# Environment Southland Wetland Inventory Project: monitoring wetland extent on non-public conservation land in the Southland region. Report for 2015.

Prepared by Richard Ewans – Eco-South

For Environment Southland

12 November 2015

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Prepared by:

Richard Ewans – Eco-South

44 Mackinnon Loop, Te Anau 9600

Prepared For:

Environment Southland

Private Bag 90116, Invercargill 9840

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Cover image: Recent satellite imagery of intensive development of a large bog on the Southland plains.

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This report has been prepared by Eco-South for Environment Southland. If used by other parties, no warranty or representation is given as to its accuracy and no liability is accepted for loss or damage arising directly or indirectly from reliance on the information within it. The site specific information herein should not be used as evidence. The "Environment Southland Wetland Inventory Project: monitoring wetland extent on non-public conservation land in the Southland region" data are derived from analysis and interpretation of aerial photography and satellite imagery along with wetland polygons previously delineated by organisations other than Eco-South and limited field survey (ground-truthing). The data comprises a provisional inventory of wetlands within the areas sampled and is subject to revision through consultation with Environment Southland or other appropriate sources. Eco-South strongly advises that the data be used only to identify areas of interest and that field surveys be carried out for any assessments of significance and/or decisions on resource consents, the development of district and regional plan schedules or funding priorities.

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# Executive Summary

Wetlands are a key ecosystem for regional councils in New Zealand to manage and encompass values in both the biodiversity and water quality aspects of land management. Current and proposed National Policy Statements on indigenous biodiversity and freshwater management both highlight the requirement of councils to protect wetlands. Lack of accurate delineation of wetland extent has been identified as an impediment to protection and national reporting on wetland state in New Zealand.

In this project, wetlands on non-public conservation land (non-PCL) were inventoried in 2014 and 2015 for approximately 38% of the Southland region with a manual digitization approach using aerial photography mostly from 2007 to provide a baseline of wetland extent. Non-PCL was randomly sampled in three land categories (Lowland, Inland Basin and Hill Country) and wetland polygons drawn for areas of wetland greater than 0.5 ha in size. In total, 749 wetland polygons were developed covering 10,573 ha across the region. Wetland polygons were ascribed attribute data detailing wetland classifications and broad condition scores for hydrology and indigenous vegetation.

A total of 422 wetland polygons covering 8,287 ha was then compared between the 2007 aerial photography and 2014 aerial photography where coverage was available. The 2014 aerial photography was incomplete for the Southland region and covered mostly lowland areas. Therefore mapping of wetland polygons in 2015 from the 2007 aerial photography and data derived from comparisons with 2014 aerial photography are biased towards lowland areas. Wetland polygons from approximately 53% of lowland, 7% of hill country and 2% of inland basin were compared between the 2007 aerial photography and 2014 aerial photography, totalling 23% of non_PCL in Southland.

Twenty-one wetland polygons (106 ha) were considered to be lost i.e. converted into pasture and a further 78 wetland polygons were reduced in extent by a total of 703 ha, mainly by pasture conversion. Therefore the total wetland area lost between 2007 and 2014 was 809 ha (equivalent to 800 rugby fields), or approximately 10% of the area of wetland polygons mapped in 2007, mostly in lowland areas. Although much of the area lost was wetland broadly assessed as in poor to moderate condition, such areas may still provide ecosystem services such as denitrification and/or retain threatened or at risk indigenous species. In addition, some areas cleared would almost certainly have been considered as significant indigenous vegetation under the RMA and therefore should not have been cleared.

Although coverage of the Southland region is incomplete and biased towards lowland areas, the trends identified in this report suggest wetlands are still being rapidly lost from the Southland region despite being a national priority for protection on private land since 2007. Continued work should be maintained in this area to meet national reporting requirements and inform improved wetland management outcomes by: 1. Increasing the accuracy of attribute data associated with the wetland polygons with further research into other sources of available survey information and ground-truthing, 2. Rationalising the numerous wetland layers of varying utility available for the Southland region into a comprehensive database, 3. Further mapping and comparison of wetland polygons using the 2007 and 2014 aerial photography to cover (preferably) all of the region and 4. Identifying wetlands that meet national and regional significance criteria.

# 1. Background

Wetlands are areas where water is the primary factor controlling the environment and associated plant and animal life (MfE, 2007a). It is estimated that 90% of the extent of pre-human wetlands have been lost in New Zealand, with palustrine wetlands now present on just 1% of New Zealand's land mass (Ausseil et al., 2008; 2011).

Wetlands contain a large range of ecological values and perform valuable ecosystem services. They are important habitats for indigenous plants, birds and fish, and provide flood mitigation, water quality improvement and carbon storage. They also have high recreational and cultural values.

Most wetlands, particularly in lowland environments, are reduced to small remnants and surrounded by developed land. Nationally, 74% of wetlands are less than 10 ha in size (Ausseil et al., 2011) and therefore protection of small wetlands is critical to the retention of freshwater wetland diversity and extent nationally (Myers et al., 2013).

Legislation in New Zealand identifies the protection of wetlands as a matter of national importance, with wetlands on private land a national priority (Myers et al., 2013). Regional and district councils have responsibilities to protect wetlands and prevent damage and degradation to these highly threatened ecosystems. Lack of accurate delineation of wetland extent has been identified as an impediment to protection and national reporting on wetland state (Ausseil et al., 2008; Myers et al., 2013).

## 1.1 The case for keeping wetlands

Wetlands provide a wide range of economic, social, environmental and cultural benefits which are often termed as ecosystem services. Such services include provisioning services such as providing breeding grounds for native fish, traditional *mahinga kai* such as eels, or other resources such as flax and *Sphagnum* moss; habitat services such as biodiversity maintenance; and cultural services such as recreation (e.g. duck shooting), spiritual, aesthetic and educational values (Clarkson et al., 2013). Of particular interest in the Southland context are regulating services such as water quality improvement, flood abatement and carbon management.

Wetlands purify water through sediment capture and storing nutrients in their soils and vegetation, particularly those nutrients associated with agriculture such as phosphorus and nitrogen, which contribute significantly to eutrophication of waterways, lakes, estuaries and coastal zones (Clarkson et al., 2013; Tanner & Kadlec, 2013). Nutrient removal efficiency depends on a range of factors including the position of the wetland in the landscape or catchment and water retention time, however all wetlands help prevent nutrients from reaching toxic levels in groundwater. It has been estimated that between 3-7% of a river catchment area should be retained as wetlands to maintain water quality (Mitsch & Gosselink, 2000).

Wetlands are increasingly recognised as assets in productive landscapes as the impacts of excessive nutrient losses become less acceptable to communities, and regulators and polluters seek to mitigate the environmental impacts associated with producing income and move towards environmental sustainability. Restored and constructed wetlands have been identified as useful tools to intercept and attenuate nitrate-rich agricultural runoff (Hamill et al., 2011; Tanner & Kadlec, 2013). Surface-flow wetlands, particularly those containing herbaceous emergent species, support high nutrient uptake and the resulting supply of organic carbon-rich detritus combined with saturated anaerobic conditions promotes microbial denitrification (Tanner & Kadlec, 2013). Phosphorus tends to be sustainably removed from water in wetlands via particulate settling (Hamill et al., 2011).

Recent analysis of the use of wetlands to help manage nutrient load in the Lake Rotorua catchment suggested that keeping existing wetlands is cheaper than restoration or construction of new wetlands and therefore the most cost-effective way to manage the nutrient load into Lake Rotorua is to protect existing natural and seepage wetlands from drainage. However, this alone would only maintain a status quo of water quality (assuming other factors remained the same) which would require the use of additional restored or treatment wetlands to improve (Hamill et al., 2011).

Wetlands are lands that are transitional between terrestrial and aquatic systems and therefore encompass values in both the biodiversity and water quality aspects of land management. New Zealand's indigenous terrestrial and aquatic biodiversity and the physicochemical condition of New Zealand's freshwater ecosystems are continuing to decline significantly, particularly on private land in productive landscapes (see Joy, 2014; Walker et al., 2006). Therefore wetland protection must be considered as an important priority when addressing such declines, and wetland protection needs to consider a range of factors including functionality within the landscape. Several international examples suggest that wetland biodiversity and nutrient attenuation services can co-exist provided nutrient loadings do not surpass critical limits, particularly for phosphorus (Hefting et al., 2013).

## 1.2 Wetlands in the Southland region

Wetland loss continues nationally and regionally on non-PCL in Southland through both permitted and illegal drainage and conversion, primarily for agriculture. In Southland, peat bogs are still being ditch drained for pasture conversion and tile drainage is still regularly used to drain degraded wetland habitats, also for pasture conversion (Ledgard, 2013). However, no data are reported nationally or regionally on the rates of loss of extent or condition (Myers et al., 2013).

Historic wetland loss in the Southland region is in line with the national average with 10.8% of original wetlands remaining. However, some wetland ecosystems such as swamps and marshes have been more severely impacted than others such as bogs. Such a large reduction in wetland extent indicates that virtually all remaining wetlands in the Southland region could be considered significant (Clarkson et al., 2011).

Many of the large, relatively intact wetlands nationally and within the Southland region are protected and managed by the Department of Conservation (DOC). However, smaller wetlands are particularly vulnerable to destruction and degradation, especially in lowland environments (Ausseil et al., 2008, Myers et al., 2013).

