How well does LCDB2 map wetlands in the Wellington region?

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M. Davis, D. Brown, H. Robertson and L. Chadderton

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Abstract

Wetlands are nationally rare in New Zealand as a result of their on-going loss through land development. The Department of Conservation's natural heritage responsibilities call for the development of a national database for wetlands. A number of regional wetland databases already exist, but the Land Cover Database (LCDB) is considered to have applicability at a national level and has previously been used by several projects to map the extent of wetlands in New Zealand. However, LCDB is based on remote sensing and can produce variable results depending on factors such as scale, image quality, image interpretation and field verification. In this study, we assessed the ability of LCDB (LCDB2) to map wetlands in the Wellington region, by comparing areas identified as 'wetlands' with those identified using other information sources. Over 3700 ha of wetlands were assessed, including parts of Lake Wairarapa. We found that LCDB2 underestimated the area of wetlands in the region, with many wetlands not being identified or their boundaries often being inaccurate. LCDB2 is generally more effective at identifying larger wetlands, especially if they include open water, but is less useful for identifying smaller wetlands, particularly in areas dominated by grassland or pasture. This study of the Wellington region indicates that LCDB2 should not be used on its own to identify wetlands, whether it is for resource management, ecological or significance assessment purposes. It is recommended that this analysis is repeated for other regions where good quality wetland databases exist, to ensure that the findings are applicable nationally Updated versions of LCDB are likely to retain similar errors until wetland mapping issues are resolved.

Keywords: wetlands, LCDB2, mapping, Greater Wellington, Kapiti Coast, Wairarapa, regional database, aerial photographs

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1. Introduction

There has been an on-going loss of wetlands in New Zealand due to land development, resulting in them becoming nationally rare (MfE 2007a; Ausseil et al. 2008). This is reflected in the Resource Management Act 1991 (RMA) where, under section 6(a), it is considered a matter of national importance to preserve the natural character of wetlands and protect them from inappropriate subdivision, use and development. Similarly, government policy has made it a national priority to protect indigenous vegetation associated with wetlands, because they are uncommon due to human activity (MfE 2007a). The Department of Conservation's (DOC's) natural heritage responsibilities call for the development of a national database for wetlands.

A number of regional wetland databases already exist, but the Land Cover Database (LCDB) has applicability at a national level for mapping freshwater wetlands. Several studies have used LCDB and the regional databases to map the extent of wetlands in New Zealand; for example, the Waterbodies of National Importance (WONI) project, which mapped bog, fen, swamp, marsh, seepage and inland saline wetlands (Ausseil et al. 2008). The products of LCDB are also applied in some regional planning forums (e.g. Hearings on Proposed Horizons Regional Council One Plan; Walker et al. 2008). However, LCDB was developed using a combination of remote sensing, ancillary data and field verification (Thompson et al. 2003), and this process may produce variable results, depending on factors such as scale, image quality and image interpretation.

LCDB (LCDB2) was based on satellite imagery acquired in 2001–02 and has a minimum mapping unit of 1 ha. It uses 43 land cover classes (MfE 2007b), four of which are wetland classes (Appendix 1). In this study, we assessed the ability of LCDB2 to map wetlands by comparing areas identified as 'wetlands' with those identified using other information sources. The Wellington region was chosen for this case study because it had two suitable local authority databases (Greater Wellington Regional Council 2003; Kapiti Coast District Council 2004), good quality colour aerial photographs and considerable environmental diversity.

The first stage of the project involved reviewing and mapping wetlands in the Wellington region to produce a wetland database that was verified by DOC. The second stage involved comparing this verified wetland database with wetlands mapped by LCDB2.

This report describes the second stage of the project. It presents the wetland mapping results for each area assessed followed by a general discussion of LCDB2, including additional observations about its dryland classifications (i.e. all areas that are not classified as wetland)[1]. The report then provides some conclusions and recommendations about the usefulness of LCDB2 for mapping wetlands.

[1] Wetlands are defined in the RMA as being 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.

2. Methods

Four NZMS 260 map quarters were chosen for this study: Kapiti Coast (R26b)[2], Martinborough (S27b), South Wairarapa (S27c) and East Wairarapa Coast (T27b) (Fig. 1). These map quarters were selected to reflect the ecological diversity and climatic variation in the Wellington region and to ensure that a wide range of wetland types would be included in the analysis. As it is recognised climatic factors can influence wetland distribution, information on the altitude and climate obtained from NIWA's National Climate Database is presented (Table 1). Data were most comprehensive for Kapiti Coast (Paraparaumu), Martinborough and the East Wairarapa Coast (Castlepoint). No data were available for South Wairarapa so available information from Ngawi (near Cape Palliser) was used instead. The Martinborough and Ngawi data suggested that rainfall in South Wairarapa may be of the order of 750 mm, although the adjacent Rimutaka Range may result in a higher figure than this.

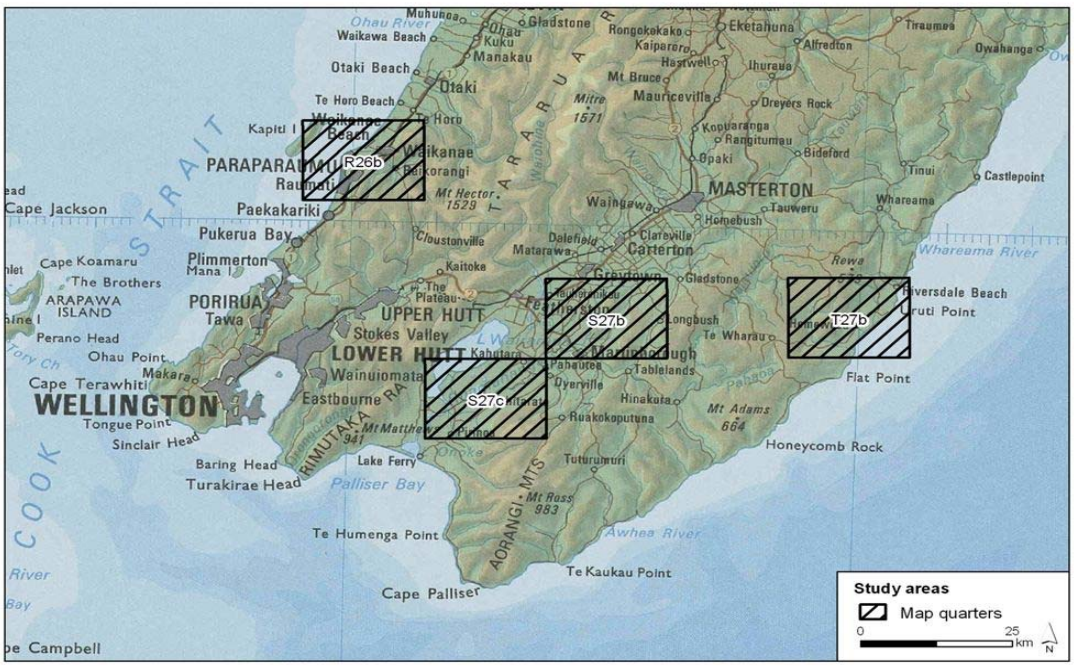

Figure 1. Location of the four NZMS 260 map quarters in the Wellington region used in this analysis.

