Area of Organic Soils

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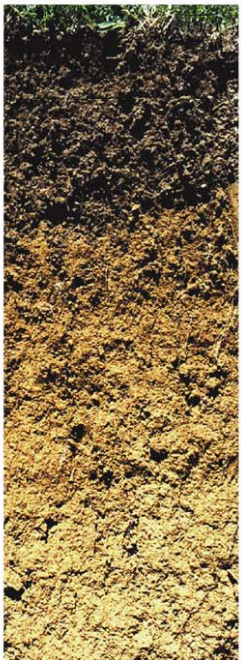

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Contract: MAF-12273

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Manaaki Whenua

Area of Organic Soils

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Contents

Summary

Project

- Landcare Research was contracted by MAF to classify organic soils to conform to the IPCC definition of organic soils and to determine the area of organic soils in New Zealand as at 1990. The work would include collaboration with relevant parties.

Objectives

- Hold an initial workshop to determine the work required for this project.
- Review the definitions of organic soils used for IPCC reporting.
- Clarify the distinction between cultivated and managed organic soils.
- Provide a rationale for the reported area of organic soils in New Zealand.
- Provide a method to evaluate the area of organic soils and the proportions of that area under specified agricultural management.
- Estimate the areas of organic soils in Waikato and Southland and change in area due to cultivation/modification between 1990 and 2008.
- Discuss annual updating of cultivated/managed organic soils.

Methods

- A workshop was held in Wellington on 21 February 2011 to decide on working principles and to set objectives.

Results

- Clearer definitions were proposed for organic soils as reported by the LULUCF and Agriculture sectors.
- Managed and cultivated organic soils were defined and these were assigned to LUCAS Land Use Map categories.
- A rationale was given to determine the area of organic soils in New Zealand and organic soil definitions were proposed for LULUCF and Agriculture sectors of the National Greenhouse Gas Inventory.
- A method was trialled to estimate the change in area of organic soils and was applied to the Waikato and Southland regions. The trial highlighted the uncertainties of determining temporal changes in the area of organic soils using soil surveys that span a range of dates.
- Updating of the area of managed and cultivated organic soils needs to be matched to the rate of provision of soil class mapping and land use mapping.

Recommendations

- It is appropriate that LULUCF and Agriculture sectors use differing but linked definitions of organic soils as a basis for reporting to meet their differing goals. It is judged that mineral soils with peaty topsoils will have similar emissions behaviour to that of Organic Soils and therefore for the agricultural sector mineral soil with peaty layers should be included with organic soils when estimating nitrous oxide emission from cultivation of organic soils.
- In order to implement the 2006 IPCC guidelines research is required on whether mineral soils with peaty topsoils have similar emissions behaviour to that of Organic Soils under the definition of "managed/drained" rather than "cultivated".
- The total national area of Organic Soils is 258 748 ha and the area of mineral soils with peaty layers is 591 193 ha.
- The total area of Organic soils under agricultural production is 186 165 ha, and the area of mineral soils with a peaty layer under agricultural production is 99 464 ha.
- The estimated proportion of the total national area of Organic Soils plus mineral soils with peaty layers that are managed is 33.6%.
- The estimated proportion of the total national area of Organic Soils plus mineral soils with peaty layers that is potentially cultivated is 19% in any given year.
- The current assumption of 5% of the potentially cultivated Organic Soil plus mineral soils with peaty layers is cultivated on an annual bases should be retained until further information has been gathered. This results in an annual area of 8,019 ha.

1 Introduction

Landcare Research was contracted by MAF to classify organic soils to conform to the IPCC definition of organic soils and to determine the area of organic soils in New Zealand as at 1990. The work would include collaboration with relevant parties.

2 Background

2.1 New Zealand's Greenhouse Gas Inventory

The New Zealand's Greenhouse Gas Inventory 1990–2008

> *is the official annual report of all human-caused emissions and removals of greenhouse gases in New Zealand and is a Tier 1 statistic. The inventory measures New Zealand's progress against its obligations under the Kyoto Protocol as well as the United Nations Framework Convention on Climate Change (UNFCCC).*

The Inventory provides a snapshot of where New Zealand is at in 2010, and states:

> *New Zealand is unique amongst developed countries as agriculture is the source of nearly 50 per cent of total emissions, whereas in other developed countries such emissions are typically less than 10 per cent of the total.*

The report continues:

> *Agriculture is a major component of the New Zealand economy, and agricultural products comprise 56% of total merchandise exports (Ministry of Agriculture and Forestry 2009). This is facilitated by the favourable temperate climate, the abundance of agricultural land and the unique farming practices used in New Zealand. These practices include the use of year-round extensive grazing systems and a reliance on nitrogen fixation by legumes rather than nitrogen fertiliser.*

In August 2010, the UNFCCC expert review team came to review the New Zealand Greenhouse Gas Inventory 1990–2008. One of the issues they raised was that the area of organic soils reported under the Agriculture section differed to that reported under the Land Use, Land Use Change and Forestry (LULUCF section). This anomaly was due to a difference in the definitions of organic soils used in these two sections. The difference was due primarily to soil depth variations but the relationship between the two sets of organic soils in Agriculture and LULUCF was not clearly defined.

2.2 Definition of organic soils in 'Agriculture Sector'

The definition New Zealand has used to report the area of Organic Soils within the Agriculture section of the National Greenhouse Gas Inventory has comprised two parts:

1. Organic Soils

Organic Soils are soils described as Histosols[1], which are defined as:

> *Organic soils that have organic soil materials in more than half of the upper 80 cm, or that are of any thickness overlying rock or fragmented materials that have interstices filled with organic soil materials.*

An organic soil material is defined as:

> *Soil materials that are saturated with water and have 174 g/kg or more organic carbon if the mineral fraction has 500 g/kg or more clay, or 116 g/kg organic carbon if the mineral fraction has no clay, or has proportional intermediate contents, or if never saturated with water, have 203 g/kg or more organic carbon.* (Soil Survey Staff 1999)

2. Mineral soils with peaty layers

Mineral soils may have organic layers that are not sufficiently thick, or are buried too deep, for the soil to be classified as an Organic Soil. It was argued that the modification of mineral soils with a peaty layer would result in emissions similar to those classified as Organic Soils (Kelliher et al. 2002). Therefore these thinner peaty soils were included in the Organic Soils definition, and Kelliher et al. (2002) extended the definition of Organic Soils to encompass these mineral soils. They defined organic soils

> *as having 17% organic matter content (thus including slightly peaty, peaty and peat soils of 17–30, 30–50 and >50% organic matter content, respectively* (Milne et al. 1995)

with at least 0.1 m of this material occurring within 0.3 m of the surface (following Hewitt 2010).

