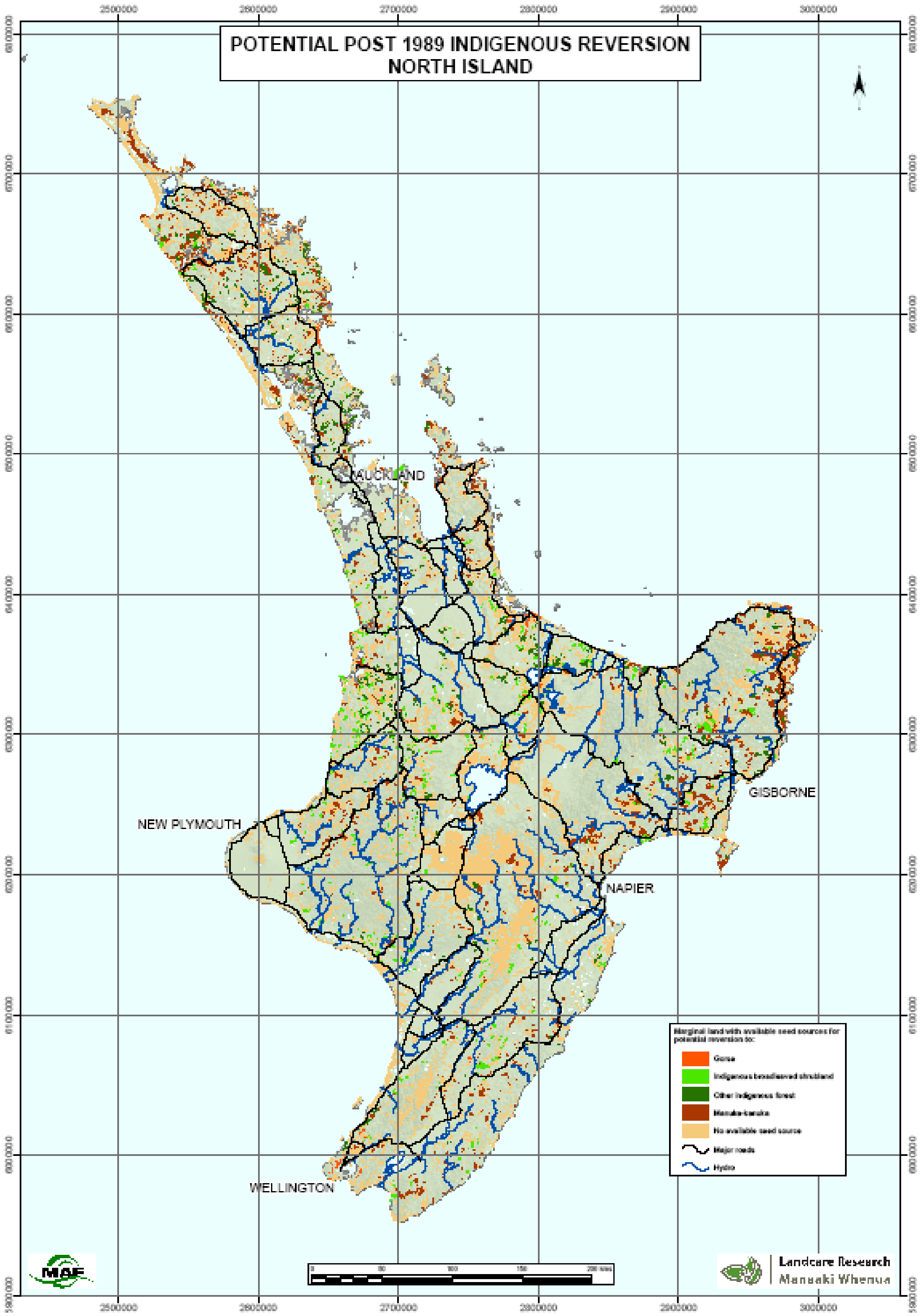

Fig. 3 Areas of potential change from marginal grassland to mānuka/kānuka shrubland, other indigenous shrubland, gorse/broom, other exotic shrubland or regenerating indigenous forest, in the North Island of New Zealand.