Table 1. Altitude and mean annual climate data for the study areas.

MAP QUARTER	ALTITUDE (m)*	RAINFALL (mm)	TEMPERATURE (°C)	SUNSHINE HOURS
Kapiti Coast—R26b	0–770	1024 (range 740–1445)	13.1	2055
Martinborough—S27b	11–440	775 (range 515–1160)	13.0	2050
South Wairarapa—S27c	1–860	739	14.6	No data
East Wairarapa Coast—T27b	0–525	995 (range 650–1350)	13.6	No data

Source: NIWA 2009

* In all four areas, the altitude of the rolling downs and flats where most wetlands occur is generally less than 100 metres.

[2] Note: Since the project was restricted to mainland wetlands, Kapiti Island was not included in the assessment of R26b.

Wetland data from the Greater Wellington Regional Council (GW) and Kapiti Coast District Council (KC) provided the baseline information for the current extent of wetlands in the region (Greater Wellington Regional Council 2003; Kapiti Coast District Council 2004). This information was supplemented by potential wetlands identified from aerial photographs to create a merged wetland database in ArcView 3.2 (see Appendix 2 for database attributes). A total of 82 wetlands from the merged database (including point locations for potential wetlands) were field-checked to verify their presence, clarify boundaries and provide brief ecological descriptions.

In the three Wairarapa map quarters, wetlands were initially identified using the GW wetland database, which was developed from a combination of existing databases, information about wetlands, aerial photographs and field checking. It is important to note that significance assessments were central to identifying wetlands in the GW database, whereas in the present project all wetlands meeting the RMA definition of wetlands were identified. Consequently, the GW wetlands were supplemented by potential wetlands identified from GW aerial photographs (scale 1:5000). The boundaries of all wetlands were reviewed using the aerial photographs and field-checked on 20–21 December 2003, 24–28 January 2004 and 30–31 January 2004. Where wetlands were confirmed, their boundaries were mapped by logging a GPS route or recording manual waypoints, which were imported into ArcView 3.2 to generate shape files. Boundaries were finalised with the aid of aerial photographs if necessary. Where access was physically difficult or the site was too large to assess in the time available (e.g. Lake Wairarapa), some boundary adjustments were made using aerial photographs alone. A total of 54 wetlands were field-checked or observed from close by (e.g. see Appendix 3). Where boundary or classification differences occurred, precedence was given to the field survey, followed by aerial photographs and, finally, council surveys.

For the Kapiti Coast, the initial wetlands were derived from a combination of the GW wetland database and wetlands extracted from the KC ecological site database, which was based on a survey and report by Wildland Consultants (2003). Where wetland and dryland vegetation occurred within one site, the mapped boundaries did not distinguish between them, meaning that wetland boundaries were not delineated. This situation was common and these sites were not visited, as they were typically too large, complex or difficult to access. Only significant sites were identified by Wildland Consultants, so KC wetlands did not include all wetlands meeting the RMA definition. Therefore, additional potential wetlands were identified from aerial photographs supplied by KC (scale 1:10 000 for rural areas and 1:1000 for urban areas). The GW and KC wetlands and their boundaries were reviewed using the aerial photographs and field-checked on 21–23 February 2004 where significant boundary irregularities were apparent. Where they were confirmed, their boundaries were mapped using the same methods as those used in the Wairarapa. A total of 28 wetlands were field-checked or observed from close by.

The spatial data used in this study were clipped to the four map quarters, and where a feature crossed a map boundary only the portion inside the boundary was assessed. Spatial data (polygons) in the verified wetland database were classified as 'confirmed wetlands,' 'potential wetlands' or 'no wetlands.' The land cover types in LCDB2 were similarly classified by their likely wetland presence as 'wetlands,' 'potential wetlands' or 'no wetlands' (Appendix 1). The two datasets were then intersected, and the areas (ha) of the resulting polygons were calculated.

For all four map quarters, a comparison was made between the verified wetland database (i.e. field-checked and/or aerial photograph-checked) and wetlands mapped by LCDB2 to determine the extent to which LCDB2 correctly identified wetlands in the study area. Each individual wetland was assessed to determine whether it was identified by both wetland databases (even if there were boundary differences) or by only one of the datasets.

3. Results and discussion

3.1 Ability of LCDB2 to identify wetlands

Over 3700 ha of wetlands in the Wellington region were assessed in this study, including Lake Wairarapa (2344 ha). Table 2 shows the level of overlap between LCDB2 and the verified wetland database across the four map quarters.

If mapping was consistent between the datasets (100% overlap), LCDB2 cover types identified as 'wetlands' would align precisely to the areas mapped as 'wetland present' in the verified dataset, and areas identified as 'no wetlands' would also correspond between the two. However, from Table 2 it can be seen that this is not the case. Instead, it was found that LCDB2 greatly underestimated the extent of wetlands that were known to be present; for example, in map sheet

Table 2. Overlap between wetlands mapped in LCDB2 and wetlands verified during this study (ha).

		VERIFIED WETLANDS IN THIS STUDY														
		Kapiti Coast R26b			Martinborough S27b			South Wairarapa S27c			East Wairarapa Coast T27b			Total		
		Yes	Potential	No	Yes	Potential	No	Yes	Potential	No	Yes	Potential	No	Yes	Potential	No
LCDB2 WETLAND	Yes	**57.0**	2.8	26.9	**5.3**	0.0	0.0	**2842.0**	30.2	0.3	**11.0**	0.2	0.0	**2915.3**	33.2	27.2
	Potential	69.4	**4.5**	44.9	6.5	**0.3**	0.0	42.0	**0.1**	0.0	3.1	**0.3**	0.2	121.0	**5.2**	45.1
	No	85.8	5.8	**68.5**	28.9	3.4	**2.2**	317.6	31.9	**6.2**	44.3	0.0	**3.4**	476.6	41.1	**80.3**
	Total	212.2	13.1	140.3	40.7	3.7	2.2	3201.6	62.2	6.5	58.4	0.5	3.6	3512.9	79.5	152.6
	Quarter total	365.6			46.6			3270.3			62.5			3745.0		

R26b, only 57 ha (26.9%) of the 212 ha of known wetlands were identified by LCDB2 (Table 2), and of the 311 ha of verified wetlands on the Kapiti Coast, Martinborough and East Wairarapa Coast, only 73 ha (23.5%) were identified by LCDB2. There was higher overlap for South Wairarapa, with 2842 ha (88.8%) being correctly identified, primarily due to the presence of Lake Wairarapa.