## 1.3 Wetland surveys and inventories

Numerous national and regional assessments of remaining wetlands in New Zealand have been carried out using a variety of approaches to delineate wetland extent. This has built up a large resource of information nationally and within the Southland region in the last few decades.

This includes field surveys such as: the Protected Natural Area Programme (PNAP) surveys (Simpson, 1998; Walls & Rance, 2003) and High Value Area (HVA)/Significant Natural Area (SNA) surveys (e.g. Kessels et al., 2010). Field surveys carried out by Wildlife Service during the 1970s and 1980s led to the first national wetlands database inventory, the 'Wetlands of Ecological and Representative Importance (WERI)', of about 3,000 wetlands.

Remote sensing based approaches have become more technically feasible in the last decade and include: regional surveys (Ausseil et al., 2007), the wetlands of national importance for biodiversity project (Ausseil et al., 2008) which arose from the Waters of National Importance project (WONI); and Land Cover Database (LCDB1-4) surveys (MfE, 2007b).

Many Territorial Local Authorities (TLA's) including Environment Southland have carried out wetland inventories for their regions (see Lambie, 2008; Davis et al., 2013; Cameron, 2008; Clarkson et al., 2011; Wildlands, 2011), mostly using a combination of field surveys, local knowledge, reports on protected areas, interpretation of aerial photographs and occasionally, remote sensing (Ausseil et al., 2007). Many have also ranked wetlands to help prioritise important and/or significant sites.

More recently, the Freshwater Ecosystems of New Zealand (FENZ) database has been developed which contains a set of spatial layers describing environmental and biological patterns in New Zealand's freshwater ecosystems (Leathwick et al., 2010).

Many of the earlier national delineations of wetlands such as NZMS260, WERI, LCDB, and LCDB2 contained large errors and were inconsistent, often missing large numbers of wetlands (Ausseil et al., 2008). This was addressed at the national scale with the Wetlands of National Importance (WONI) delineation which used a GIS remote sensing approach (Ausseil et al., 2008). However, further calibration and refinement of the wetlands in the Southland region was required and carried out using previous survey information, minor field checking and manual digitization (Fitzgerald et al., 2010, Clarkson et al., 2011).

A manual digitisation approach was chosen for the current project as it was considered to be more accurate for small wetlands than remote-sensing approaches, but more efficient and achievable than field surveys. Versions of LCDB were also considered to be too inaccurate for small wetlands (see Davis et al., 2013).

## 1.4 Legislation

New Zealand is obliged to protect wetlands as a signatory to the Convention on Biological Diversity - 1992 and the Ramsar Convention on Wetlands - 1971. Regional councils are responsible for protecting natural areas including wetlands on non-public conservation land. Appendix 2 in Lee & Allen (2011) sets out the mix of statutory requirements and policy instruments that underpin regional council requirements to monitor terrestrial indigenous biodiversity, which includes the Resource Management Act 1991 (RMA), Local Government Act 2002, national and regional policy statements, regional plans and state of the environment reporting.

Wetlands encompass values in both the biodiversity and water quality aspects of land management and therefore are important elements of legislation that seeks to protect and enhance such values. In the statement of national priorities for protecting biodiversity on private land, National Priority 2 specifies protecting indigenous vegetation associated with sand dunes and wetlands; ecosystem types that have become uncommon due to human activity (MfE, 2007a). The National Policy Statement on freshwater management states “The overall quality of fresh water within a region is maintained or improved while…protecting the significant values of wetlands”.

Section 4.5 of the Regional Water Plan (Environment Southland, 2010) recognises the importance of wetlands but sets no specific objectives around the condition or extent of wetlands in the region. A schedule of regionally significant wetlands is provided in Appendix B of the Regional Water Plan, most of which are on public conservation land. It is recognised that there are many important wetlands on private land and non-regulatory methods are suggested as the primary means of protection for these and the many vulnerable small wetlands in the region. A resource consent is required to divert water from any regionally significant or naturally occurring wetland in the region.

A recently released draft land and water plan for Southland should provide for better recognition and protection of wetlands and associated ecosystem services with specific policies and rules pertaining to wetlands and indigenous biodiversity, provided such policies and rules are retained in the final document. These policies and associated rules provide for protection of significant values, preventing loss of wetland extent and function and recognition of the potential of wetlands to help improve water quality (Environment Southland, 2015).

Environment Southland currently has no wetland monitoring programme to determine trends in either the extent or condition of wetlands in the region, and therefore whether the significant values of wetlands are being protected.

# 2. Introduction

An extensive assessment of current and historic wetland extent was completed in 2011 for the Southland region (Clarkson et. al., 2011). Large and medium-sized wetlands greater than 5 ha in size that were relatively intact appear to have been well accounted for on all land tenures by this survey (which excluded Stewart Island/Rakiura and Fiordland National Park). However, the Southland region currently lacks a comprehensive inventory of small wetlands. This makes it difficult to assess changes to extent and condition of wetlands in the region at a time when freshwater ecosystem issues are increasingly prioritised regionally and nationally.

This project proposed to expand the wetland inventory in the Southland region by focussing on smaller wetlands on private land currently unaccounted for in existing spatial datasets. The project was proposed to be a desktop exercise utilising existing spatial GIS layers and other information to map currently unmapped wetlands and to baseline previously mapped wetlands to the 2007 aerial photography. The primary layer for mapping wetland polygons was the 2007 aerial photography (orthophotos) which can then be compared to aerial photography at a later date (some of which is available for the region from 2014) to monitor changes in wetland extent and condition in the region.

It was considered unlikely that all currently unmapped wetlands on private land could be captured within the resources of the project in the 2014 or 2015 years. Therefore a sampling regime needed to be applied for the search areas, which was expandable in future years, but that would also stand-alone if the project is not resourced in the future. The primary project outcomes are an assessment of recent changes in wetland extent in Southland and an extension of inventoried wetlands in the region. The project outcomes are also designed to inform Stage 2 of a proposed project to monitor wetland condition in the Southland region (Clarkson et al., 2013). Stage 2 requires the identification and prioritisation of wetlands for condition monitoring and this project will help provide a platform from which to select these sites.

# 3. Objectives

A critical component of wetland protection is a comprehensive inventory of what currently exists, with which future comparisons can be made, allowing assessments of the effectiveness of protection mechanisms. Myers et al. (2013) recommend comprehensive monitoring of wetland extent and condition at national and regional levels, which builds on existing methods and frameworks. This project aims to address this need by:

1. Further inventory of wetlands in the Southland region to include wetlands greater than 0.5 ha in size on non-public conservation land until all of the non-public conservation land in the region has been covered.
2. Using the wetland inventory to monitor changes in the extent of wetlands greater than 0.5 ha in size on non-public conservation land in the Southland region.
3. Recommending further work, improvements and utilization of the wetland inventory that could be implemented to strengthen ongoing monitoring of wetland extent and protection of wetlands in the Southland region to meet council obligations.

# 4. Methodology

## 4.1 Study area

Southland is the second largest region in New Zealand by land area covering 3,176,000 ha, 12.5% of New Zealand's land area. Just over half of the region lies within public conservation land, mostly in Fiordland National Park and Rakiura National Park. Approximately 36% of the region is occupied by pastoral land (Ledgard, 2013).

Natural resources underpin the regional economy and are a key asset economically and culturally to the Southland community. However, like many other regions in New Zealand, water quality has been declining in intensively farmed lowland catchments, and wetland ecosystems continue to be lost to intensive farming agricultural practices (Ledgard, 2013; Myers et al., 2013).

The study area identified was all non-public conservation land (PCL) within the Southland region excluding that on Rakiura/Stewart Island.

## 4.2 Wetland definition

Numerous definitions for wetlands exist both nationally and internationally. For example, the international Ramsar Convention on Wetlands defines wetlands as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres".

The Resource Management Act (RMA) definition of wetlands "includes permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions".

This definition in the context of delineating wetlands for inventory may exclude modified and/or degraded wetlands that still maintain an important role in maintaining water quality and biodiversity, and are also the most likely to be in the process of being modified and vulnerable to loss. Therefore, in order to provide the most accurate assessment of wetland state possible within the parameters of the project, a broad interpretation of the RMA definition of wetlands was used to delineate wetland boundaries in this project. This interpretation did not presume that a "natural" ecosystem of plants and animals meant an indigenous ecosystem of plants and animals.

Although the most likely scenarios for wetland change are for losses of wetland number and extent and the broader interpretation of the RMA definition of wetlands applied here is likely to include a greater number of wetlands, it is also more likely to capture areas of pasture 'reverting' back to wetland vegetation types e.g. developed pasture reverting back to rush and sedge vegetation.