2.3 Definition of organic soils in LULUCF

MfE reports changes in organic soils relating to land-use change in the LULUCF section. Quantification of change requires that areas where change has occurred are explicitly mapped out to demonstrate the areal extent of change. The definition that is used by New Zealand to report the area of organic soils within the LULUCF section of the National Greenhouse Gas Inventory is taken from the New Zealand Soil Classification (Hewitt 2010). This definition is used because it is the basis for mapping organic soils in the New Zealand Land Resource Information System database.

[1] Organic Soils are termed 'Histosols' in the US Soil Taxonomy (Soil Survey Staff 1999).

The LULUCF definition accords with Hewitt (2010) and states:

> *Soils that have horizons that consist of organic soil material (including soils that have skeletal layers in which the matrix of the gravel consists or organic soil material) that within 60 cm of the soil surface are either*
>
> *—30 cm or more thick (cumulative) and are entirely formed from peat or other organic soil materials that have accumulated under wet conditions (they are saturated with water for at least 30 consecutive days in moist years, or have been artificially drained) (O horizons), or*
>
> *—40 cm or more thick and are formed from partly decomposed or well decomposed litter (F and H horizons)*

Within the LULUCF section, New Zealand is required to report on soil organic carbon and changes in organic carbon in mineral and organic soils (including peat) to a specified depth chosen by the country and applied consistently through the time series. New Zealand is reporting to a depth of 30 cm for both mineral and organic soils. This is based on GPG-LULUCF where, for Tier 1 estimates,

> *carbon stocks are measured to a default depth of 30 cm and do not include carbon in surface residues (i.e., dead organic matter) or changes in inorganic carbon (i.e., carbonate minerals)* (GPG-LULUCF 2003, Section 3.3.1.2.1).

Emissions from land-use change on mineral soils with a peaty layer, which are not classed as Organic Soils using the LULUCF definition, are reported in the mineral soils pool, and so are accounted for in the system.

It is important to note that the definition for Histosols (in the Agricultural Sector) uses a thickness of 40 cm, while the New Zealand Organic Soils definition uses a thickness of 30 cm. Although different, this disconnect in thickness is not likely to affect the estimate of the total national area of Histosols, because the mapping uncertainty is greater than 10 cm.

3 Objectives

- Hold an initial workshop to determine the work required for this project.
- Review the definitions of organic soils used for IPCC reporting.
- Clarify the distinction between cultivated and managed organic soils.
- Provide a rationale for the reported area of organic soils in New Zealand.
- Provide a method to evaluate the area of organic soils and the proportions of that area under specified agricultural management.
- Estimate the areas of organic soils in Waikato and Southland and change in areas of cultivation and modification between 1990 and 2008.
- Discuss annual updating of cultivated/managed organic soils.

4 Methods

4.1 Workshop

A workshop to specify the required work (21 February 2011) was attended by Marc Dresser, Allan Hewitt, Janice Willoughby, Kevin Tate, Stella Belliss and Donna Giltrap (Landcare Research), Andrea Pickering (MAF), Jude Addenbrooke and Bridget Fraser (MfE), and Frank Kelliher (AgResearch).

The workshop determined that:

- There needed to be a clearer definition of what constitutes an Organic Soil.
- Differences between the Agriculture and LULUCF sector usage of organic soils* need to be clearly described.
- The term 'managed' should be adopted to refer to an organic soil that has been altered to such a degree that it can support high producing and low producing grassland, and annual crop production. Alterations to managed soils would include drainage, liming and the addition of superphosphate.
- To map the areas of organic soils for each definition, the LULUCF Organic Soils layer should be used as a base layer and extra areas needed for Agriculture Sector reporting should be added to that base layer.

*** In this report the name of a formally defined soil class, as in the 'Organic Soils' of the New Zealand Soil Classification, is capitalised. Informal references to soils that have organic soil characteristics are not capitalised.**

4.2 GIS workflow

The following GIS workflow was designed to map the national extent of LULUCF and Agriculture Sector areas.

- Label the ORG component from the '**LUCAS IPPC soils**' layer as '**LUCAS-O**' layer.
- Identify all polygons from the LRI soils layer with subgroup that contains 'peaty' as '**LRI-P'** layer.
- Generate the Agriculture Sector's new organic layer (consisting of Organic Soils + mineral soils with Peaty subgroups) by combining '**LUCAS-O**' + '**LRI-P'** = '**New-O**' layer.
- Measure the national area of '**New-O'** soils.
- Overlay '**New-O'** with the LUCAS Land Use Map areas from Table 1 that are ticked as 'managed' and call this '**Managed-new-O**'.
- Measure the national area of '**Managed-new-O**' soils.
- Measure the national area of '**Not-managed-new-O**' soils.

- Calculate the proportion of '**New-O**' that is managed.

The proposed approach was applied to also estimate the regional extent for areas of organic soils in Southland and Waikato regions, both with significant areas of Organic Soils. The regions were mapped (1) from available data up to 1990, and (2) from mapped areas using data generated between 1990 and 2008. The derived maps were then compared to see if there were significant changes in the area of organic soils over the specified time frame.

5 Results and Discussion

5.1 Definition of 'organic soils' for use in LULUCF and Agriculture Sector reporting in New Zealand

In this section we justify the inclusion of mineral soils with peaty layers within 'organic soils' and propose definitions of organic soils for use in LULUCF and Agriculture Sector reporting in New Zealand

5.1.1 Justification for inclusion of mineral soils with peaty layers

The current area of Organic Soils under the Agriculture Sector definition includes mineral soils with a peaty layer. It is suggested that inclusion of mineral soils with a peaty layer is justified due to the loss of organic matter from these soils under cultivation and other agricultural development practices.

If the reporting guidelines are changed from 'cultivated' to include all 'managed land' as proposed by the 'Agriculture, Forestry and Other Land Use' guidelines (IPCC 2006), then the inclusion of mineral soils with a peaty layer needs to consider the following factors.

1. Cultivation of mineral soils with a peaty layer is expected to produce a similar amount of N_2O emissions as cultivation of Organic Soils (Kelliher et al. 2002).

2. The carbon stock of mineral soils with a peaty layer is smaller and more quickly exhausted by management-driven degradation, compared with Organic Soils.

3. There is evidence suggesting that farmers no longer cultivate to the degree that they have in the past when they carry out pasture renewal. Direct drilling of pastures has become a more favoured practice. Less soil disturbance is likely to produce fewer emissions.

4. Increasing use of shorter-life pasture varieties requires more frequent pasture renewal.

Analysis of farming practice suggests revision of the 5% pasture renewal per annum estimate. This is being investigated in Ministry of Agriculture and Forestry contract 12270.

Location of 'mineral soils with peaty layers' can be made on the basis of soil maps classified according the New Zealand Soil Classification (Hewitt 2010). This section of the classification is presented in Appendix 1. In most cases 'mineral soils with peaty layers' identifies soils with peaty topsoils. However, it also encompasses small areas of Gley Soils where the peaty material is buried – 'soils that have a peaty topsoil either at the surface or

buried with its upper surface within 60 cm of the soil surface'. This allows recognition of peaty topsoils that have been buried by younger sediments in alluvial terrain.