Since large open water wetlands are easily identified, their inclusion biased our assessment of LCDB2. Therefore, the data were also analysed with the five largest wetlands successfully identified by LCDB2 excluded (Table 3). One c. 31-ha wetland was removed from R26b, and the largest wetland retained was c. 25 ha. The other four wetlands were removed from S27c and ranged in size from 2344 to 134 ha (combined area 2984 ha) and the largest wetland retained was c. 48 ha. From Table 3 it can be seen that the removal of these wetlands from the analysis resulted in major changes to the figures for those map quarters and the entire study area. For example, excluding the Lake Wairarapa parts (2344 ha) from the analysis of map quarter S27c resulted in a four-fold increase in the misclassification.

Table 4 summarises the overall ability of LCDB2 to identify known wetlands. When all wetlands were included in the analysis, LCDB2 successfully identified 83% of verified wetlands based on their total area. In contrast, when the five largest wetlands were removed from the analysis, the success rate fell dramatically to 20%, indicating that the apparent ability of LCDB2 to identify wetlands is inflated by the inclusion of large, easily identified wetlands. The data also indicated that LCDB2 performed equally poorly in identifying wetlands in the individual map quarters.

LCDB2 overestimated the wetland area on the Kapiti Coast (Tables 2 & 3), but not in the other map quarters. For the entire project area, the area and percentage of wetlands overestimated was negligible (<1%) compared with the area and percentage of wetlands that were underestimated (Table 4).

Table 3. Overlap between wetlands mapped in LCDB2 and wetlands verified during this study (ha), with large wetlands excluded from the analysis. (Note: values in brackets remain unchanged from Table 2.)

		VERIFIED WETLANDS IN THIS STUDY														
		Kapiti Coast R26b			Martinborough S27b			South Wairarapa S27c			East Wairarapa Coast T27b			Total		
		Yes	Potential	No	Yes	Potential	No	Yes	Potential	No	Yes	Potential	No	Yes	Potential	No
LCDB2 WETLAND	Yes	**26.4**	1.7	26.9	**(5.3)**	(0.0)	(0.0)	**57.7**	30.2	0.3	**(11.0)**	(0.2)	(0.0)	**100.4**	32.1	27.2
	Potential	69.3	**3.0**	44.9	(6.5)	**(0.3)**	(0.0)	40.0	**0.1**	0.0	(3.1)	**(0.3)**	(0.2)	118.9	**3.7**	45.1
	No	85.3	3.6	**68.4**	(28.9)	(3.4)	**(2.2)**	119.8	31.9	**6.2**	(44.3)	(0.0)	**(3.4)**	278.3	38.9	**80.2**
	Total	181.0	8.3	140.2	(40.7)	(3.7)	(2.2)	217.5	62.2	6.5	(58.4)	(0.5)	(3.6)	497.6	74.7	152.5
	Quarter total	329.5			(46.6)			286.2			(62.5)			724.8		

Table 4. Success of LCDB2 in identifying known wetlands (as a % of total area).

MAP QUARTER	ALL VERIFIED WETLANDS	WITH LARGE WETLANDS EXCLUDED
Kapiti Coast—R26b	26.9%	14.6%
Martinborough—S27b	13.0%	(13.0%)
South Wairarapa—S27c	88.8%	26.5%
East Wairarapa Coast—T27b	18.8%	(18.8%)
All map quarters	83.0%	20.0%

3.2 Mapping issues

Most of the wetlands in the project area occur in urban areas or on fairly intensively farmed land, making it inevitable that they would be modified. Field work confirmed that many were degraded, with exotic grasses being common, but wetlands were only confirmed if the RMA wetland definition was met. An example of mapped outputs from the Kapiti Coast is provided in Figure 2.

When evaluating the usefulness of LCDB2 for identifying wetlands, the potential for non-wetland classes to include wetlands was recognised. These classes were coastal sand and gravel, e.g. estuaries and coastal lagoons; deciduous hardwoods, e.g. willows (*Salix* spp.); gorse (*Ulex europaeus*) and broom (*Cytisus scoparius*); indigenous forest, e.g. kahikatea (*Dacrycarpus dacrydioides*); mānuka (*Leptospermum scoparium*) / kānuka (*Kunzea ericoides*); and river or lakeshore gravel and rock. In most cases, these classes actually represented dryland cover, and on the rare occasion that they did represent wetlands, the wetland portion tended to be small. Therefore, it is likely that only a small percentage of these classes actually represent wetlands.

The 1-ha mapping threshold is not consistently applied by LCDB2, as many classified sites are smaller than this. This often occurs when underlying topographical map vectors represent units <1 ha, e.g. open water or wetland units. However, many vectors larger than 1 ha have not been classified as wetlands despite them being verified by this project. The type of wetland vegetation can also affect mapping accuracy (e.g. sedgelands in pasture are sometimes missed by remote sensing), although this was not specifically analysed in this study.

In general, LCDB2 is more successful at identifying and classifying open water wetlands, and has more accurate boundaries for larger wetlands such as Lake Wairarapa. The fact that smaller wetlands (and indigenous dryland remnants or vegetation linkages) are often not recognised raises serious concerns about the use of LCBD2 in statutory RMA processes without accompanying field work.