## 4.3 Sampling design

1. Private and lease-hold land i.e. all non-public conservation land (non-PCL) in the Southland region was stratified using GIS software into the three main land strata commonly used by Environment Southland; Lowland, Inland Basins and Hill Country.
2. A 5 km x 5 km fishnet grid was placed over the region and clipped to the regional boundary to create search tiles using GIS software. Each part/whole tile was clipped to a land use category and numbered. Some partial tiles were not automatically assigned a tile number and will need to be accounted for later in the project if full coverage is to be achieved.
3. Tiles within each land use category were randomly selected for wetland searching on the 2007 aerial photography using a random number sequence with a minimum of 20 tiles per land use category. Land use categories were sampled in proportion to the land area occupied by each category with 46 Lowland, 22 Inland Basin and 62 Hill Country tiles searched in 2014 (approximately 25% of each land category and in total for the Southland region). The large majority of the 2007 aerial photography referred to in this report was flown in 2007 with some areas flown in 2008 and a very small portion flown in 2010/11.
4. In 2015, the area searched on the 2007 aerial photography was extended but only for the lowland land category. This was due to the limited coverage of the 2014 aerial photography which was heavily focussed on lowland areas and it was considered more important to sample areas that could be compared over time, than to maintain proportionality of land categories sampled. An additional 65 randomly selected lowland tiles were searched on the 2007 aerial photography in 2015. This boosted coverage of the Southland region on the 2007 aerial photography to 38% (Lowland 111 tiles, 62% coverage; Inland Basin 22 tiles, 25% coverage; Hill Country 62 tiles, 25% coverage).

This sample design allows for expansion of sampled areas in proportion to resourcing. Tiles already sampled are omitted from the random number sequence and remaining tiles sampled randomly. Over time, all private land in the region can potentially be sampled.

## 4.4 Search methodology

1. Each tile was searched for wetlands using the 2007 aerial photography dataset (0.75 m per pixel). This is the primary image layer with which future aerial photography will be compared. GoogleEarth imagery (dating between 2003-2014 depending on location) was also used extensively to refine and calibrate wetland extent. A number of secondary layers available within Environment Southland were used to refine and calibrate the search e.g. Environment Southland Regionally Significant Wetlands, Waituna Wetland Survey, Department of Conservation Wetlands, Southland Waituna Wetlands Present Version 7, Southland High Value Areas 2007-6/2013, QEII sites, Land Cover Database 3, Southland Soil Types, Topomap 50.
2. Wetlands >0.5 ha were mapped by creating a simple polygon area. Wetlands previously mapped in other layers were remapped to create a consistent 2007 baseline.
3. Each wetland polygon mapped had data entered for the following attributes;

Table 1. Attribute data variables for wetland inventory shapefile.

| Attribute | Description |
|---|---|
| FID | Generated automatically. |
| ID | Unique identifier for each wetland polygon. |
| Date_creat | Date the wetland polygon was drawn. |
| Land_cat | Land use category (Lowland, Inland Basin, Hill Country). |
| Area | Area (hectares) of the wetland polygon. |
| Wetland_co | Confidence the polygon drawn is a wetland (%). |
| Ground_tr | Date on which the polygon was field checked. |
| Comment | Note of adjoining DOC wetland polygon or presence of wetland polygons from other data sources included in polygon boundary. |
| Random_tile | The random tile number searched in which the wetland polygon was created. |
| Data_sourc | Data layer/s used to inform presence of a wetland and/or delineate wetland polygon boundaries. |
| Notes | General notes. |
| Subsystem* | A descriptive level relating to water regime e.g. water source, movement, periodicity. None ascribed. |
| Wet_Class* | Wetland Class, the primary typology (Bog, Fen, Swamp, Marsh, Seepage, Shallow water, Ephemeral wetland, Pakihi and gumland, Saltmarsh). |
| Hydrosyste*# | Hydrosystem (Marine, Estuarine, Riverine, Lacustrine, Palustrine, Inland saline, Plutonic, Geothermal, Nival). |
| Wet_form*# | Landforms wetlands occupy, forms which wetlands create, forms or features which wetlands contain. |
| Struct_Cla*# | Vegetation structural class (Forest, Treeland, Scrub, Shrubland, Flaxland, Tussockland, Fernland, Reedland, Rushland, Sedgeland, Grassland, Cushionfield, Herbfield, Turf, Mossfield, Lichenfield, Algalfield). |
| Veg_Comp*# | Vegetation compositional description. |
| Class_Conf | Confidence the wetland class assigned is correct (%). |
| Cond_Hydr | Condition of the natural hydrological function in the wetland (good, moderate, poor). |
| Cond_Veg | Condition of the indigenous vegetation in the wetland (good, moderate, poor). |
| Checked_by | Person/s who has reviewed the wetland polygon boundaries, using the same GIS layers as polygon creator. |
| Created_by | Person who drew the original wetland polygon in the current project. |
| Grnd_tr_by | Person/s who ground-truthed the wetland polygon. |
| Link | Links to other wetland layers containing a wetland polygon at the same site. None ascribed. |
| Signif_pln | Significance of wetland according to regional or district plans. None ascribed. |

*From Johnson and Gerbeaux (2004). #Not ascribed for additional 2015 polygons.

A hydrological condition rank of ‘good’ reflected relatively unmodified hydrology of the wetland in the immediate vicinity of the polygon. A rank of poor in this attribute reflected potential and actual changes of hydrological function due to the presence of anthropogenic modifications e.g. tile drains and ditches. A vegetation condition rank of good reflected dominance of indigenous species and relatively unmodified vegetation patterns whereas a score of poor reflected exotic plant species dominance.

A confidence score (%) was assigned to the Wetland_cla attribute (Class_Conf) as well as a confidence score that the polygon is indeed a wetland (Wetland_co). These scores reflect current information on the site, the clarity of the images used to map the polygon and whether or not the site has been ground-truthed in any way.

Wetland classification attributes followed Johnson and Gerbeaux (2004). Condition rankings were made deliberately broad as they are difficult to assess accurately in a predominantly desktop exercise. Additionally, condition rankings are a secondary outcome within the current project to the monitoring of extent. Long-term monitoring of the condition of a representative range of wetlands in the Southland region should follow Clarkson et al. (2013).

Where multiple wetland classes (or other attribute classes) existed within one polygon the dominant type was assigned e.g. a wetland polygon containing more than one wetland class was described according to the dominant class. In general it was difficult to assess wetland extent in forest ecosystem types, and wetland polygons were only created in this situation where there was evidence from previous survey information of a wetland type.

All public conservation land was excluded from the sampling area except for areas of marginal strip. Marginal strip boundaries are often convoluted and were included within mapped polygons to allow for more rational polygon boundaries to be created.

Table 2. Wetland layers used to help identify and delineate wetland areas.

| Internal Environment Southland GIS layer name | Description and information sources |
|---|---|
| DOC wetlands | Polygon data showing large wetland areas past and present on public conservation land. |
| SouthlandWaituna_WetlandsPresent_v7 | Polygon data showing wetland areas across the Southland region mostly >5 ha and in good condition from Clarkson et al. (2011). |
| Waituna wetland survey | Polygon data showing areas of indigenous vegetation within the Waituna catchment including wetlands. |
| ES Regionally Significant wetlands | Point data showing location of regionally significant wetlands. |
| Fish and Game | Point data showing wetlands and ponds. |
| QEII | Polygon data showing boundaries of QEII covenants. Attribute data does not distinguish ecosystem types. |
| ICC significant wetlands | Polygon data showing areas of significant indigenous vegetation within the Invercargill City Council boundaries including wetlands. |
| DOC land register | Polygon data showing public conservation land as at 5/12/2012. |
| HVA | Polygon data showing Southland Region High Value Area survey areas of indigenous vegetation mapped between 2007 and 6/2013 including wetlands. |

All wetland polygons were saved in one shapefile called 'Wetland inventory' and stored within the Environment Southland GIS folder structure. All GIS work was carried out using ARCMAP 9.3.1 (ESRI, 2009) using the New Zealand Transverse Mercator projection and NZ Geodetic datum 2000.

## 4.5 Checking and ground-truthing

In 2014, in order to increase confidence in some of the less obvious wetland polygons mapped, independent checking was carried out by an experienced wetland observer (George Ledgard - Environment Southland). Limited ground-truthing was also carried out in 2014 for some polygons which consisted of simply driving to the nearest vantage point and inspecting the site with binoculars to increase confidence in the data. In many cases, the sites were unable to be observed satisfactorily and this was noted in the attribute data.

## 4.6 Changes in wetland extent

To assess recent changes in wetland extent in the Southland region, wetland polygons mapped on the 2007 aerial photography were compared with aerial photography from 2014 (0.4 m per pixel). The 2014 aerial photography was incomplete for the Southland region having good (but not full) coverage of lowland areas and little coverage of inland basin or hill country areas. Wetland polygons on approximately 23% of the total non-PCL area in Southland were able to be compared, mostly in lowland areas. Coverage of the non-PCL area available to be compared between years was 53% of lowland, 7% of hill country and 2% of inland basin.

A new shapefile was created containing all the polygons mapped so far on the 2007 aerial photography. Original polygon unique identifiers were retained. All polygons mapped on the 2007 aerial photography in 2014 and 2015 were remapped if the 2014 aerial photography coverage included the polygon. This meant some partial tiles were resampled.

Polygon boundaries were re-shaped where changes in wetland extent were evident. Polygons that were no longer wetlands were deleted from the new shapefile. Data was derived on the number of wetland polygons deleted and the new area (ha) of wetland extent on the 2014 aerial photography. Notes on any change observed were made and hydrological and vegetation condition scores were reassessed.