Fig. 4 Areas of potential change from marginal grassland to mānuka/kānuka shrubland, other indigenous shrubland, gorse/broom, other exotic shrubland or regenerating indigenous forest, in the South Island of New Zealand.

4.2 How much of this land is likely to enter the ETS (Forestry) as indigenous reversion?

Modelled results

We applied version 1 of the LURNZ model (Hendy et al. 2007) to address this question.

We modelled three scenarios:

S1: Reference case: no ETS
S2: Reward carbon in shrubland only (from 2008)
S3: GHG price on non-CO_2 emissions from dairy and sheep & beef and reward for carbon in shrubland (from 2013)

We modelled a reward for shrubland by assuming that sheep/beef land will respond to a price on shrubland in the same way that shrubland responds to a change in the price of sheep/beef land.

We assumed that landowners receive value equivalent to three tonnes of New Zealand units per year. This smooths out their cashflow even though actual carbon sequestration rates vary considerably across the years. This could correspond either to the government offering a stable flow of credits or to a private calculation by the landowner. This figure takes into account several factors:

- A carbon sequestration yield curve from Landcare Research[5] combined with a sigmoidal evolution of forest cover. We assumed that it takes 10 years to reach canopy cover (see Hendy & Kerr (2005), which also provides details on modelling of methane and nitrous oxide)
- The likely upward bias of this yield curve if used as a national average curve given that it was developed based on East Cape mānuka/kānuka forest
- The need to discount future carbon sequestration to account for a return on capital and uncertainty in the future value of carbon

We did not model a price for the carbon in plantation forestry because we are not confident about how this land use will respond to the Forestry ETS. Our estimates suggest that the response of plantation forestry to the ETS will be relatively small in any case.

We assumed a price of $25 per tonne CO_2e.

Both shrubland and sheep/beef land areas are predicted to fall in the reference case (Table 5). The ETS exacerbates the decline in sheep/beef and reduces the decline in shrubland.

Our results suggest a substantial increase in shrubland relative to the reference case (Table 6). The reference case predicts a net loss of around 300 000 ha of shrubland (Table 5). Applying the two ETS policies almost reverses that net effect. Because the shrubland that is lost in the reference case is most likely to be converting to plantation forestry, these losses are unaffected

[5] www.landcareresearch.co.nz/research/globalchange/carbon_calc/carboncalc.aspx

by the two ETS scenarios. Most of the response comes from the reward for shrubland rather than the cost of greenhouse gas emissions in sheep/beef farming (which in any case only begins to apply in 2013. The response to the shrubland policy must involve new shrubland on land that is currently sheep/beef (and is hence likely to be eligible for the ETS). Around 450 000 ha of sheep/beef land is predicted to shift to shrubland between 2007 and 2015.

Table 5 Land use changes from 2007 to 2015 for three modelled scenarios

Land use	Scenario	Land area (000’s ha)		Change in land area	
		2007	2015	%	000’s ha
Dairy	S1	1462	1646	13	184
	S2	1462	1646	13	184
	S3	1462	1631	12	170
Sheep/Beef	S1	6878	6654	−3	−223
	S2	6878	6431	−6	−447
	S3	6878	6412	−7	−465
Plantation	S1	1451	1776	22	326
	S2	1451	1776	22	326
	S3	1451	1773	22	323
Shrubland	S1	1188	901	−24	−287
	S2	1188	1125	−5	−63
	S3	1188	1161	−3	−27

Table 6 Policy-induced change in shrubland area

Land use	Scenario	Land area (000’s ha)		Change from reference case	
		2007	2015	%	000’s ha
Shrubland	S1	1188	901	0	0
	S2	1188	1125	25	224
	S3	1188	1161	29	260

To put these results in perspective we show the time series history and reference case for each of the four LURNZ private land uses (Fig. 5) and the effect of an ETS payment on shrubland (Fig. 6). Although the latter reverses the decline in shrubland, this is only temporary – further increases (reductions in net decrease) would require that the carbon price continues to rise faster than the returns on sheep/beef land and that shrubland is able to compete with forestry for this very marginal land.