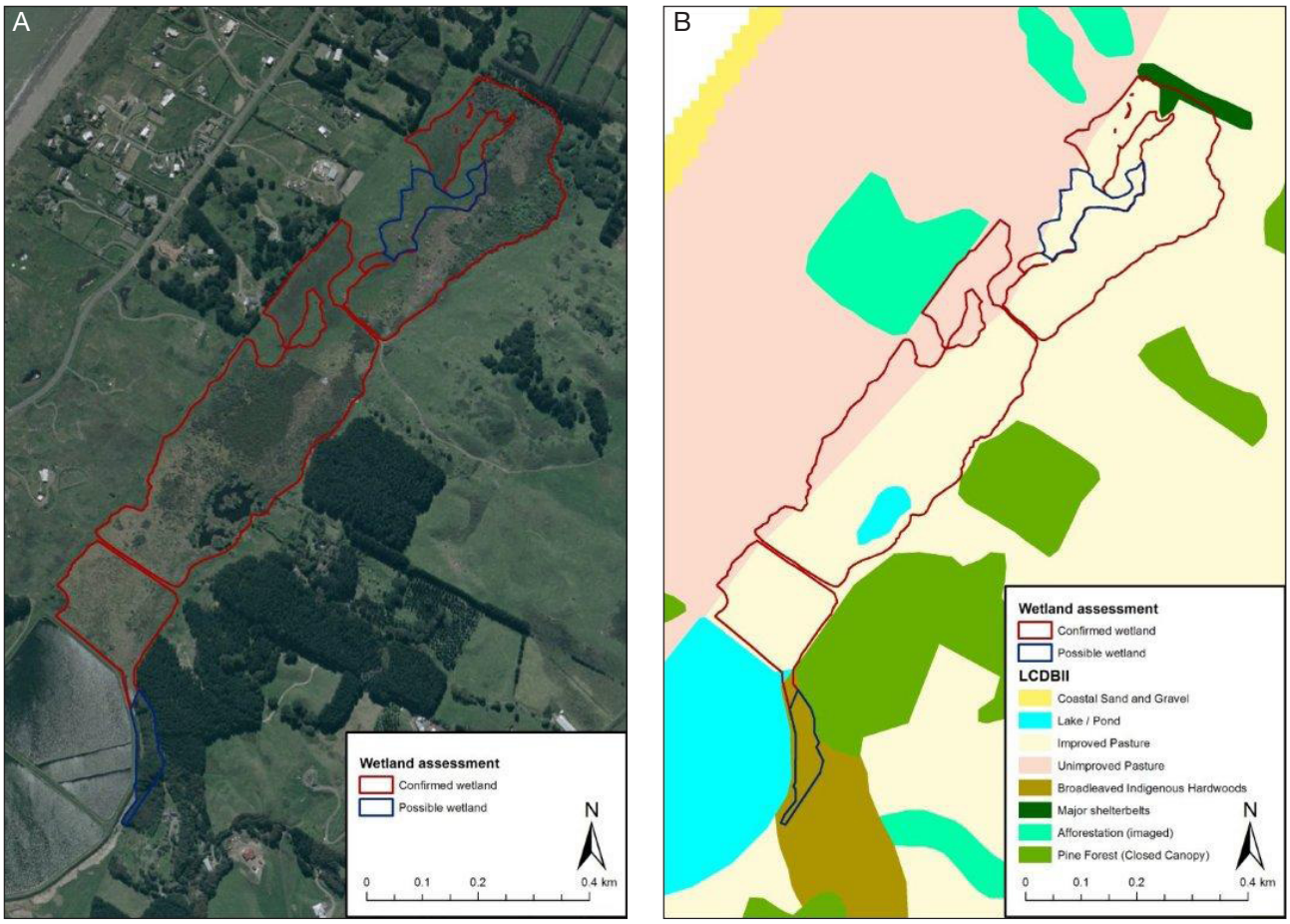

Figure 2. Example of the LCDB2 mapping for the Wellington Region overlain with wetland boundaries confirmed during this study (KC66). A. Aerial photograph. B. LCDB2 map. LCDB2 correctly classifies c. 0.5-ha as lake and pond, while the remainder is misclassified.

3.3 LCDB2 misclassifications

Many wetland misclassifications were identified during this project (Table 5). Several additional misclassifications related to dryland cover were also discovered, but comments on these are, by necessity, brief, as this was not the research focus and they were often only picked up because of their proximity to wetlands. Representative maps that illustrate typical classification inconsistencies from each map quarter are presented in Appendix 3, with explanatory comments about the wetland mapping and any misclassifications.

In all four map quarters, the most common LCDB2 misclassification was high producing exotic grassland (Appendix 3). Of all verified wetlands, 36% of the misclassified wetlands occurred in this class. Another problem was not being able to distinguish between the wetland and dryland contexts for mānuka/kānuka on the Kapiti Coast. Sometimes a mānuka wetland appears to have been identified fortuitously by LCDB2 as part of a wider dryland mānuka/kānuka site, rather than as a wetland. Although similar difficulties are encountered when assessing aerial photographs, the assessor can at least consider the topographical context and make an informed judgement. It appeared that LCDB2 judgements were less rigorous and field-verification may not have been adequate in the Wellington region.

LCDB2 also had difficulties in distinguishing mānuka/kānuka from gorse/broom, particularly on the Kapiti Coast. A number of mānuka wetlands occur within wider areas of gorse or have a gorse/blackberry (*Rubus fruitcosus*) margin, and it appears that LCDB2 could not distinguish between gorse and mānuka, or between gorse and a mosaic of open water and mānuka. In some instances, 'semi' built-up areas were also misclassified as gorse/broom, perhaps because of the presence of garden shrubs and hedges. Aerial photograph assessments face a similar difficulty

in distinguishing gorse from wetland mānuka. Another misclassification involved classifying mānuka/kānuka as deciduous hardwoods such as willow and poplars (*Populus* spp.), despite their colour and textural differences. These difficulties might be reduced if more detailed aerial photographs were used (e.g. 1:1000).

Table 5. Summary of LCDB2 misclassifications.

LCDB2 CLASSIFICATION	ACTUAL LAND COVER
High-producing exotic grassland	Flax (*Phormium tenax*)-raupō (*Typha orientalis*) Mānuka/kānuka Open water (sometimes with willow margins) Herbaceous wetland vegetation (sedges, rushes, etc.)
Broadleaved indigenous hardwoods	Herbaceous wetland vegetation (sometimes with mānuka)
Urban parkland and open space	Raupo and coprosma scrub
Mānuka/kānuka	Urban parkland and open space Gorse/broom Open water and herbaceous wetland vegetation
Orchards and perennial crops	Urban parkland and open space
Gorse/broom	Herbaceous wetland vegetation Open water and emergent wetland vegetation 'Semi' built-up area
Lake or pond	Residential land Pine trees
Closed canopy pine forest	Open water Deciduous hardwoods
Herbaceous freshwater vegetation	Pasture or exotic grassland Deciduous hardwoods
Deciduous hardwoods	Swamp and mānuka/kānuka 'Semi' built-up area

4. Conclusions

Based on this evaluation of four map quarters in the Wellington region, LCDB2 has major limitations for identifying wetlands. LCDB2 underestimated the area of wetlands in the Wairarapa and Kapiti Coast, with many wetlands not being identified or their boundaries being inaccurate. It was found that LCDB2 is likely to be more effective at identifying larger wetlands, especially if they include open water. Conversely, if the wetlands are smaller than a few hectares, it may not be very useful, particularly in areas dominated by grassland or pasture. The findings of this project suggest that LCDB2 may be similarly unreliable in identifying wetlands (particularly small ones) in other intensively farmed or peri-urban parts of New Zealand, but this remains to be verified.