Some of these buried peaty topsoils will not be recognised in carbon stock inventories as they occur below the 30-cm depth IPCC Tier 1 default. Soil maps will not always differentiate buried peaty topsoils from peaty topsoils at the soil surface. However, areas of soils with buried peaty topsoils are not likely to be significant. Because of their depth, buried topsoils are unlikely to be affected by land management.

5.1.2 Proposed definitions of organic soils

We propose that definitions for organic soil reported in the Agriculture and LULUCF sectors are based on the New Zealand Soil Classification (Hewitt 2010).

LULUCF definition

Soils that have horizons that consist of organic soil material (including soils that have skeletal layers in which the matrix of the gravel consists of organic soil material) that within 60 cm of the soil surface, are 30 cm or more thick (cumulative) and are entirely formed from peat or other organic soil materials that have accumulated under wet conditions (they are saturated with water for at least 30 consecutive days in moist years, or have been artificially drained)

This definition is currently used for LULUCF reporting by MfE and aligns with the IPCC definition given in the LULUCF good practice guidance (IPCC 2003). This excludes peaty subgroups of mineral soils and Organic Soils formed in thick forest litter.

Agriculture definition

Organic soils include both parts 1 and 2 of the following:

1. *Soils that have horizons that consist of organic soil material (including soils that have skeletal layers in which the matrix of the gravel consists of organic soil material) that within 60 cm of the soil surface, are 30 cm or more thick (cumulative) and are entirely formed from peat or other organic soil materials that have accumulated under wet conditions (they are saturated with water for at least 30 consecutive days in moist years, or have been artificially drained),*

   OR

2. *Soils with a peaty layer 10 cm or more thick that is saturated for 30 or more consecutive days in most years (unless it is artificially drained), and has either peat, sandy peat or loamy peat texture, or slightly peaty texture (17–30% organic matter) if the clay content is less than 18%.*

Notes:

(1) In some subgroups a peaty topsoil may be buried by a surface mantle of new material of up to 60 cm in thickness.

(2) This definition merges two definitions: the Organic Soils (LULUCF definition), and the Mineral soils with peaty subgroups.

(3) The Hewitt (2010) definition of Organic Soils includes soil materials that are '40 cm or more thick and are formed from partly decomposed or well-decomposed litter (F and H horizons)'. However, this these soil materials are not included in the organic soils definition proposed in this report because the tree litter horizons (F, H, , and the fresh litter "L") are not counted in IPCC rules as part of the soil carbon stock.

5.2 Definition of 'cultivated' and 'managed' Organic Soils

Currently the Agriculture Sector guidelines characterise the impacts of agricultural land management on organic soils as 'cultivation' whereas the 2006 guidelines characterise the impacts as 'managed' soils. This distinction is important, as managed soils include a wider range of farm management practices than are encompassed under cultivation.

Kelliher et al. (2002) originally reported the total area of organic soils under agriculture at 202 181 ha. An assumption was made that only 5% of the total area was cultivated in any one year. The rationale was that pasture renewal entailed cultivation, and that pasture renewal occurred approximately every 20 years. On this basis 5% of the total organic soils area would be cultivated in an average year. This was reported as 10 109 ha.

Assumptions of modification can be mapped by applying the mapped land use units of the LUCAS (Land Use And Carbon Analysis; MfE) Land Use Map. Table 1 lists the LUCAS Land Use Map units used in this report. They are defined in Appendix 2. We have assigned the land use map classes to managed and cultivated categories.

Table 1: Assignment of LUCAS land use classes to managed and cultivated categories for Agricultural Sector reporting. Note that all land use classes are considered 'managed' under LULUCF reporting. LUCAS Land Use Map (LUM) definitions are given in Appendix 2.

LUM code	Attribute	Managed 2006 Guidelines	Cultivated	Agriculture Soils 2006
71	Natural Forest			
72	Planted Forest – Pre-1990	***Y***		
73	Post-1989 Forest	***Y***		
74	Grassland – With woody biomass	***Y***		***Y***
75	Grassland – High producing	***Y***	***Y***	***Y***
76	Grassland – Low producing	**Y**		**Y**
77	Cropland – Perennial	**Y**	**Y**	**Y**
78	Cropland – Annual	**Y**	**Y**	**Y**
79	Wetland – Open water			
80	Wetland – Vegetated non-forest			

81	Settlements or built-up area			

The land use classes (Table 1) that are characterised as managed are predominantly under forest, agricultural, or urban use. Any organic soils within these areas will have been disturbed to some degree by forest planting and harvesting, or by grazing and associated pasture modification and fertilisation.

The 'Grassland – Low producing' category has a wide range of probable modifications. The most managed land is likely to occur at the margins with 'Grassland – High producing', which is considered 'cultivated'. 'Grassland – low producing' is not included in the cultivated category but infrequent cultivation may occur. The least managed land is likely to occur on mountain tussock grasslands above the treeline, e.g. the Fiordland Mountains. Such areas may be grazed by feral animals but impacts contributing to emissions can be expected to be very low. It would be possible to define and mask out these non-farmed areas by delineating national park areas and climate zones outside the normal range of farming.

Areas of 'Wetlands – Vegetated non-forest' commonly include organic soils or mineral soils with peaty layers. In pre-European times most areas of organic soils and mineral peaty soils would have been classed as some variety of wetland. The areas that have been subsequently managed by drainage are now included under one of the other 'managed' land use categories.

5.3 Change in Organic Soil areas in Waikato and Southland between 1990 and 2008

The process described in Section 4.2 was applied to determine the area of organic soils in Waikato Region for 1990 based on soil data derived from the best available soil data as at 1990. For the area of organic soils at 2008, surveys produced between 1990 and 2008 were used. For the Waikato these were the updated-Coromandel-Thames, Waikato Lowlands, Taupo Region and Kaingaroa Plateau, Hauraki Plains and Matamata County surveys. Similarly the area of organic soils in Southland Region for 1990 was based on soil data derived from the best available soil data as at 1990. This entailed use of NZLRI data (NWASCO 1979). Topoclimate data was used to represent the data between 1990 and 2008. Southland and Waikato soil surveys used in the analysis are listed with dates of publication in Table 2. There is no soil mapping dated at 1990 or 2008.

An understanding of the true rates of change in organic soils is confounded by changing soil survey methods and precision and the nature of the metadata on survey dates. Care is needed to distinguish between the date that a soil survey was conducted the date at which it was published, and the date at which the data may appear in a later compilation.

The estimate of Agricultural Sector organic soils by Kelliher et al. (2002) was derived from the NZLRI (NWASCO 1979). This is a compilation of data that incorporated a variety of soil surveys with a range of earlier publication dates. The NZLRI data thus cannot precisely express the areas of organic soils at one point of time.