Tiles containing polygons were not systematically re-searched and tiles containing no polygons were not re-searched due to the limited time available. Therefore the data does not account for any possible newly created wetlands or significant reversion of pasture into wetland vegetation that may have occurred but was not associated with already mapped wetland polygons (where most new wetlands are likely to be seeded from). It is unlikely that newly artificially created wetlands between 2007 and 2014 would be of sufficient scale to strongly influence the data, and pasture reversion to wetland vegetation is likely to result in highly modified rushy paddocks which were not considered as wetlands when mapping. However it is acknowledged that the data here technically represent gross change rather than net change in wetland area.

Table 3. Attribute data variables for wetland inventory re-map shapefile.

| Attribute | Description |
|---|---|
| FID | Generated automatically. |
| ID | Unique identifier for each wetland polygon. Same as original (see Table 1 above). |
| Date_creat | Date the wetland polygon was drawn. Same as original (see Table 1 above). |
| Land_cat | Land use category (Lowland, Inland Basin, Hill Country). Same as original (see Table 1 above). |
| Area_2015 | Re-mapped area (hectares) of the wetland polygon. Polygons were reshaped where obvious changes had occurred between time periods. |
| Date_remap | Date the wetland polygon was re-mapped. |
| Comment | Note of adjoining DOC wetland polygon or presence of wetland polygons from other data sources included in polygon boundary. Same as original (see Table 1 above). |
| Random_tile | The random tile number searched in which the wetland polygon was created. Same as original (see Table 1 above). |
| Wetland_co | Confidence the polygon drawn is a wetland (%). Same as original (see Table 1 above). |
| Notes | General notes. Same as original (see Table 1 above). |
| Notes_2015 | Comments on changes in wetland extent between 2007 and 2014. |
| Cond_Hydr | Condition of the natural hydrological function in the wetland (good, moderate, poor). Same as original (see Table 1 above). |
| Cond_Veg | Condition of the indigenous vegetation in the wetland (good, moderate, poor). Same as original (see Table 1 above). |
| Cond_Hyd15 | 2014 condition of the natural hydrological function in the wetland (good, moderate, poor). |
| Cond_Veg15 | 2014 condition of the indigenous vegetation in the wetland (good, moderate, poor). |

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# 5. Results

In total, 195 5 km x 5 km tiles were searched (sampled) on the 2007 aerial photography with 749 wetland polygons mapped across approximately 38% of non-public conservation land area in the Southland region. The total land area of the 749 wetland polygons mapped was 10,573 ha. Approximately 500 small and/or modified wetlands were identified that had not been accounted for in previous inventory layers.

In total, 422 wetland polygons covering 8,287 ha were able to be re-mapped on the 2014 aerial photography. Of these, 21 wetlands covering 106 ha were considered to have been lost i.e. converted into pasture. A further 78 wetlands recorded a decrease in extent. The decreased wetland extent totalled 703 ha. Total net loss of wetland area in 2014 from the wetland polygons mapped on the 2007 aerial photography was 809 ha.

Table 4. Summary of wetland polygons mapped and compared on 2007 and 2014 aerial photography.

| | **Lowland** | **Inland Basin** | **Hill Country** | **Total** |
|---|---|---|---|---|
| Number of wetland polygons mapped on 2007 aerial photography | 391 | 57 | 301* | 749 |
| Total area (ha) of wetland polygons mapped on 2007 aerial photography | 7,831 | 637 | 2,105 | 10,573 |
| % of non-PCL in Southland searched on 2007 aerial photography | 62 | 26 | 25 | 38 |
| Number of wetland polygons re-mapped on 2014 aerial photography# | 354 | 2 | 66 | 422 |
| Total area (ha) of wetland polygons re-mapped on 2014 aerial photography# | 7,583 | 7 | 697 | 8,287 |
| % of non-PCL in Southland re-mapped to compare wetland polygon extent between 2007 and 2014 aerial photography# | 53 | 2 | 7 | 23 |
| Number of wetland polygons lost between 2007 and 2014 | 17 | 0 | 4 | 21 |
| Total area (ha) of wetland polygons lost between 2007 and 2014 | 94 | 0 | 12 | 106 |
| Number of wetland polygons with decreased extent between 2007 and 2014 | 71 | 0 | 7 | 78 |
| Total area (ha) lost from wetland polygons with decreased extent between 2007 and 2014 | 677 | 0 | 26 | 703 |
| Number of wetland polygons with increased extent between 2007 and 2014 | 0 | 0 | 0 | 0 |
| Total area (ha) gained by wetland polygons with increased extent between 2007 and 2014 | 0 | 0 | 0 | 0 |
| Number of wetland polygons lost or with decreased extent between 2007 and 2014 | 88 | 0 | 11 | 99 |
| Total area (ha) lost from wetland polygons between 2007 and 2014 | 771 | 0 | 38 | 809 |

*A large proportion (125) of the wetland polygons mapped in the Hill Country land use category were in the extensive alpine wetland system located in the southern end of the Garvie Mountains. #Not all polygons mapped on 2007 aerial photography were able to be re-mapped on 2014 aerial photography due to the limited coverage of the 2014 aerial photography.

Wetland loss was approximately 10% of the re-mapped wetland polygon area over a 7 year period giving a rate of decline of 1.5% per year. Approximately 23% of the re-mapped 422 wetland polygons were smaller in 2014 than they were in 2007 or had disappeared altogether. The large majority of losses occurred in lowland areas, reflecting the large bias in sampling towards this land category, although it is likely that this land category is also the one undergoing the most rapid development for agriculture.

# 6. Discussion

The results reported here represent the first attempt to monitor recent changes in wetland extent at the regional level in Southland, and possibly nationally (see Myers et al., 2013). Although coverage of the region is incomplete, the results suggest wetlands are still undergoing rapid decline in lowland areas of Southland, mainly due to land development for agriculture.

Although many wetlands that have been lost or reduced in extent appeared to be of poor or moderate quality, some good quality wetlands that are highly likely to meet significance criteria are still being modified or lost, and even poor quality wetlands are likely to be providing some level of ecosystem service. The conversion of even poor or moderate quality wetlands to pasture is likely to amplify nutrient losses to receiving waters by both reducing nutrient interception properties and by increasing the land area upon which agricultural nutrients are applied.

The project did not assess whether wetland changes were consented or otherwise and therefore it is difficult to target where the current regulatory environment for managing wetlands is least effective. Regional rules around wetland modification in Southland are relatively permissive compared to most other regional TLA's in New Zealand (see Myers et al., 2013). The example of Wetland ID 210 (see Appendix 5b) where 40 hectares of a large significant lowland bog was developed between 2007 and 2014 suggests there is plenty of work to be done in both educating and regulating for wetland values.

Wetlands are increasingly being recognised for their functional values within the landscape. The ability of wetlands to intercept and attenuate agricultural runoff (e.g. removing nitrates via denitrification) means wetlands individually and cumulatively may be able to contribute to managing nutrient budgets on farms and limit setting in catchments. An example of how the cumulative effects of wetlands in catchments can be assessed is provided by Hamill et al. (2011) for reducing nutrient load into Lake Rotorua. There are many factors that influence how effective wetlands are at removing nutrients, including position in the catchment, vegetation cover, flow stability, nutrient load and temperature of input water, and wetland type. In Southland, nutrient removal rates for different wetland types could be assessed and denitrification potential mapped to inform limit setting within vulnerable catchments.

The current schedule of regionally significant wetlands in the Regional Water Plan (Environment Southland, 2010), most of which are on public conservation land, is likely to significantly underrepresent the real number of wetlands in the Southland region having significant indigenous vegetation or significant habitats of indigenous fauna under the Section 6(c) of the RMA (1991). It is also likely to be inadequate to meet national priorities for protecting rare and threatened native biodiversity on private land (see Ministry for the Environment, 2007a).

The project does not currently provide for ranking priority wetlands like Ausseil et al. (2011) which ranked wetlands nationally within biogeographic units to identify a minimum group of wetlands that ensured a representative set of wetland diversity, or Wildlands (2011) which ranked wetlands in Northland to inform a comprehensive state of the environment report on significant wetlands. Ranking of priority wetlands should start with the identification of a comprehensive set of regionally significant wetlands consistent with the Southland Regional Policy Statement 2012 Biodiversity Variation currently undergoing consultation.

Most recent estimates suggest that, excluding Fiordland National Park and Stewart Island, approximately 10 % of original (pre-European; 1840AD) wetland extent remains in Southland (Clarkson et al., 2011). However, some wetland ecosystems such as swamps and marshes have been more severely impacted than others such as bogs. Clarkson et al., (2011) suggest that such a large reduction in wetland extent indicates that virtually all remaining wetlands in the Southland region could be considered significant.

Wetlands in Southland require further assessment of their values on a range of scales and criteria to provide greater certainty to landowners and councils and to allow for more appropriate management of this important ecosystem and resource. Important factors include significance criteria, size, wetland type (e.g. swamps and marshes are highly threatened), condition of hydrology and indigenous vegetation, and functionality within the landscape and catchment.