Despite many boundary inaccuracies (Appendix 3) a preliminary evaluation suggested that dryland classifications were typically more reliable than wetland classifications, even though misclassifications still occurred. For example, it was found that some dryland areas are likely to be misidentified as wetlands, such as rough pasture that formerly may have supported rushes, or gorse/broom on relict sand dunes.

It is clear that LCDB2 should not be used on its own to identify wetlands, whether it is for RMA purposes including significance assessments and land development proposals, or other resource assessment projects. Furthermore, where LCDB2 has been used as a primary data source in the WONI wetland mapping project (Ausseil et al. 2008), data validation should be undertaken to ensure accuracy. However, the use of LCDB2 may be acceptable where it occurs in conjunction with other information sources, such as aerial photographs and existing databases. This viewpoint is not intended to discredit the value and future use of LCDB2, but it is essential to recognise its limited ability to identify wetlands, and its wider limitations for resource and land-use assessments. The study suggests that future versions of LCDB need to be more thoroughly reviewed, so that its classification units more accurately represent the cover actually present on the ground.

5. Recommendations

The authors make the following recommendations:

- Given the significant limitations of LCDB2 in delineating wetlands, it should not be used as the sole method for identifying and mapping wetlands.
- LCDB2 should not be relied upon to provide a consistent classification of dryland cover.
- LCDB2 should not be relied upon to provide accurate boundaries for classified areas.
- LCDB2 should be used with caution in statutory planning processes and ecological assessments, and only in conjunction with other information sources and ground verification.
- Comprehensive and careful ground verification, or improved remote sensing validated with survey records (e.g. NVS dataset), should be undertaken to improve the classifications and accuracy of LCDB2's unit boundaries. The updated version should then be rigorously peer reviewed to ensure its accuracy and practical value.
- Consideration should be given to repeating this analysis for other regions where good quality wetland databases exist, to ensure that the findings of this project are applicable at a national level.

Note from Authors:

During the revision and publication of this document in 2012, LCDB3 was released. The new version of the LCDB provides updated mapping of land cover in New Zealand. LCDB3 contains 33 classes designed to be compatible with earlier LCDB versions and compatible in scale and accuracy with Land Information New Zealand's 1:50,000 topographic database. We undertook a rapid assessment of LCDB3 in the Wellington region and identified that while there were some improvements in wetland delineation, many of the mapping issues that were identified in this report remain unresolved.

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Appendix 1

LCDB2 land cover classes and alignment with wetlands

LCDB2 NAME	LIKELY WETLAND PRESENCE
Afforestation (imaged, post LCDB1)	No
Afforestation (not imaged)	No
Alpine grass/herbfield	No
Alpine gravel and rock	No
Bracken fern	No
Broadleaved indigenous hardwoods	No
Built-up area	No
Coastal sand and gravel	Potential
Deciduous hardwoods	Potential
Depleted tussock grassland	No
Dump	No
Estuarine open water	Saline
Flaxland	Yes
Freshwater sedgeland/rushland	Yes
Gorse and broom	Potential
Grey scrub	No
Herbaceous freshwater vegetation	Yes
High producing exotic grassland	No
Indigenous forest	Potential
Lake and pond	Yes
Landslide	No
Low producing grassland	No
Major shelterbelts	No
Mangrove	Saline
Manuka and or Kanuka	Potential
Matagouri	No
Mixed exotic shrubland	No
Orchard and other perennial crops	No
Other exotic forest	No
Outside LCDB2 study area	No
Permanent snow and ice	No
Pine forest—closed canopy	No
Forest harvested	No
Pine forest—open canopy	No
River	No
River and lakeshore gravel and rock	Potential
Rural infrastructure	No
Saltmarsh	Yes
Short tussock grassland	No
Short-rotation cropland	No
Sub alpine shrubland	No
Surface mine	No
Tall tussock grassland	No
Transport infrastructure	No
Unclassified	No
Urban parkland/open space	No
Vineyard	No

Appendix 2

List of attributes recorded in wetland database

ATTRIBUTE HEADINGS	DESCRIPTION
LCDB2 class	LCDB2 class number
LCDB2 name	LCDB2 name
LCDB2 wetland potential	Assessment of LCDB2 wetland potential
TA name	Territorial authority name
Region name	Region
Map sheet	Map quarter number
Ids	Davis reference number
Source theme	GIS source files
Wetland assessment number	Wetland assessment
Wetland assess	Wetland assessment text
Hectares	Hectares

Appendix 3

Wetland mapping examples

Each figure in this appendix consists of a paired aerial photograph (A) and LCDB2 map (B).

Table A3.1. Coordinates of wetland mapping examples.

WETLAND ID	EASTING	NORTHING
SR16	2681802	6036210
SR17	2681470	6036174
KC112	2680193	6035659
SR20	2726790	6006583
GW173	2712407	5998038
GW210	2697231	5988176
GW213	2690251	5987297
GW214	2690623	5987412
SR10	2760785	6003624
GW165	2763851	6001504

Kapiti Coast (R26b)