Table 2: Additional soil surveys used in the mapping of 2008 coverage. The dates represent original publication dates. The Waikato surveys have been since updated in the period 1990 to 2008.

Original date	Area	Authors
1972	COROMANDEL–THAMES	McCraw & Bell (1972)
1984	WAIKATO LOWLANDS	McLeod (1984)
1986	TAUPO REGION	Rijkse (1986)
1988	KAINGAROA PLATEAU	Rijkse (1988)
1992a	HAURAKI PLAINS COUNTY	McLeod (1992a)
1992b	MATAMATA COUNTY	McLeod (1992b)
2001	SOUTHLAND	Topoclimate

5.4 Area of Organic Soils and proportions under specified agricultural management

Areas of LULUCF Organic Soils and mineral soils with peaty layers are given for New Zealand, and Waikato and Southland regions (Newsome & Shepherd 2009) in Tables 3, 4 and 5, respectively. The areas of managed and cultivated land for 1990 and 2008 were drawn from the LUCAS Land Use Map (LUM) version 6 (provided by Ministry for the Environment).

Table 3: 1990 areas of soil types for New Zealand

1990 New Zealand	Area (ha)
Total area of New Zealand	26 851 092
Area of Managed soils	17 085 256
Area of Cultivated soils	6 250 311
Area of Organic Soils	258 748
Area of MinPeat	591 193
Area of Organic + MinPeat	849 941
Area of Organic & Managed soils	191 003
Area of Organic + MinPeat & Managed	292 274
Area of Organic & Cultivated soils	135 718
Area of Organic + MinPeat & Cultivated	160 385
Proportion Organic + MinPeat (managed)	34%
Proportion Organic + MinPeat (cultivated)	19%

Where **Organic** = Organic soils as delineated by LULUCF, **MinPeat** = Mineral soil with peaty layers, as delineated by the NZLRI. "&" denotes a GIS intersection between two areas, similarly in other Tables. Data for areas are derived using the Transverse Mercator 2000 projection.

Table 4: 1990 areas of soil types for New Zealand agricultural land for use with 1996 IPCC and Good Practice Guidelines. Note we have used agricultural land and agricultural soils synonymously.

	Area (ha)
Total area of agricultural land (74-78)	15,407,287
Area of agricultural (74-78) & cultivated (75,77,78) soils	6,250,311
Area of agricultural soils (74-78) & Organic	186,165
Area of agricultural soils (74-78) & MinPeat	99,464
Area of agricultural soils (74-78) & Organic + MinPeat	285,629
Area of agricultural soils (74-78) & Organic & Cultivated soils (75,77,78)	135,718
Area of agricultural soils (74-78) & Organic + MinPeat & cultivated (75,77,78)	160,385

Where **Organic** = Organic soils as delineated by LULUCF, **MinPeat** = Mineral soil with peaty layers, as delineated by the NZLRI. Data for areas are derived using the Transverse Mercator 2000 projection.

Table 5: 1990 areas of soil types for New Zealand agricultural land for use with 2006 IPCC Guidelines

1990 New Zealand	Area (ha)
Total area of Managed soils	
Area of Organic managed Soils	
Area of managed MinPeat	
Area of managed Organic + MinPeat	

Where **Organic** = Organic soils as delineated by LULUCF, **MinPeat** = Mineral soil with peaty layers, as delineated by the NZLRI. Data for areas are derived using the Transverse Mercator 2000 projection.

Table 4: Areas of soils types for Waikato

Waikato	Area (ha) 1990	Area (ha) 2008
Total area of Waikato	2 452 841	2 452 841
Area of Managed soils	1 712 795	1 717 101
Area of Cultivated soils	968 399	996 054

Area of Organic Soils	99 235	99 301
Area of MinPeat	6 836	8 556
Area of Organic + MinPeat	106 071	107 857
Area of Organic (75,77,78)Managed soils	81 963	82 297
Area of Organic + MinPeat & Managed	87 875	90 209
Area of Organic & Cultivated soils	71 450	72 218
Area of Organic + MinPeat & Cultivated	75 986	78 715
Proportion Organic + MinPeat (managed)	83%	84%
Proportion Organic + MinPeat (cultivated)	71%	73%

Table 5: Areas of soil types for Southland

Southland	Area (ha) 1990	Area (ha) 2008
Total area of Southland	3 175 659	3 175 659
Area of Managed soils	1 656 360	1 658 970
Area of Cultivated soils	695 401	687 233
Area of Organic Soils	56 042	50 467
Area of MinPeat	561 926	559 959
Area of Organic + MinPeat	617 968	610 425
Area of Organic & Managed soils	30 147	27 633
Area of Organic + MinPeat & Managed	87 875	86 538
Area of Organic & Cultivated soils	7 980	8 901
Area of Organic + MinPeat & Cultivated	8 686	13 881
Proportion Organic + MinPeat (managed)	14%	14%
Proportion Organic + MinPeat (cultivated)	1.4%	2.3%

For the Waikato the change in Organic Soils is minor, and is probably within limits of error. Mineral peat soils, however, show an increase of 1720 ha. This is likely due to better mapping rather than real soil change. Increases in total areas of managed and cultivated land in the Waikato Region probably represent real change. The LUM mapping was designed to show change over time whereas the soil mapping has not been repeated comprehensively at points in time. In Southland the large area of mineral peat soils is due to the extensive areas of montane grassland peaty soils in Fiordland, and Stewart Island. Changes in soil areas, as in Waikato, are likely to be due to remapping rather than real soil change. In both Waikato and Southland the changes in proportions of organic soils and mineral peat soil that are either managed or cultivated are small and probably not distinguishable from the effects of soil remapping.

If it is assumed that the estimated changes in areas of Organic Soils and mineral peat soils between 1990 and 2008 in Waikato and Southland are due solely to new soil mapping, then remapping may change the estimated area of these soils by an amount that ranges from 1% to 20% depending on the terrain.

5.5 Annual updating of developed/managed organic soils

Apparent soil class boundaries and areas will change either because of (1) real soil change or (2) increased accuracy of new soil survey. It can be expected that locations of organic soil boundaries and soil areas will show faster real soil change than most other soil types, especially areas of thin peaty topsoils. The ideal monitoring period, however, would be in the order of 5 years and that may only require change detection in sensitive areas. An efficient solution would be to match monitoring frequency to the refresh rate of land use mapping.

The current organic soil boundaries and areas are based principally on 40-year-old data. For an estimate of 1990 organic soils the NZLRI data that has been used is the best available. Updating is needed to make more accurate estimates of organic soils after 1990. Although new soil mapping is being undertaken by the S-map project, little time has been put into characterisation of organic soils.

Monitoring of land use activities that may be characterised as either modification or cultivation may require some field examination, but much can be inferred from remote sensing imagery. Imagery includes KiwiImage (where available), the SPOT-5 data from 2007–2008 that was used to derive the LUCAS layers, and other more localised and specific datasets. Examples include time series of optical and SAR imagery for key areas of Southland (centred on Awarua), and time series of optical imagery over Canterbury.