## 6.1 Informing wetland management and reporting requirements

The outcomes from this project can inform several aspects of wetland and freshwater management in the region for Environment Southland including;

- State of the Environment (SOE) monitoring - changes in regional wetland extent, identification and prioritisation of wetlands for condition monitoring (Stage 2 of Clarkson et al. 2013).
- Identification of priority areas for HVA (High Value Area) survey.
- Plan effectiveness monitoring i.e. how effective are our city, district and regional plans in protecting wetlands?
- Additional information for RMA consenting, compliance or land sustainability processes e.g. identification of likely areas of significant indigenous vegetation.
- Assess the level of formal protection for wetlands on private land e.g. QEII.

These can be framed to partially meet the data collection requirements of several of the key indicators of the recommended monitoring framework for regional councils assessing biodiversity outcomes in terrestrial ecosystems outlined in Lee & Allen (2011).

- State and Condition Indicator 2 Biodiversity Condition – Vulnerable ecosystems: (i) wetland condition and extent (ha); (iii) naturally rare ecosystems (% of area remaining).
- Threats and Pressures Indicator 4 Habitat Loss – Habitat and vegetation loss.
- Effectiveness of policy and management Indicator 6 Biodiversity protection – Vegetation consents compliance.
- Effectiveness of policy and management Indicator 9 Protection and restoration - New areas (ha) protected through initiatives on private land.

This framework is similar to national reporting requirements on environmental reporting which are currently being refined and improved. Monitoring of wetland extent could inform reporting on the 'state' of both freshwater and land (terrestrial) environments under the topics of 'Condition and physical characteristics of freshwater habitats' and 'Vegetation and other land cover', and 'impact' on biodiversity on land (MfE & Statistics New Zealand, 2015).

In order to better service these requirements, this project should lead to the provision of a combined wetland inventory layer for Environment Southland. Currently there are several different layers containing wetland extent information which should be combined to help complete the inventory and better service outcome objectives. Many useful attributes can be added to the database such as Land Environments of New Zealand (LENZ), Threatened Environment classification, soil types and Ecological Region/District. Further work could be then carried out to rank significant and/or priority wetlands as several other regional councils have done.

Many other regional councils have wetland inventories for their regions or are in the process of collecting the information e.g. Northland Regional Council (Wildlands, 2011), Horizons Regional Council (Ausseil et al., 2007; Lambie, 2008), Wellington Regional Council (Davis et al., 2013), Bay of Plenty Regional Council (Wildlands, 2004; Fitzgerald et al., 2013), Tasman and Marlborough District Councils (George Ledgard, pers. comm. 20/3/2014).

## 6.2 Towards an integrated regional wetland database

Many different organisations within the Southland region have responsibilities or interests regarding wetlands. Alongside Environment Southland they include the Department of Conservation, Invercargill City Council, Gore District Council, Southland District Council, Fish and Game New Zealand, Forest and Bird New Zealand, New Zealand Landcare Trust and QEII National Trust among others.

There currently appears to be little integration of the various ways each organisation accounts for and stores data about the wetlands they are responsible for, or for sharing information about changes in wetland state. An integrated regional wetlands database could service many different functions in different organisations while minimising duplication. It would also take advantage of the collective information across organisations.

An integrated wetlands database would need careful design to ensure functionality across users, comparability with other regional wetland databases and vertical integration into national databases such as FENZ, or internationally (see Lowry, 2010). It should accommodate a broad scope so it includes many different perceptions of wetlands as well as the more restrictive definitions used for land management decision making i.e. the RMA definition. As Lambie (2008) points out, an inventory of wetland areas that Fish and Game may carry out would likely yield significantly more wetlands than a survey that accounts only for intact wetlands with indigenous vegetation cover. Lowry (2010) provides a comprehensive guide to the attribute requirements of an international wetland inventory metadatabase. This could be used to guide the structure of a regional database.

## 6.3 Limitations

There are a number of limitations to the methodology and comprehensiveness of the project as it stands. The project is focussed simply on mapping the extent of wetlands in Southland on non-PCL with a coarse ranking of condition and broad classification of type reflecting the likely level of accuracy attainable by a desktop and drive-by exercise. The size constraints of the project in 2014 and 2015 means that only a sample of wetlands in Southland have been mapped and a smaller sample again used to assess change in wetland extent over time. Therefore the project thus far is best regarded as a pilot project. There remains 62% of the non-PCL land area of the Southland region yet to be mapped on the 2007 aerial photography to the level of detail required for a comprehensive regional inventory and baseline to which future changes in extent can be compared. There remains 77% of the non-PCL land area of the Southland region yet to have changes in wetland extent assessed between 2007 and 2014.

Only wetlands detectable by this method are included in the inventory. Wetlands less than 0.5 ha in size were not included and some wetlands difficult to detect on the searched images may have been missed. Additionally, there will inevitably be some error in the data, particularly the boundaries of more cryptic wetland types and in some of the wetland classifications. Extensive ground-truthing of the mapped wetlands is desirable to increase the accuracy of the data. Some TLA's have spent a number of years getting a comprehensive wetland inventory in which wetlands have been assessed for biodiversity and other values (e.g. Lambie, 2008).

The monitoring proposed in this report can help assess changes in the number and extent of wetlands within the region but only provides a coarse measure of condition. Monitoring of the condition of a representative subset of wetlands in the region would be required to confidently meet statutory monitoring obligations for this highly threatened ecosystem type. Stage 1 of such a project has already been completed for the region (Clarkson et al., 2013). This project should inform which subset of wetlands in the region should have more quantitative condition monitoring established.

# 7. Conclusions and recommendations

Comparison of the extent of wetland polygons mapped on 2007 aerial photography with the same polygons on 2014 aerial photography indicates that wetlands in lowland Southland are undergoing rapid development for agriculture. Approximately 10% of wetland area extent was lost over this time period with 23% of wetland polygons either reduced in size or lost.

Large numbers of previously unmapped wetlands have now been delineated over approximately 38% of the Southland region. There is a significant body of work still required to bring about a comprehensive wetlands management information tool, however much of the basic information is already available. Currently in the Environment Southland system there are at least 5 wetland shapefiles, an access database, and various spreadsheets all containing data relating to wetlands.

The following recommendations are made in order to further advance towards meeting council requirements for wetlands monitoring and management;

1. Increasing the accuracy of attribute data associated with the wetland polygons with further research into other sources of available survey information and ground-truthing.

2. Rationalising the numerous wetland layers of varying utility available for the Southland region into a comprehensive database.

3. Further mapping and comparison of wetland polygons using the 2007 and 2014 aerial photography to cover (preferably) all of the region. Lowland areas should be prioritised for further mapping.

4. Identifying wetlands that meet national and regional significance criteria.

5. Ensure wetland and indigenous biodiversity policies and rules in the current draft water and land plan are retained through the consultation process.

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# Appendix 1. Wetland type definitions

All wetland type definitions below are from Johnson & Gerbeaux (2004).

*Bog:* a peatland receiving its water supply only from precipitation, and therefore virtually unaffected by moving groundwater and nutrients from adjacent or underlying mineral soils; bogs are oligotrophic (nutrient-poor), usually markedly acid, and their water table is at or near the surface.

*Ephemeral wetland:* a wetland class, typically occupying a closed depression that lacks a permanent surface outlet channel, having mineral soil and a marked seasonal alternation between being ponded and dried, the wetness and the wetland tending therefore to be ephemeral.

*Fen:* a peatland receiving inputs of water and nutrients from adjacent mineral soils, and having the water table usually close to the peat surface; fens have low to moderate acidity and nutrient status.

*Marsh:* a mineral wetland which may have a peat component that is periodically inundated by standing or slowly moving water; water levels may fluctuate markedly. Marshes are usually of moderate to high nutrient status.

*Pakihi and gumland:* a wetland class characterised by mineral or peat soils of very low fertility and poor drainage because of leached and impervious basement materials on land which is level or of low relief, with the water supply being mainly from precipitation. Gumland is restricted to northern North Island.