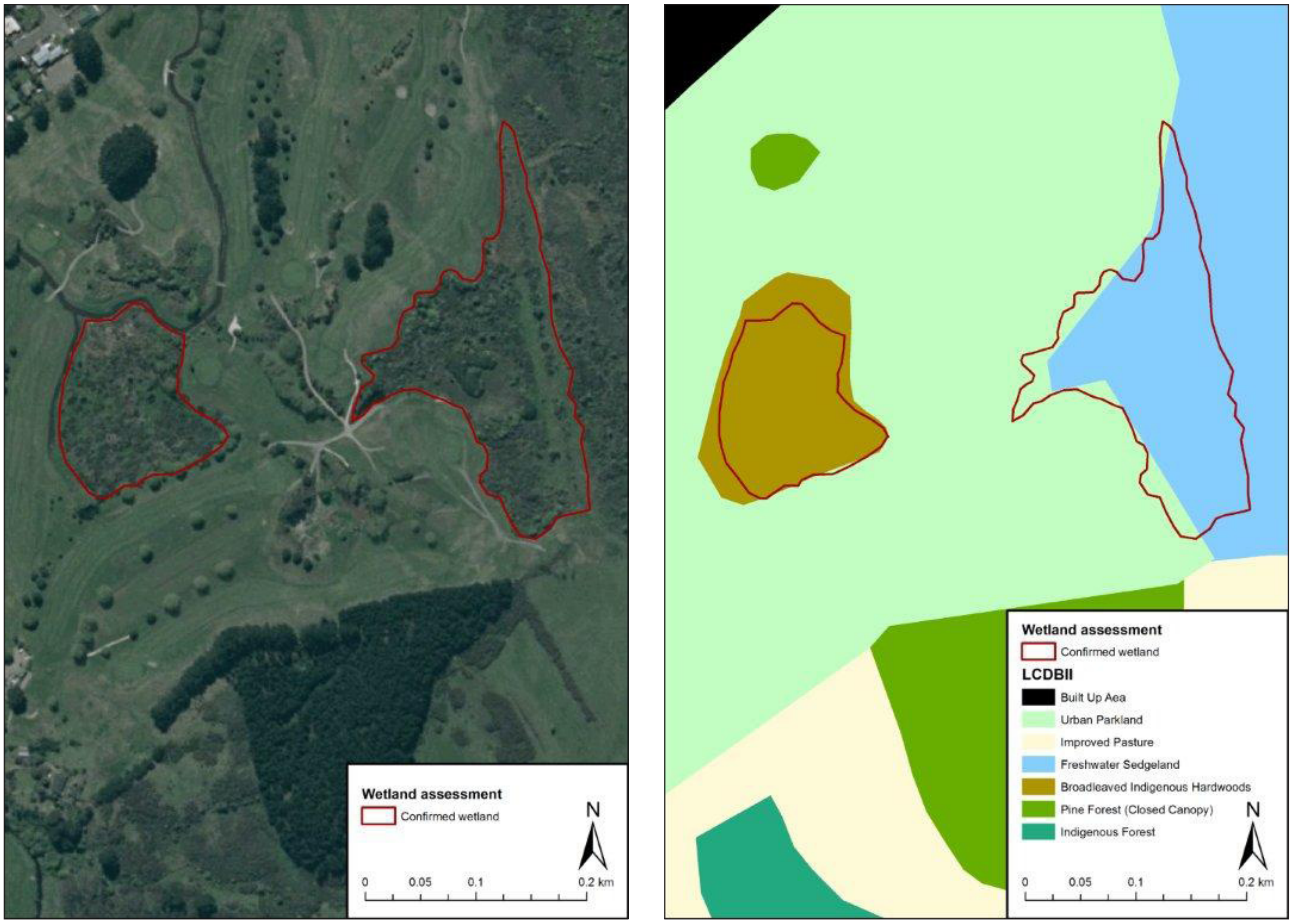

Figure A3.1. SR16 and SR17—A. Aerial photograph and B. LCDB2 map. SR16 (3.1 ha) and SR17 (1.7 ha) occur in close proximity to each other on a golf course. Both support a broadly similar mosaic of vegetation, including lowland flax, raupō, toetoe (*Cortaderia toetoe*), sedges, *Coprosma* spp., cabbage tree (*Cordyline australis*) and mānuka. Despite their similarity, LCDB2 classifies SR16 as herbaceous freshwater vegetation and SR17 as broadleaved indigenous hardwoods. This is partly correct for SR16, but incorrect for SR17.

Figure A3.2. KC112—A. Aerial photograph and B. LCDB2 map. This 5.5-ha wetland was not field-checked, but is described as including raupō and *Coprosma* scrub (Wildland Consultants 2003). The open water portion is correctly classified by LCDB2 as lake or pond, but the remaining 4 ha is misclassified as urban parkland/open space.

Martinborough (S27b)

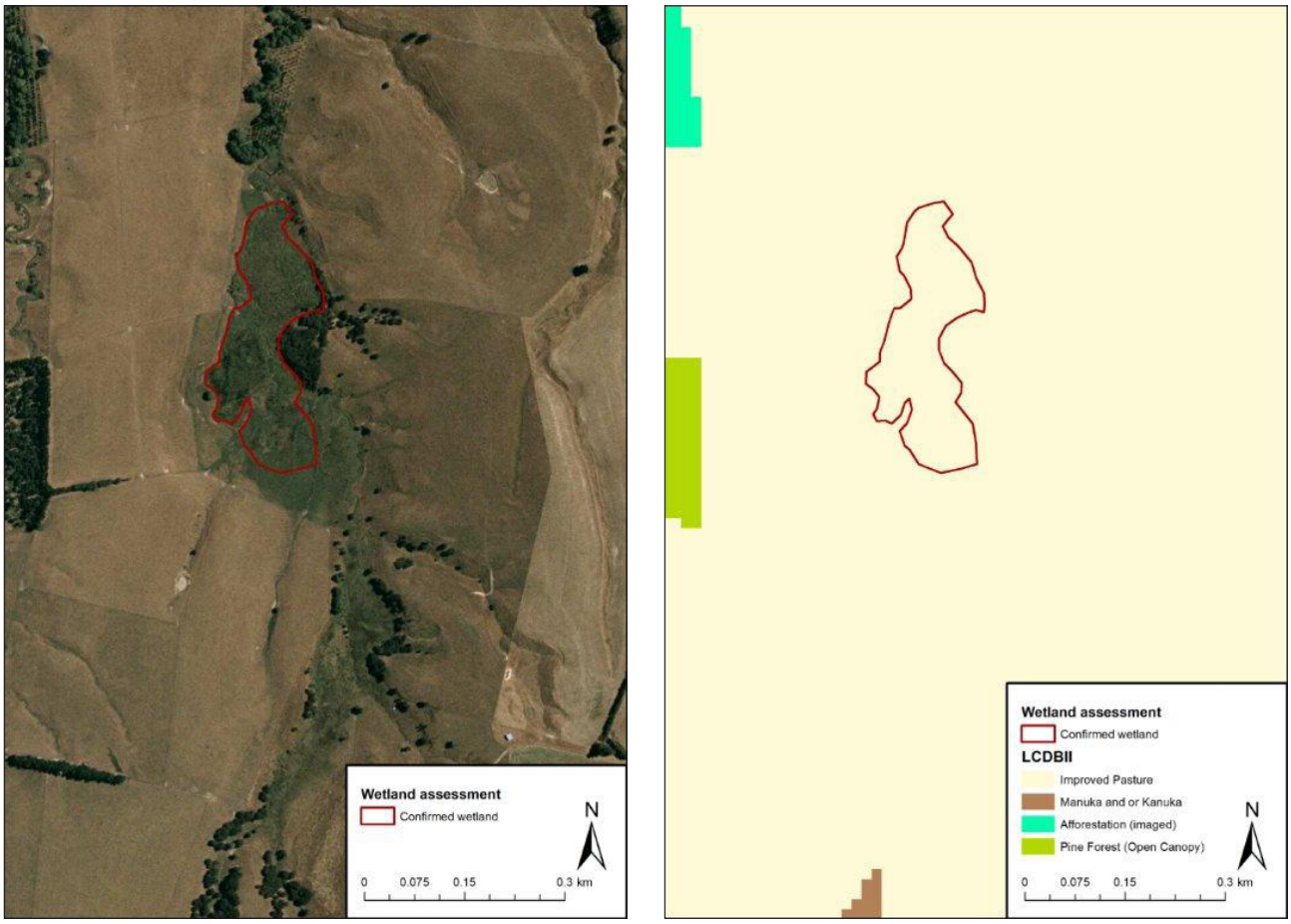

Figure A3.3. SR20—A. Aerial photograph and B. LCDB2 map. This 3.9-ha gully wetland is the largest of several similar wetlands visited in the hills to the east of Martinborough. The site could arguably have been larger, to include more wetland vegetation. Duckweed (*Lemna minor*) is common in open water among rushes, and *Carex geminata* is also quite common. The entire wetland is misclassified as high-producing exotic grassland by LCDB2.