6 Conclusions

Rationale for the reported area of organic soils in New Zealand

It is appropriate that LULUCF and Agriculture sectors use differing but linked definitions of organic soils as a basis for reporting to meet their differing goals. The reporting focus for the LULUCF sector is soil carbon change with change in land use. The soil organic carbon included in mineral soils with peaty layers is accounted for in the relevant IPCC mineral soil classes. The reporting focus for the agricultural sector in New Zealand is dominantly greenhouse gas emissions, and it is judged that mineral soils with peaty topsoils will have similar emissions behaviour to that of Organic Soils. Definitions for LULUCF and Agriculture sector reporting were proposed.

Differentiation of managed and cultivated organic soils

This report has allocated MfE land use map classes to managed and cultivated categories. However, some land use map classes do not align well with these categories. For example, the 'Grassland – low producing' map unit includes substantial areas that are managed but also includes montane herbfields and above-treeline-scrubland vegetation that is clearly not managed. Use of land use map subcategories may achieve better alignment.

Total reported area and proportions of that area under specified agricultural management

A GIS work flow was designed to reproducibly derive total areas of organic and mineral soils with peaty layers for New Zealand and selected regions. The total national area of Organic Soils is 258 748 ha and the area of mineral soils with peaty layers is 591 193 ha. The estimated proportion of Organic Soils plus mineral soils with peaty layers that is managed is 34% and that is potentially cultivated is 19% in any given year.

Trial estimation of 1990 and 2008 total areas in Waikato and Southland

Data on organic soils for 1990 and 2008 are not available. Inferences have to be made from soil survey information prior to those dates that assume slow rates of change over time. An understanding of the true rates of change in organic soils is confounded by changing soil survey methods and precision and the nature of the metadata on survey dates. Greater accuracy will require resurvey of Organic Soil areas. The Waikato and Southland trial indicates that resurvey may change the estimated area of Organic and mineral soils with peaty layers by an amount that ranges from 1% to 20% depending on the terrain.

Annual updating of managed and cultivated organic soils

Monitoring of land use on organic soils to infer agricultural greenhouse gas emissions would not be required annually. If assessment of soil carbon change and emissions is based on soil classes and land use map units then monitoring frequency needs to be matched to the rate of change in soil classes and land use map types. A 5-year update would probably be suitable.

7 Acknowledgements

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Appendix 1 – Definition of the Organic Soils order and Peaty Subgroups in the New Zealand Soil Classification (Hewitt 2010)

Diagnostic horizons

The NZSC defines diagnostic soil horizons and materials and then uses these in the definition of classes.

Organic Soil Material (page 25, NZSC 3rd edn, Hewitt 2010)

Organic soil material is soil material dominated by organic matter, excluding fresh litter (L horizons) and living plant material. Organic soil material usually has at least 18% organic carbon (approximately 30% organic matter) but it is defined here using morphology and simple analyses for easier recognition. (For most New Zealand soils, organic carbon may be estimated by total carbon.)

Organic soil material has either

1. All of the following:
   (a) Colour value moist of 3 or less (after exposure to air) and colour value dry of 4 or less, and
   (b) Deformable failure, and
   (c) Weight loss of 65% or more by oven-drying a field-saturated sample;

OR

2. More than 20% (by volume) unrubbed fibre content;

OR

3. More than 35% (by weight) loss on ignition except in materials dominated by allophanic soil material or by limestone.

OR

4. 18% or more total carbon.

Organic soil materials that have been accumulated under wet conditions are subdivided into three classes, based on evidence of decomposition (Milne et al. 1995). These classes are used to distinguish soil groups of Organic Soils.

Fibric soil material (Of horizon) consists mainly of well-preserved plant remains that are readily identifiable in terms of botanical origin. The fibre content after rubbing is at least 75% by volume.

Fibres are pieces of plant tissue large enough to be retained on a 100-mesh (0.15 mm) sieve, except for wood fragments that cannot be crushed or shredded in the hand and are larger than 2 cm in the smallest dimension. Rubbed fibre is the fibre that remains after rubbing a wet sample 10 times between the thumb and forefinger, or kneading a ball in the palm 10 times using firm pressure.

Mesic soil material (Om horizon) consists mainly of partially decomposed plant remains (semi-fibrous peat or hemic soil material) and does not meet the requirements of either fibric soil material or humified soil material.

Humified soil material (Oh horizon) consists of strongly decomposed organic material (humified peat or sapric soil material) with few or no identifiable plant remains other than resistant woody fragments >20 mm that cannot be reduced to fibres by crushing and shredding between the fingers. The fibre content is less than 15% after rubbing.

Peaty topsoil (page 28, NZSC 3rd edn, Hewitt 2010)

A peaty topsoil is 10 cm or more thick and is saturated for 30 or more consecutive days in most years (unless it is artificially drained), and has either

1. Peat, sandy peat or loamy peat texture,

OR

2. Slightly peaty texture (17–30% organic matter) if the clay content is less than 18%.

In some subgroups a peaty topsoil may be buried by a surface mantle of new material of up to 60 cm in thickness.

Categories of the New Zealand soil classification hierarchy

The hierarchy of soil classes is: soil order → soil group → soil subgroup → soil family → soil sibling. Organic soils are recognised at the soil order level as 'Organic Soils'. The Peaty topsoil classes are recognised at soil subgroup level. There are 10 soil subgroups defined, within 5 orders. An example is the 'Peaty Sandy Gley Soils'. (See the list of subgroups below.)

Organic soils order definition (page 35, NZSC 3rd edn, Hewitt 2010)

Organic soils have horizons that consist of organic soil material (including soils that have skeletal layers in which the matrix of the gravel consists of organic soil material) that within 60 cm of the soil surface are either:

1. 30 cm or more thick (cumulative) and are entirely formed from peat or other organic soil materials that have accumulated under wet conditions (they are saturated with water for at least 30 consecutive days, in most years, or have been artificially drained) (O horizons),

OR

2. 40 cm or more thick and are formed from partly decomposed or well-decomposed litter (F and H horizons).

Note: Part 2 of this definition includes soils derived from thick litter – normally in forest. Litter is not counted as soil material in the LULUCF sector and so part 2 of the definition is not relevant. This is academic anyway as no soil types have yet been defined from thick litter.