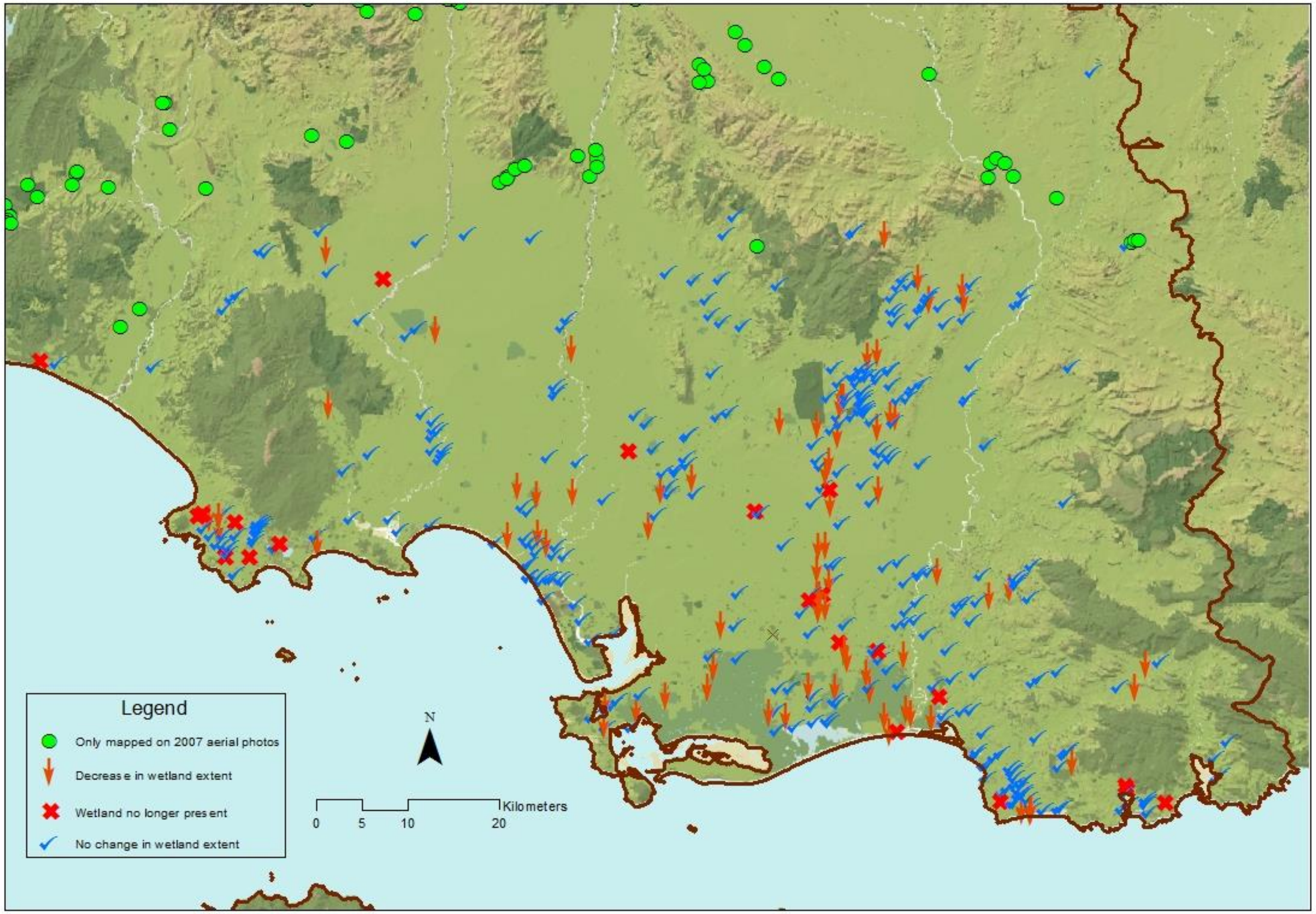
*Saltmarsh:* a wetland class embracing estuarine habitats of mainly mineral substrate in the intertidal zone, but including those habitats in the supratidal zone and inland, which although non-tidal, have similar saline substrates and constancy of soil moisture.

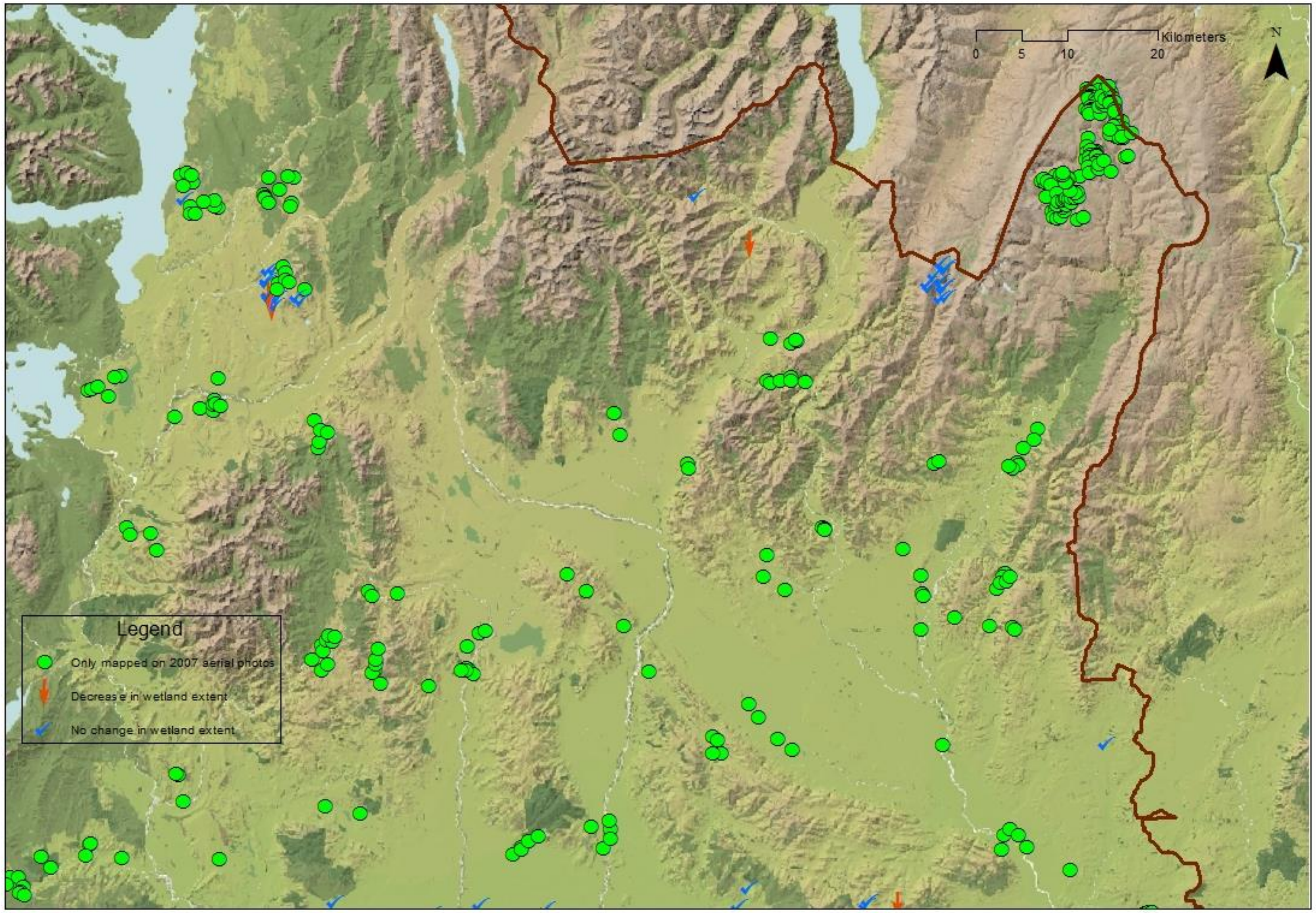
*Seepage:* an area on a slope which carries a moderate to steady flow of groundwater, often also surface water, including water that has percolated to the land surface, the volume being less than that which would be considered as a stream or spring.

*Shallow water:* aquatic habitats with water generally less than a few metres deep, having standing water for most of the time, and including the margins of lakes, streams, rivers, and estuarine waters plus small bodies of water which may occur within or adjacent to other wetland classes.

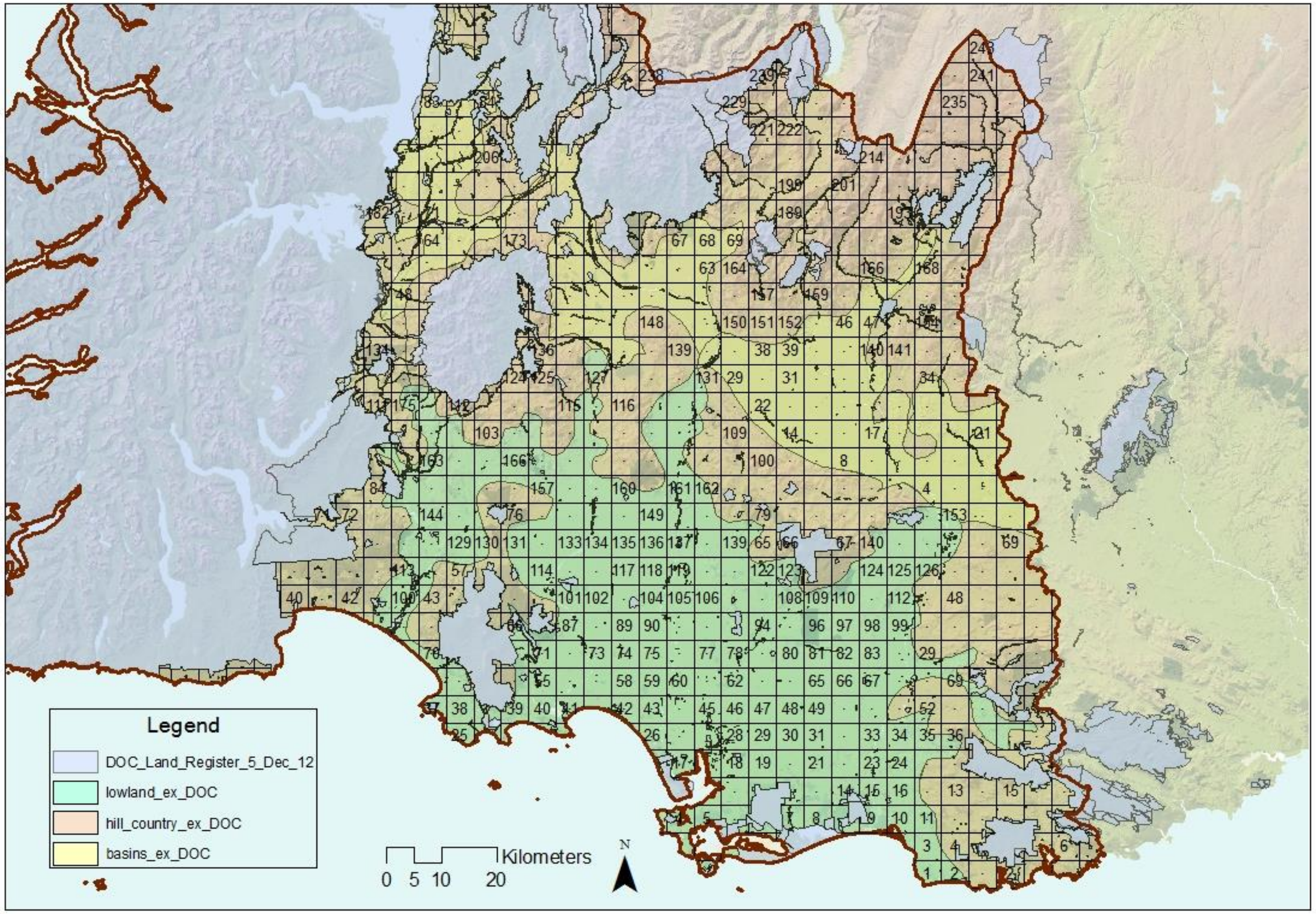
*Swamp:* a soligenous wetland, usually combining mineral and peat substrates, having moderate water flow and fluctuation, and often the presence of leads of standing water or surface channels; swamps are relatively rich in nutrients.