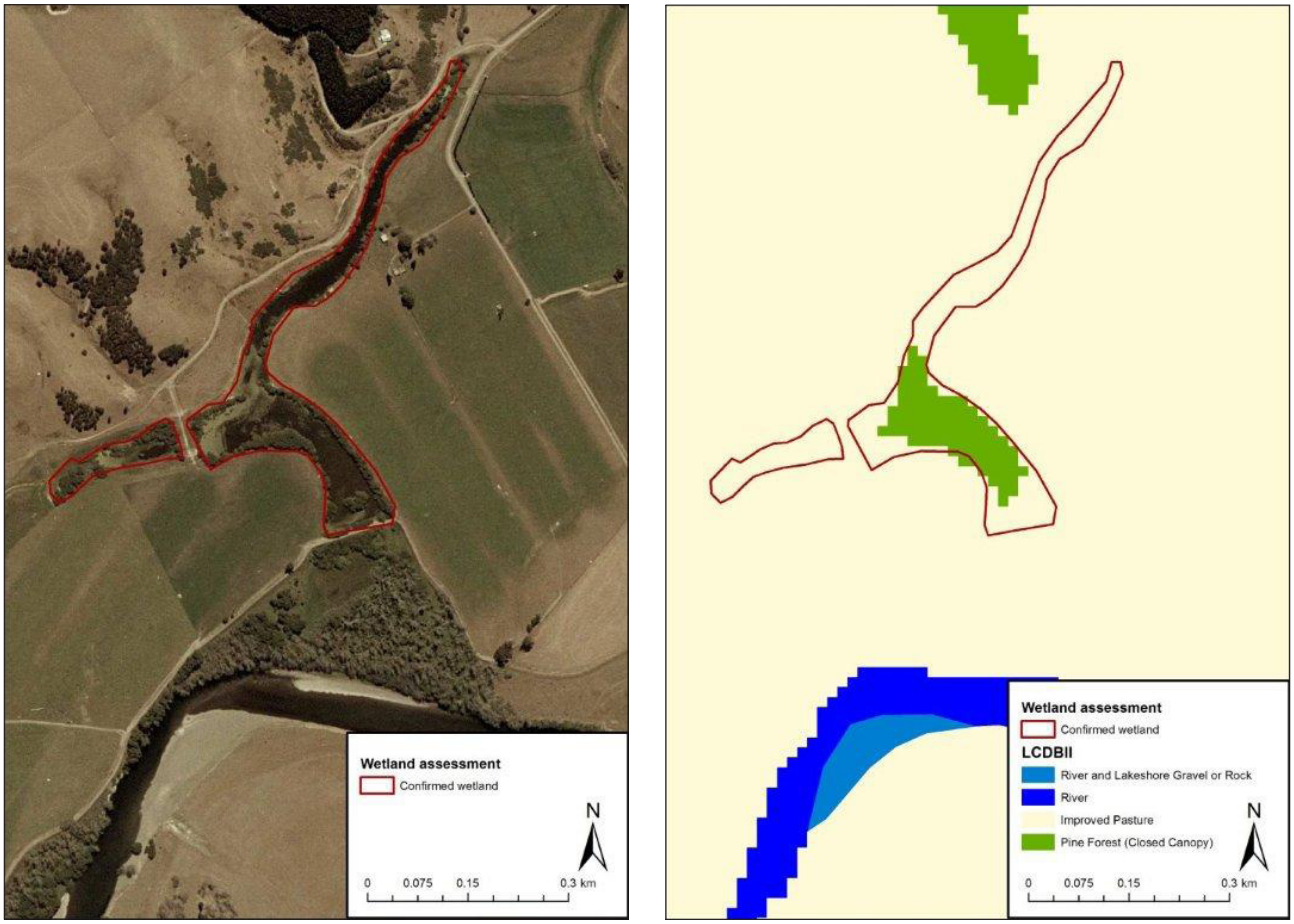

Figure A3.4. GW173—A. Aerial photograph and B. LCDB2 map. This 5.8-ha wetland was not field-checked, but it is dominated by open water with willows on the margins. LCDB2 misclassifies 1.8 ha as closed canopy pine forest, while the remainder is misclassified as high producing exotic grassland.

South Wairarapa (S27c)