Peaty subgroup definition

The following Peaty subgroups are defined:

Peaty Gley Allophanic Soils

Peaty Acid Brown Soils

Peaty Orthic Gley Soils

Peaty Acid Gley Soils

Peaty Tephric Gley Soils

Peaty Recent Gley Soils

Peaty Sandy Gley Soils

Peaty Sulphuric Gley Soils

Peaty-silt-mantled Perch-gley Podzols

Peaty-acidic Rocky Recent Soils

Appendix 2 – Landcover database land use map categories (from the Ministry for the Environment website; MfE 2001)

Land Use Class mapped	**Land Use/land cover sub-categories**
Natural Forest* (as at 1990) LUC_ID= 71	Tall forest on Department of Conservation (DOC) land, including wilding pines Short forest or shrubland (with potential to reach ≥ 5 m at maturity *in situ*) on DOC land Roads/tracks less than minimum width on DOC land, within the above 2 categories Tall forest (≥30% cover) on other (non-DOC) land Broadleaved hardwood shrubland, manuka/kanuka shrubland and other woody shrubland (≥30% cover, with potential to reach ≥ 5 m at maturity *in situ*) on other (non-DOC) land under current land management
Pre-1990 Planted Forest LUC_ID= 72	Radiata pine, Douglas-fir, eucalypts, or other planted species as at 1990 (with potential to reach ≥ 5 m height at maturity *in situ*) Harvested areas as at 1990 (assumes these will be replanted, as deforestation was extremely rare in 1990) Roads/tracks/skids less than minimum area/width within forested areas Riparian or erosion control plantings (≥30% cover, potentially ≥ 5 m *in situ*)
Post-1989 Forest (2008 only) LUC_ID= 73	These include forests which meet the forest parameters adopted by New Zealand for the Kyoto Protocol reporting and have either been planted or established after 1 January 1990 on to land which was non-forest land as at 31 December 1989. Generally these forests are planted with exotic species, but they may arise from natural regeneration of indigenous tree species as a result of management change after 1 January 1990. For exotic forest they include radiata pine, Douglas-fir, eucalypts, or other planted species (with potential to reach ≥ 5 m height at maturity *in situ*). Roads/tracks/skids less *than mi*nimum area/width within forested areas Riparian or erosion control plantings (≥30% *cove*r, potentially ≥ 5 m *in situ*)
Grassland – with woody biomass LUC_ID= 74	Grassland with tall tree species (<30% cover) Grassland with riparian or erosion control plantings (<30% cover) Grassland with matagouri and sweet briar where it is expected that the forest criteria will not be met over a 30–40 year time period under current management Grassland with broadleaved hardwood shrubland, manuka/kanuka shrubland and other woody shrubland (< 5 m and any % cover), which is expected to not meet the forest criteria over a 30–40 year time period under current management Grassland with linear shelterbelts

Grassland – high producing (NZLRI used for LUM 1990 and LUM 2008) LUC_ID= 75	Grassland with exotic species
Grassland – low producing (NZLRI used for LUM 1990 and LUM 2008) LUC_ID= 76	Low fertility grassland on hill country Tussock grasslands Montane herbfields and above-timberline shrubland vegetation (which does not have the potential to reach > 5 m height *in situ*) Tussock grassland with linear shelterbelts Other areas of limited vegetation cover and significant bare soil
Cropland – perennial (LCDB1.2 used for LUM 1990, LCDB2 used for LUM 2008) LUC_ID= 77	All orchards and vineyards (it is assumed that no crops meet the forest definition) Linear shelterbelts associated with cropland
Cropland – annual (LCDB1.2 used for LUM 1990, LCDB2 used for LUM 2008)	All annual crops All cultivated bare ground Linear shelterbelts associated with cropland
Wetland – open water	Lakes, rivers
Wetlands – vegetated non-forest	Herbaceous and/or non-forest woody vegetation periodically flooded Scattered patches of tall tree-like vegetation to be included as wetlands Estuarine/tidal areas including mangroves
Settlements	Built-up areas and impervious surfaces Grassland within 'settlements' including recreational areas Urban parklands and open spaces which do not meet the forest definition
Other	Montane rock/scree Largely bare ground (if not cropland) Any other remaining land

Appendix 3 – Maps

The following maps were made, five of which are reproduced as figures in this report. The full set was emailed to MAF as a seperate file, 28-7-2011.

Figure 1. New Zealand map of IPCC organic soils and mineral soils with a peaty layer

New Zealand map of LULUCF Organic Soils

New Zealand map of managed Organic and Peaty Soils

Waikato map of 1990 managed Organic and Peaty

Waikato map of 1990 cultivated Organic and Peaty

Figure 4. Waikato map of 2008 managed Organic and Peaty

Figure 5. Waikato map of 2008 cultivated Organic and Peaty

Southland map of 1990 managed Organic and Peaty

Southland map of 1990 cultivated Organic and Peaty

Figure 8. Southland map of 2008 managed Organic and Peaty

Figure 9. Southland map of 2008 cultivated Organic and Peaty

Figure 1. New Zealand map of IPCC organic soils and mineral soils with a peaty layer