# Appendix 2. Maps of wetland change on non-public conservation land sampled in the Southland Region

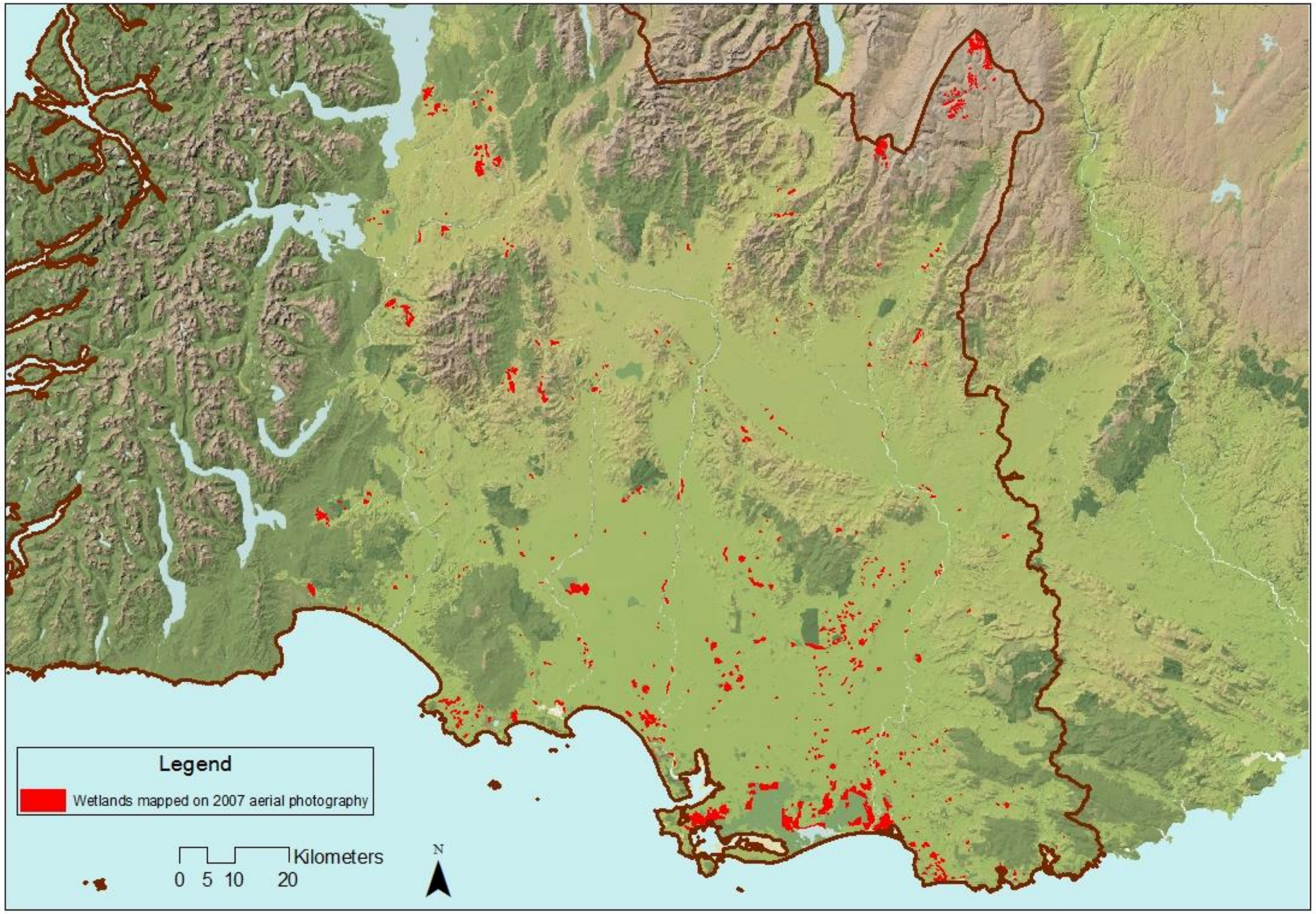



Kilometers
0 5 10 20
N
Legend
Only mapped on 2007 aerial photos
Decrease in wetland extent
No change in wetland extent

# Appendix 3. Map of sample tiles randomly sampled (searched) on each land category



# Appendix 4. Map of all wetlands mapped on 2007 aerial photography




Note: Wetland polygons are buffered to highlight location and are not to scale.

Appendix 5a. Examples of changes in wetland extent 2007 to 2014. Wetlands gone

Wetland ID 67 (2007)

Wetland ID 67 (2014)

Wetland ID 82 (2007)

Wetland ID 82 (2014)

Wetland ID 94 (2007)

Wetland ID 94 (2014)

Wetland ID 170 (2007)

Wetland ID 170 (2014)

Wetland ID 204 (2007)

Wetland ID 204 (2014)

Wetland ID 242 (2007)

Wetland ID 242 (2014)

| | |
|---|---|
|  |  |
| Wetland ID 245 (2007) | Wetland ID 245 (2014) |
|  |  |
| Wetland ID 325 (2007) | Wetland ID 325 (2014) |
|  |  |
| Wetland ID 326 (2007) | Wetland ID 326 (2014) |

Wetland ID 335 (2007)

Wetland ID 335 (2014)

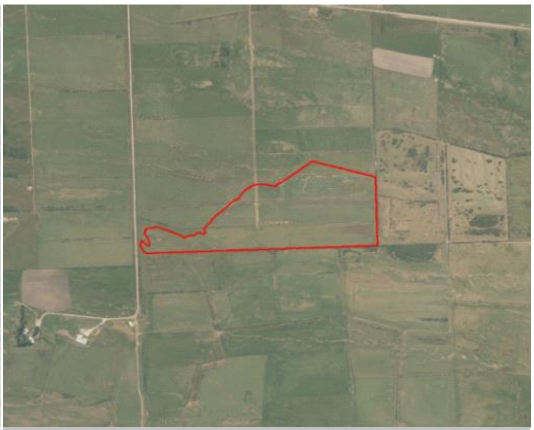
Wetland ID 499 (2011)

Wetland ID 499 (2014)

Wetland ID 535 (2007)

Wetland ID 535 (2014)

Wetland ID 539 (2007)



Wetland ID 539 (2014)

Wetland ID 562 (2007)

Wetland ID 562 (2014)

Wetland ID 563 (2007)

Wetland ID 563 (2014)

Wetland ID 612 (2007)

Wetland ID 612 (2014)

Wetland ID 714 (2007)

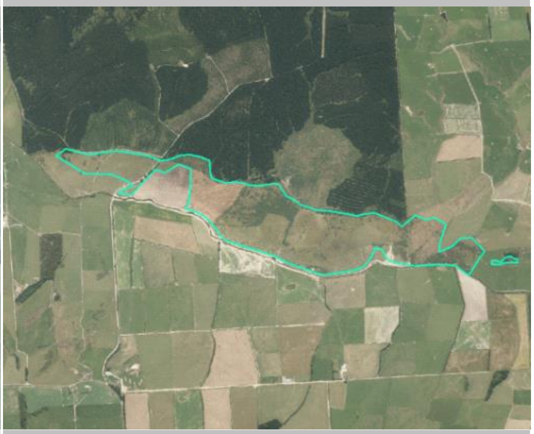
Wetland ID 714 (2014)

Appendix 5b. Examples of changes in wetland extent 2007 to 2014. Wetlands changed

Wetland ID 2 (2007)

Wetland ID 2 (2014)

Wetland ID 7 (2007)



Wetland ID 7 (2014)

Wetland ID 17 (2007)

Wetland ID 17 (2014)

Wetland ID 18 (2007)

Wetland ID 18 (2014)

Wetland ID 36 (2007)

Wetland ID 36 (2014)

Wetland ID 77 (2007)