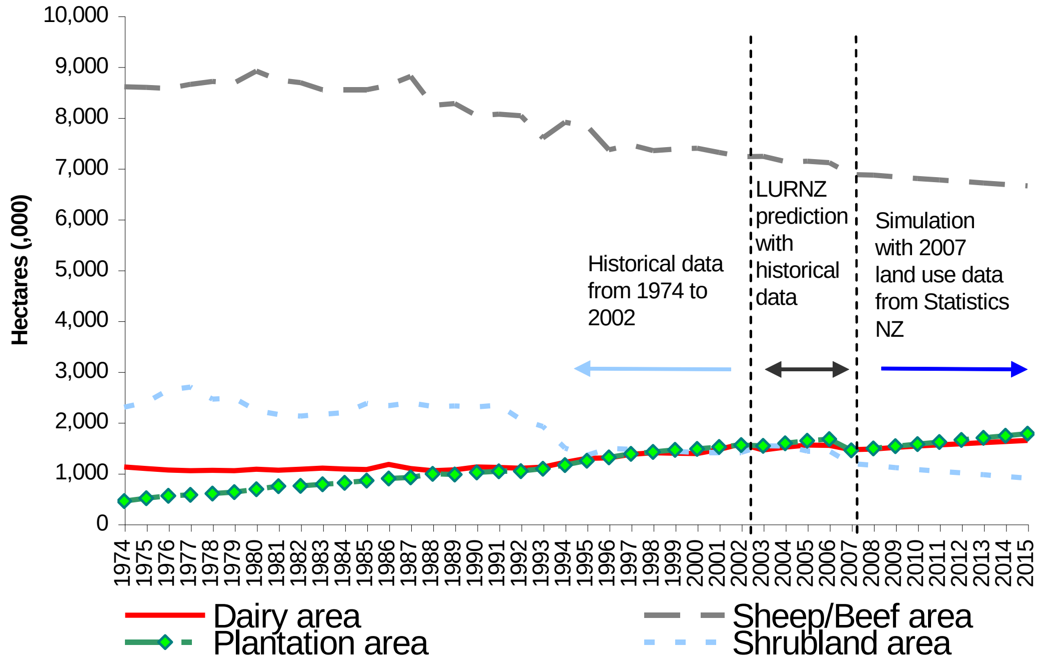

Fig. 5 Historical and simulated land use in New Zealand from 1974 to 2015: reference case.

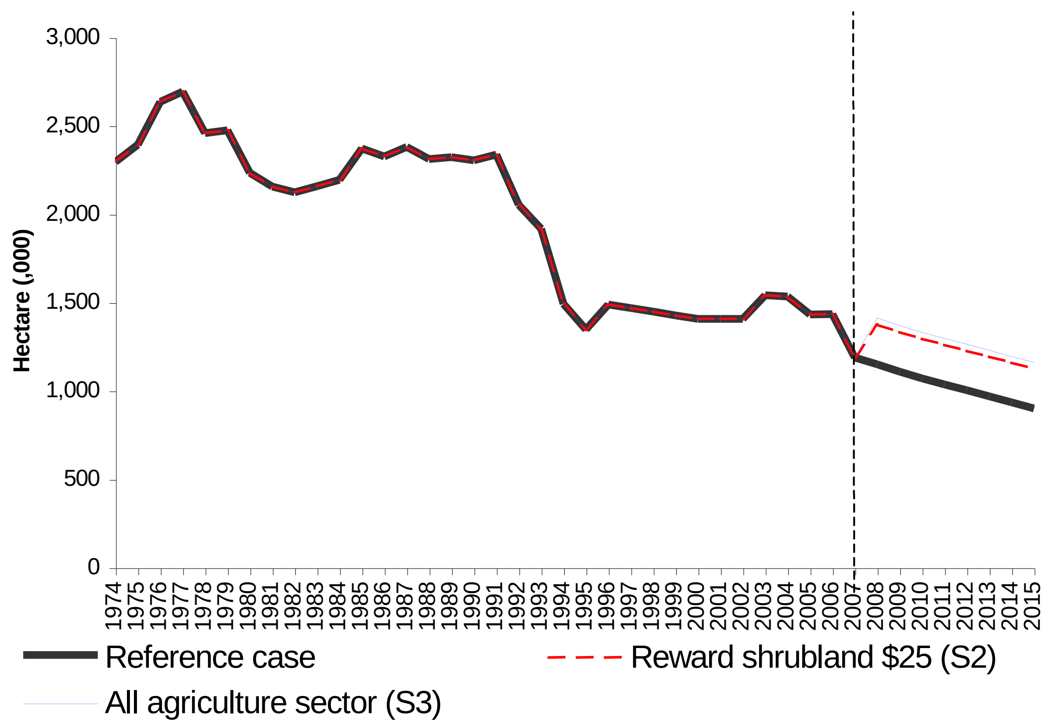

Fig. 6 Shrubland area on private land under different scenarios given $25 CO_2 price.