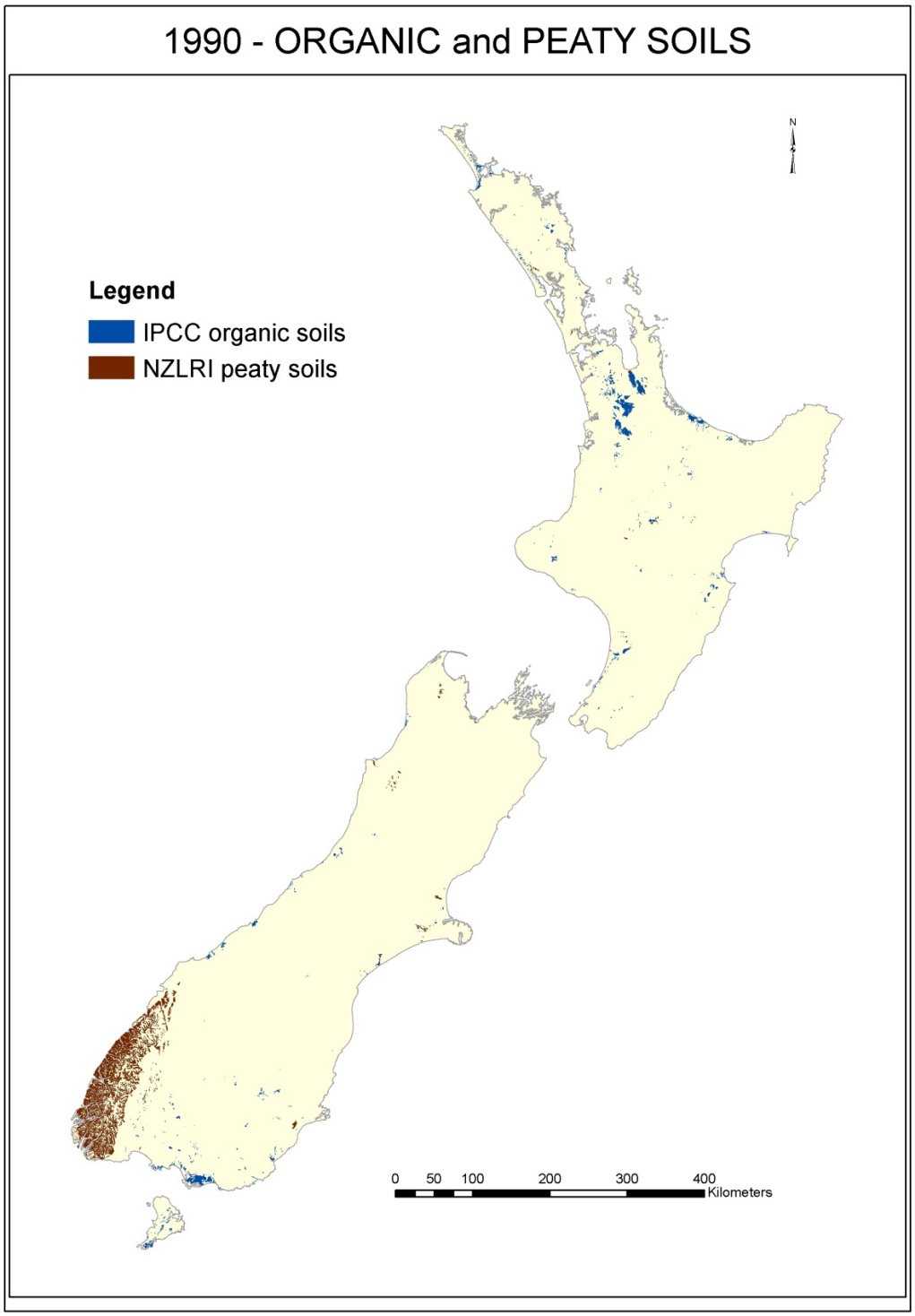

Figure 4. Waikato map of 2008 managed Organic and Peaty

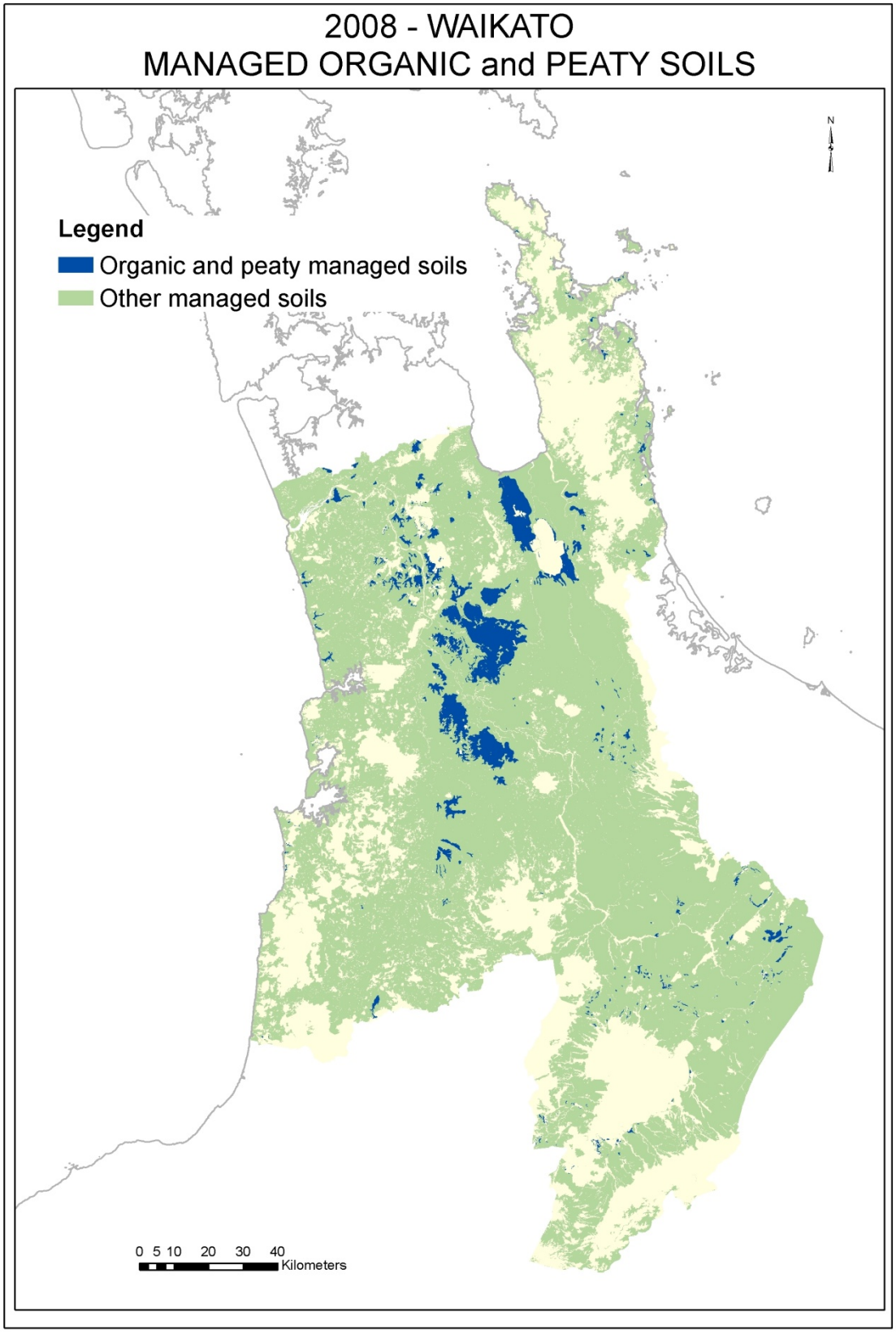

Figure 5. Waikato map of 2008 cultivated Organic and Peaty

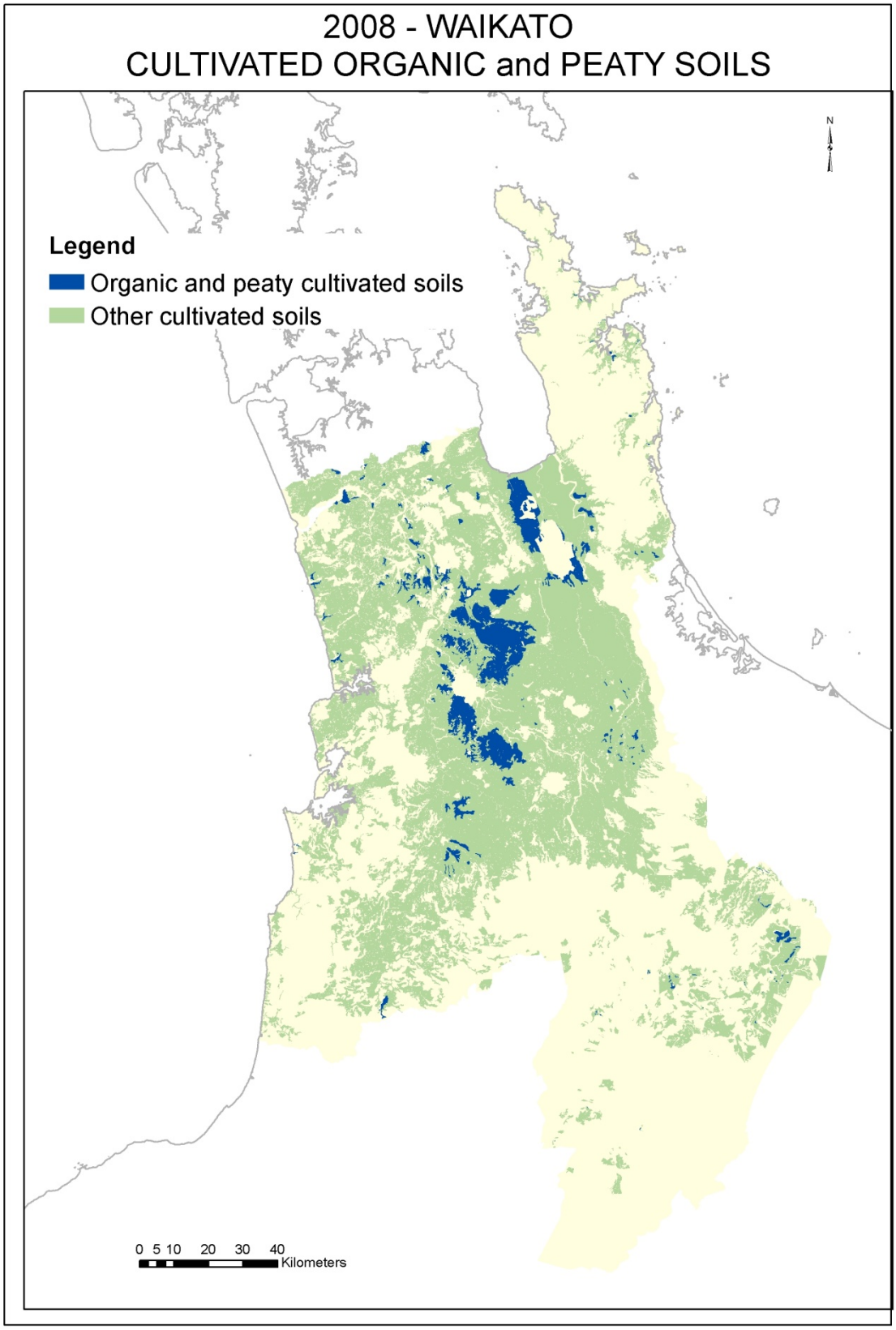

Figure 8. Southland map of 2008 managed Organic and peaty soils. The 2001 soil mapping of Southland recognised areas where organic or peaty soils occur in association