Wetland ID 77 (2014)

Wetland ID 81 (2007)

Wetland ID 81 (2014)

Wetland ID 84 (2007)

Wetland ID 84 (2014)

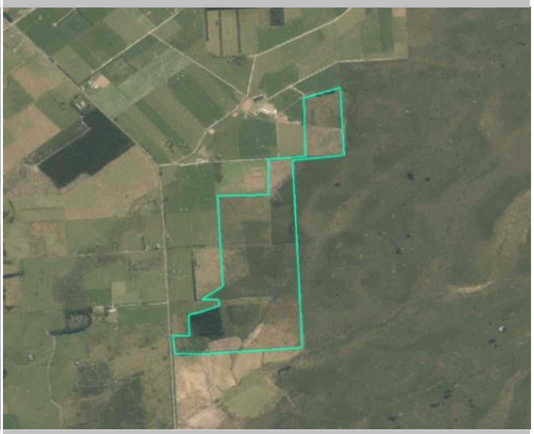
Wetland ID 85 (2007)

Wetland ID 85 (2014)

Wetland ID 87 (2007)

Wetland ID 87 (2014)

Wetland ID 97 (2007)



Wetland ID 97 (2014)

Wetland ID 99 (2007)

Wetland ID 99 (2014)

Wetland ID 114 (2007)

Wetland ID 114 (2014)

Wetland ID 125 (2007)

Wetland ID 125 (2014)

Wetland ID 129 (2007)

Wetland ID 129 (2014)

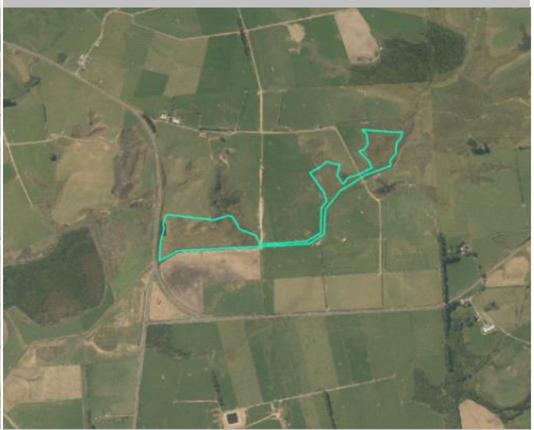
Wetland ID 136 (2007)

Wetland ID 136 (2014)

Wetland ID 171 (2007)

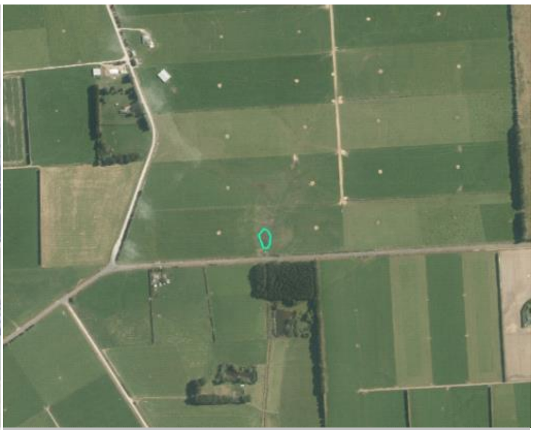
Wetland ID 171 (2014)

Wetland ID 172 (2007)



Wetland ID 172 (2014)

Wetland ID 176 (2007)

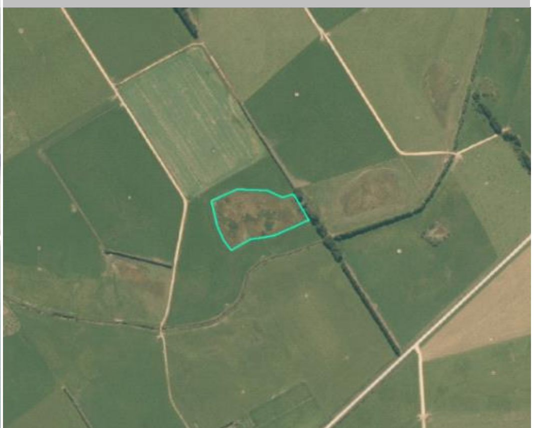


Wetland ID 176 (2014)

Wetland ID 181 (2007)

Wetland ID 181 (2014)

Wetland ID 183 (2007)



Wetland ID 183 (2014)

Wetland ID 184 (2007)

Wetland ID 184 (2014)

Wetland ID 188 (2007)

Wetland ID 188 (2014)

Wetland ID 191 (2007)

Wetland ID 191 (2014)

Wetland ID 192 (2007)

Wetland ID 192 (2014)

Wetland ID 194 (2007)

Wetland ID 194 (2014)

Wetland ID 200 (2007)

Wetland ID 200 (2014)

Wetland ID 206 (2007)

Wetland ID 206 (2014)

Wetland ID 207 (2007)

Wetland ID 207 (2014)

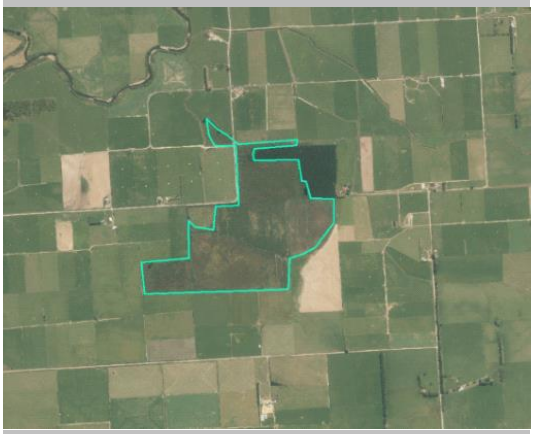
Wetland ID 209 (2007)

Wetland ID 209 (2014)

Wetland ID 210 (2007)

Wetland ID 210 (2014)

Wetland ID 212 (2007)



Wetland ID 212 (2014)

Wetland ID 233 (2007)

Wetland ID 233 (2014)

Wetland ID 234 (2007)

Wetland ID 234 (2014)

Wetland ID 284 (2007)

Wetland ID 284 (2014)

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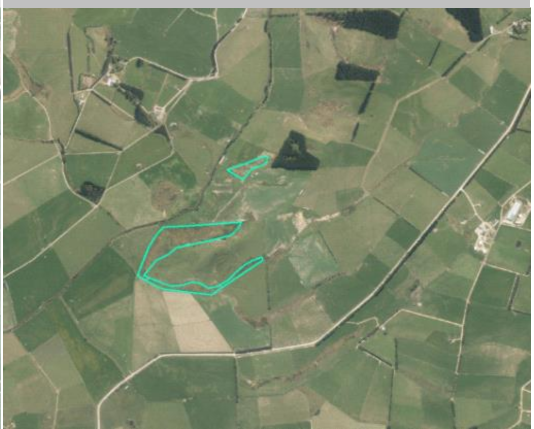

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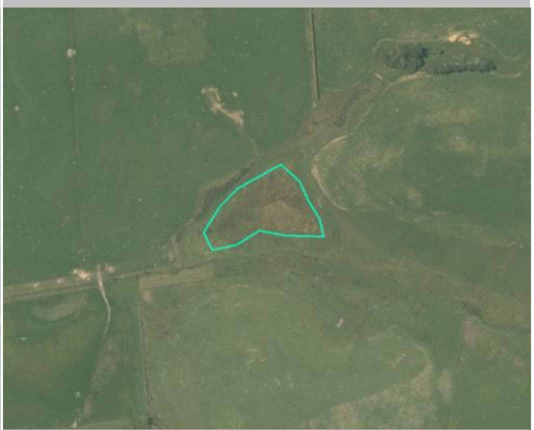

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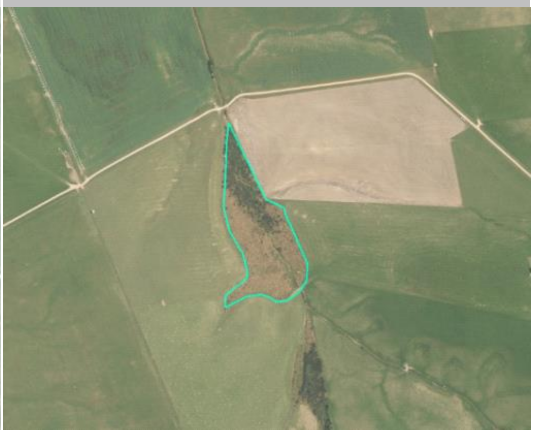

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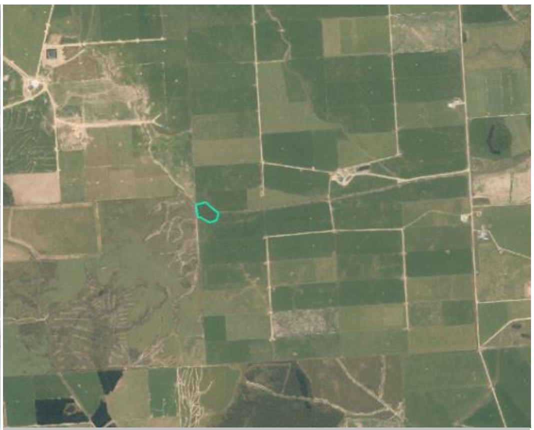

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