Likely area, spatial location, and ownership of shrubland reversion

Once we had an estimate of the likely area of regeneration in response to the shrubland price we explored where this would be likely to occur. We used the LCDB2/Agribase product provided by Landcare Research to create a map of land use – taking land cover from LCDB2 and dividing pasture into sheep/beef and dairy using the Agribase data. We then used the two maps created by Landcare Research for this contract – ownership and areas of potential change from marginal grassland (from Figures 3 and 4) – to identify potential areas for new shrubland in response to the ETS. These are private sheep/beef farms with land that can potentially revert to gorse, indigenous broadleaved shrubland and other indigenous vegetation types.

We then ranked each 25-ha pixel of land in these categories from best to worst land using a nested-sort where land is first sorted by Land Use Capability class and then, within each class, by the value of a pasture productivity variable (Baisden 2006). Figures 7 and 8 show the areas that are most likely to revert in blue, and those that could revert but are not on the least productive land in red.

The spatial allocation rule we used is based purely on an assumption that farmers will retire their least productive land. Because we used a 25 ha grid we already assume that the regeneration occurs on a reasonable scale. This reduces the likelihood that transaction costs would make it necessary to have several patches of regeneration on the same property. We are unable to predict the idiosyncratic characteristics of individual landowners that will lead some to retire land that is not of such bad quality either because they find native bush attractive and believe it will add to the value of their property, or because they are personally committed to environmental goals. These factors could lead to more, smaller patches of regeneration on the poor land within more highly productive areas – even potentially within dairy farms where farmers may also need to create riparian boundaries for water quality reasons.

Our predictions suggest that the introduction of an ETS will result in the creation of c. 447 000 ha of new shrubland. Most of this will be in the North Island, and most on private (as opposed to Māori) land (Table 7). However, the biggest area for likely shrubland reversion is the East Cape, where there is a large proportion of Māori land. Public land is not expected to respond to the ETS directly. Unless transaction costs are low, and there are acceptable ways of minimising risks (e.g. loss of carbon stock) and maintaining options for future land use change, we may be overpredicting responsiveness to change in these areas, at least in the short term.

Table 7 Area (ha) and ownership of non-public land predicted to revert to shrubland and eventually indigenous forest as a result of the introduction of an ETS.

Ownership	North Island	South Island	Total
Māori	24 825	0	24 825
Private	286 075	136 000	422 075
Total	310 900	136 000	446 900