with other soils within soil map delineations (‘polygons’). Previous soil mapping only identified the one dominant soil within polygons. This map identifies areas where organic or peaty soils are co-dominant or subdominant

members of soil associations within polygons in the 50-80% and 20-40% categories.

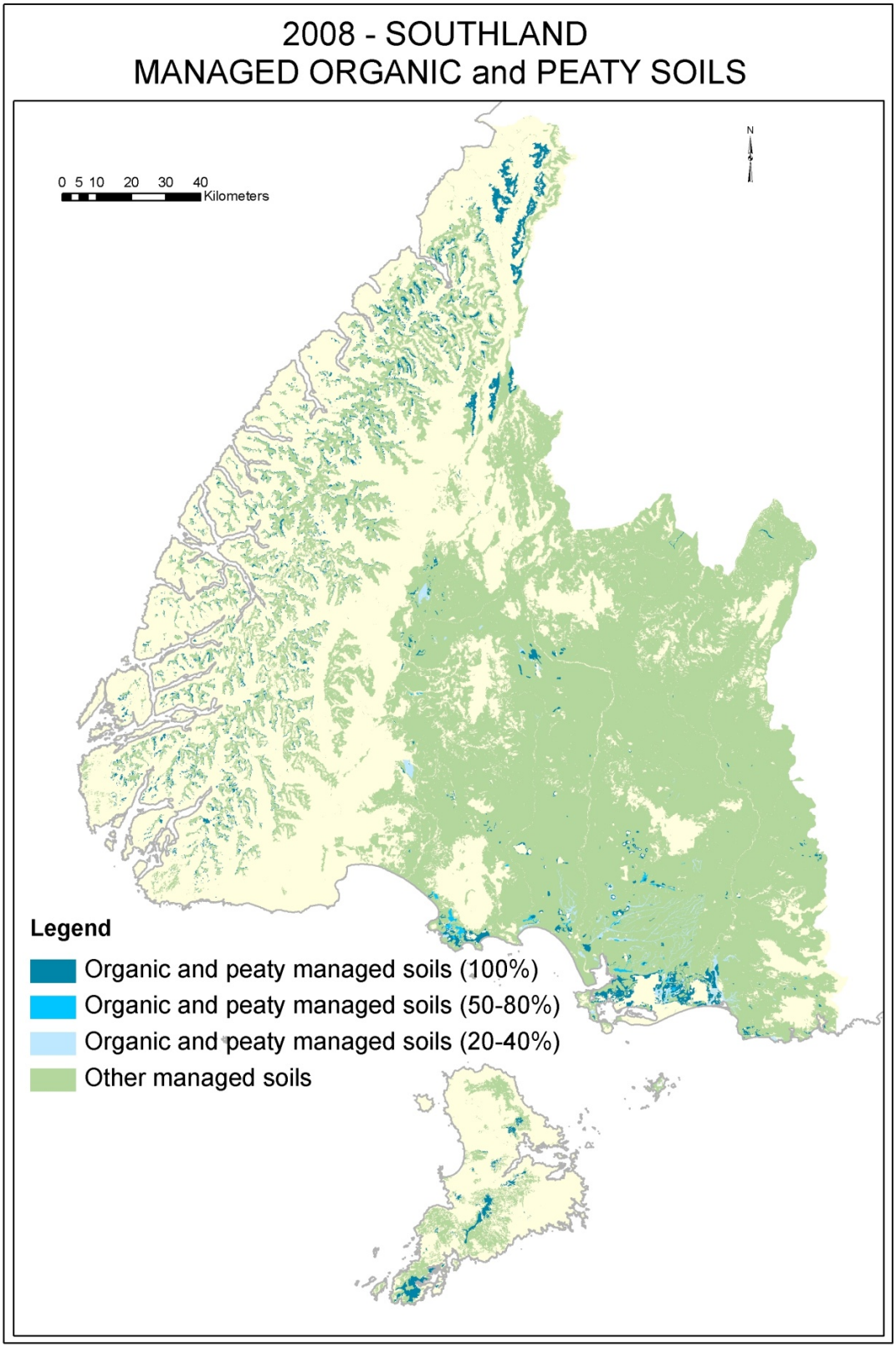

Figure 9. Southland map of 2008 cultivated Organic and Peaty