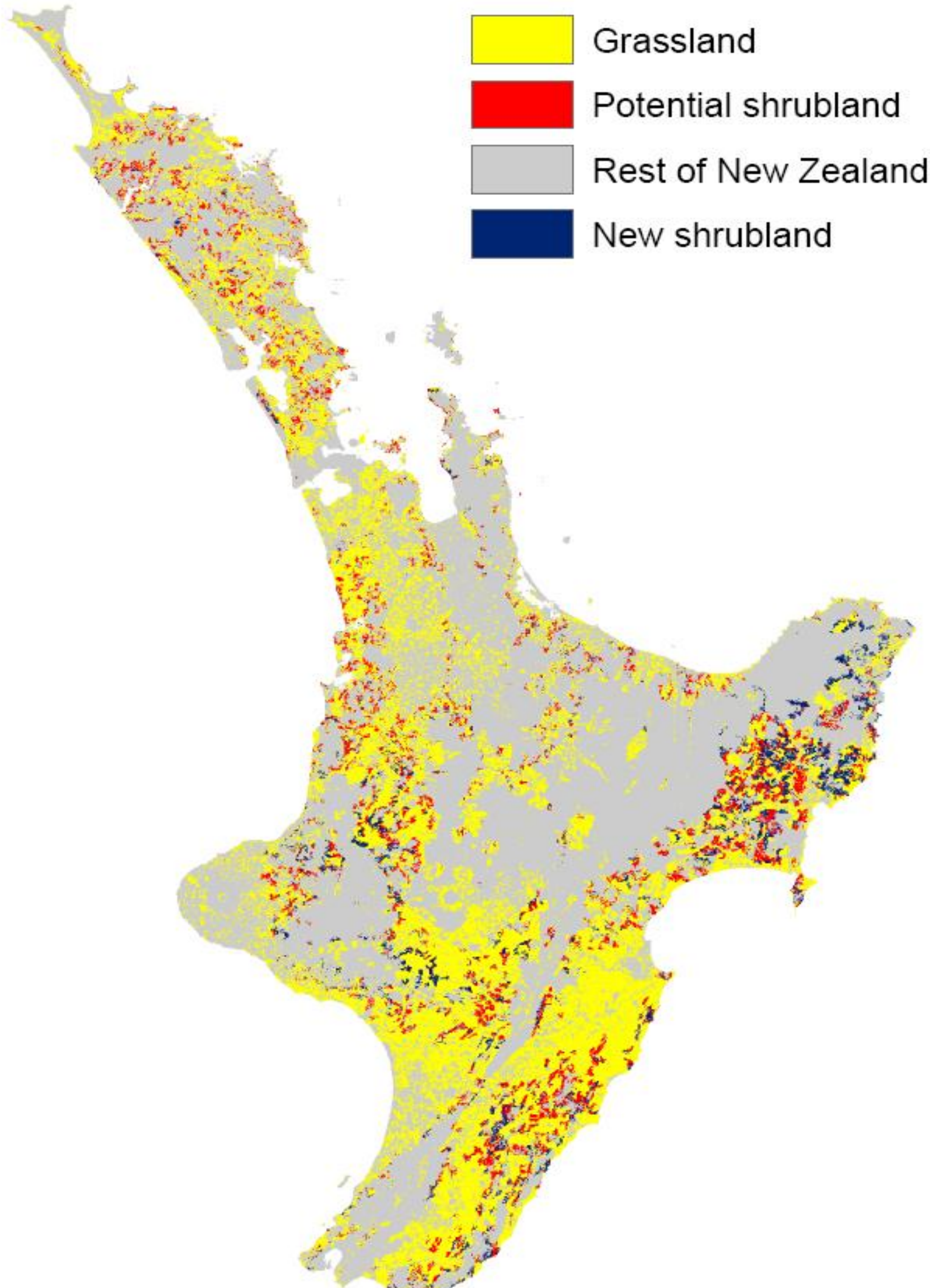

Fig. 7 Likely shrubland regeneration on privately owned land in the North Island. Areas most likely to revert (New shrubland) are shown in blue; those that could revert but are not on the least productive land (Potential shrubland) are shown in red.

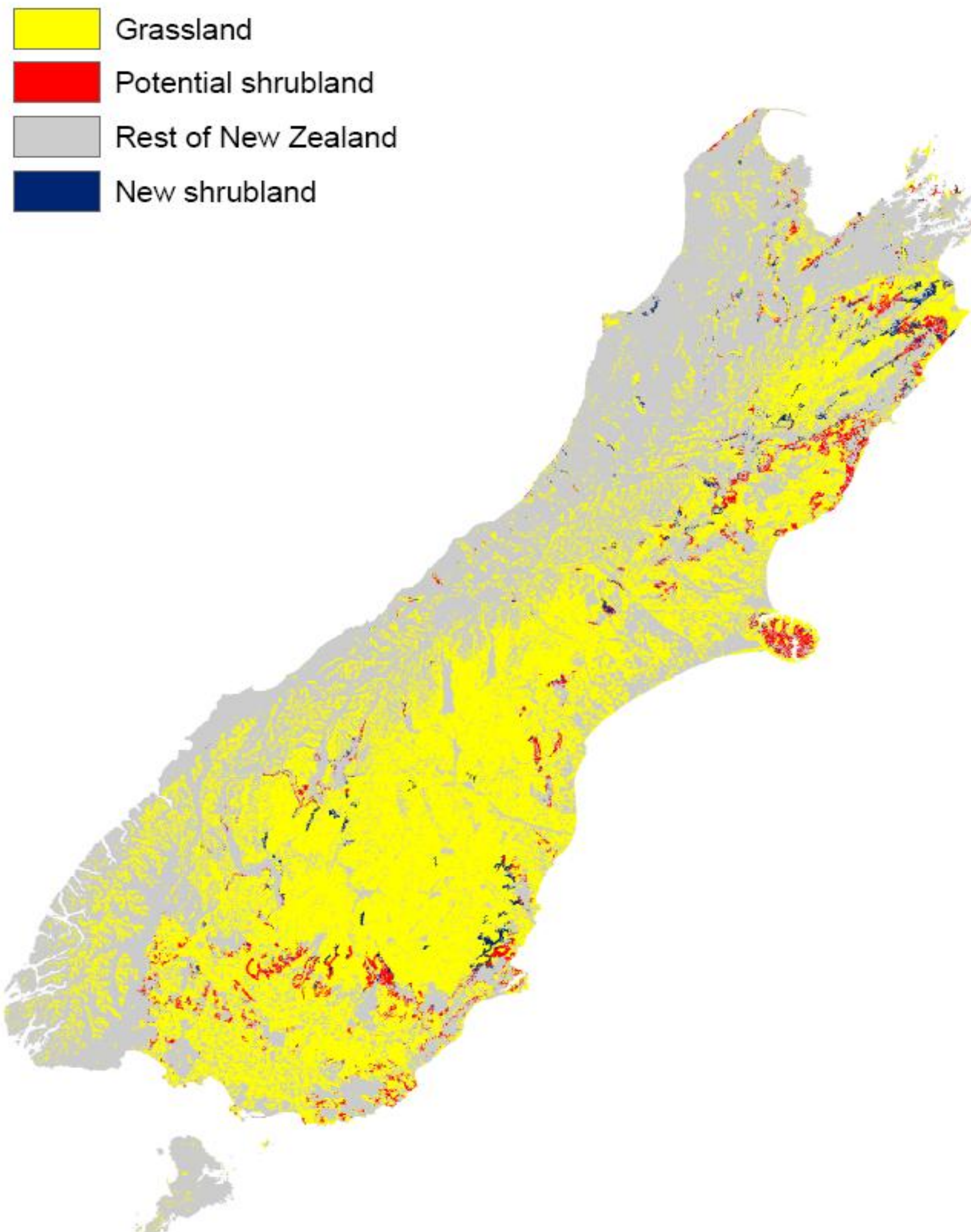

Fig. 8 Likely shrubland regeneration on privately owned land in the South Island. Areas most likely to revert (New shrubland) are shown in blue; those that could revert but are not on the least productive land (Potential shrubland) are shown in red.

Caveats

There are several reasons to interpret these results with caution. First, we need to assume symmetry between the response of sheep/beef land to a shrubland price (reward to regeneration) and shrubland to a sheep/beef price. While this is plausible, we have no evidence of actual responses to rewards for regeneration on any scale.

Second, the results are estimated from historical relationships between land use and prices. This assumes that farmers will interpret a regulatory reward in the same way that they respond to a change in a market price. If the reward has different risk characteristics or if it involves transaction costs, responses may well differ. Case study research suggests that some Māori land owners may find it difficult to coordinate to make a decision to allow regeneration, in part because of concerns about future liability and being ‘locked in’ to a given land use. Other farmers are also concerned about loss of options particularly when the long-term returns to native regeneration seem highly uncertain. Indigenous reversion may also be seen as more attractive than plantation forestry when landowners cannot afford the capital outlay associated with new plantations.

Third, historically, at a national level both shrubland and sheep/beef land have been in fairly steady decline. This means we have estimated our responses over a period where shrubland has been declining and have applied those results to simulate an increase in shrubland. It is not clear that the factors that cause a decline in shrubland are completely symmetrical with those that cause increase.

All three reasons suggest that the level of response may be lower than simulated. We do not simulate the effects of a $50 carbon charge because we believe this is too far outside the sampling range of the model we used here to make those results robust.

5. Acknowledgements

Fiona Carswell reviewed the report, Christine Bezar improved its readability, Cherie Wilson completed the final word processing, and Phil Hart approved its release.

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