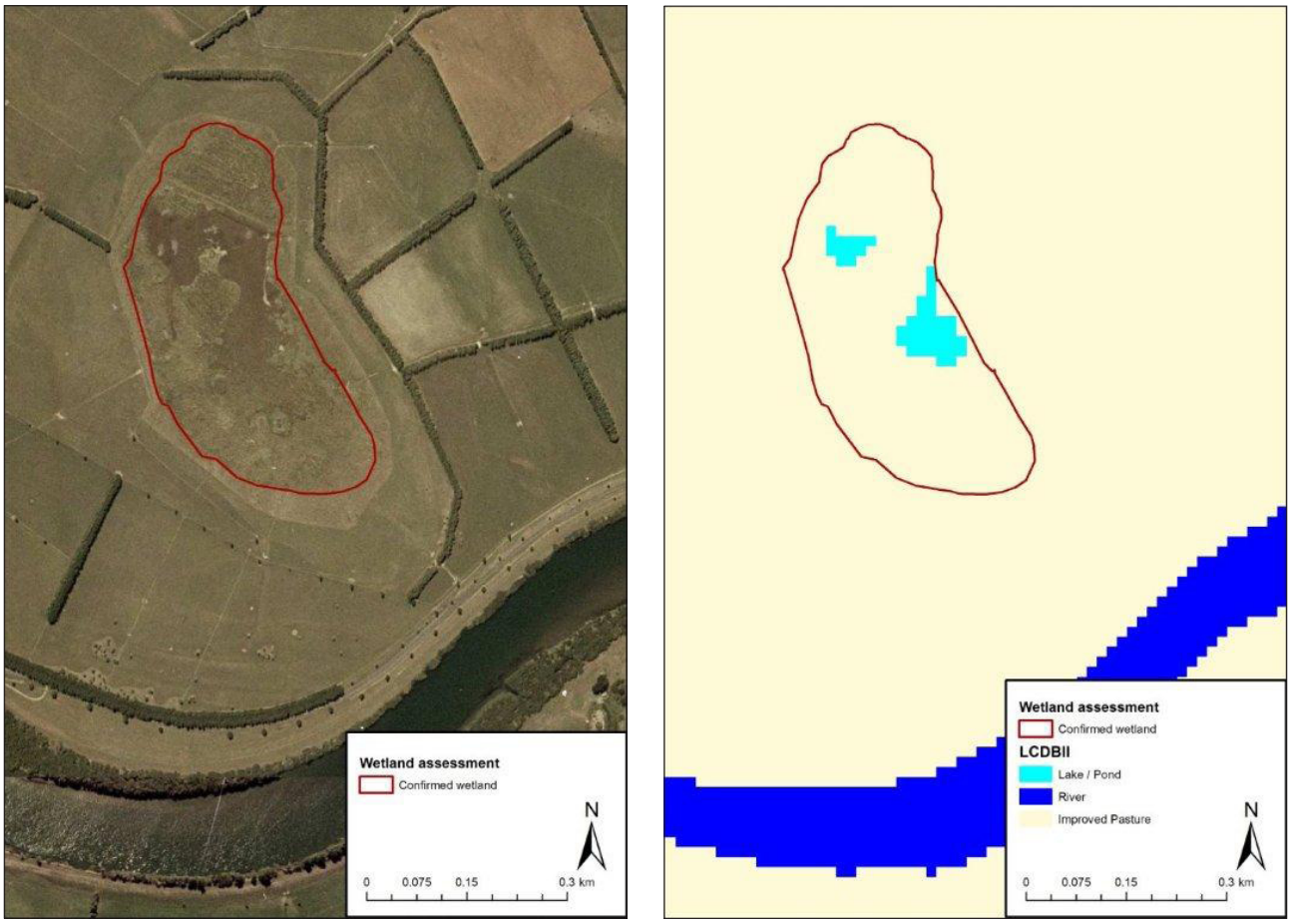

Figure A3.5. GW210—A. Aerial photograph and B. LCDB2 map. This wetland was not visited but it was reviewed using aerial photographs. LCDB2 classifies two areas of c. 1 ha as lake or pond, but it misses some open water and the boundaries are not accurate. The remaining 11 ha appears to be wetland vegetation but is misclassified as high-producing exotic grassland.

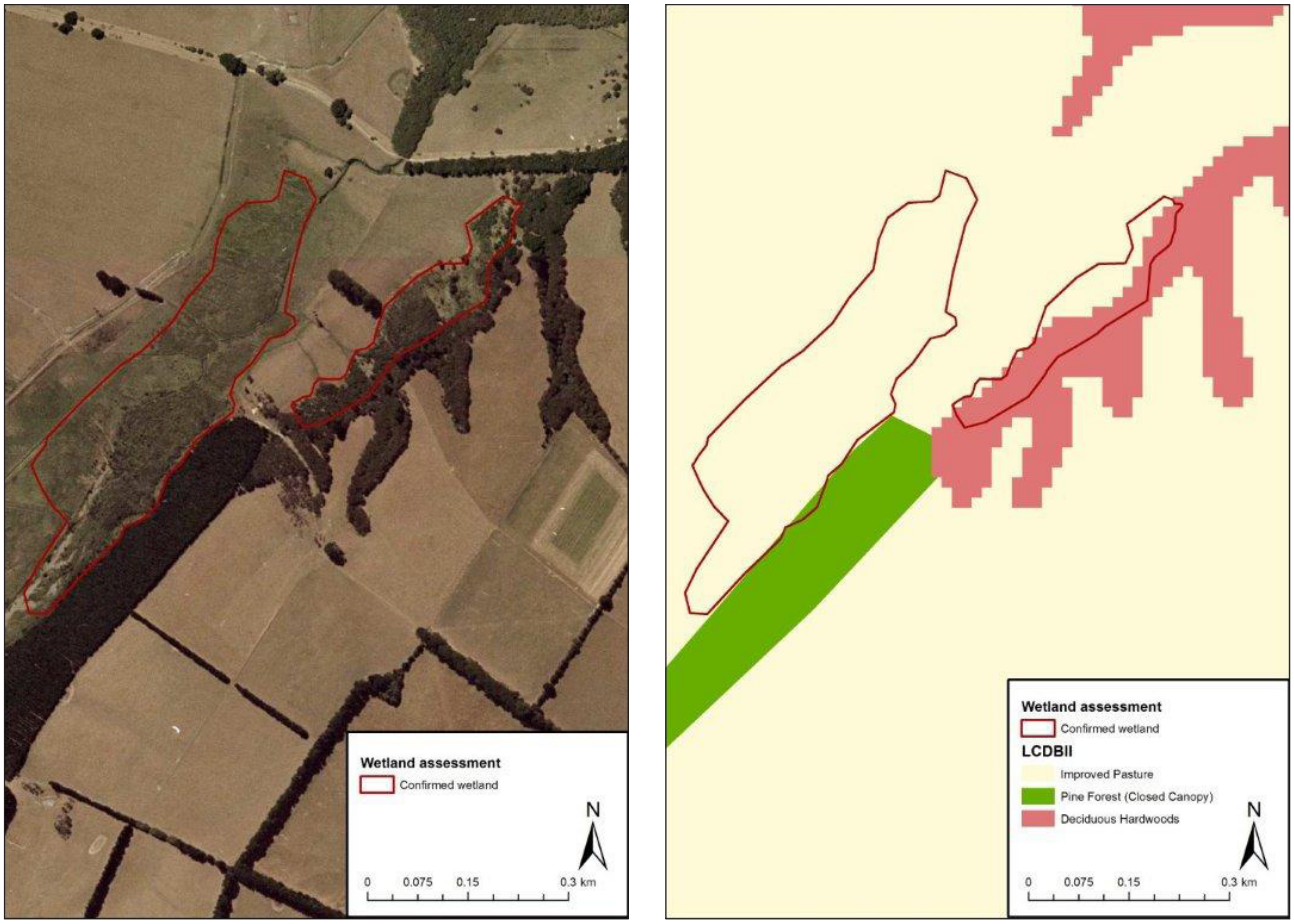

Figure A3.6. GW213 and GW214—A. Aerial photograph and B. LCDB2 map. GW213 is a 9.4-ha wetland dominated by *Carex geminata* and lowland flax. The entire wetland is misclassified as high producing exotic grassland by LCDB2. The adjacent Davies swamp (GW214) is largely misclassified as deciduous hardwoods and high producing exotic grassland. It is described as a swamp with mānuka by GW. (Note: also see GW204 c. 250 m to the north for a comparison with deciduous hardwoods there)

East Wairarapa Coast (T27b)

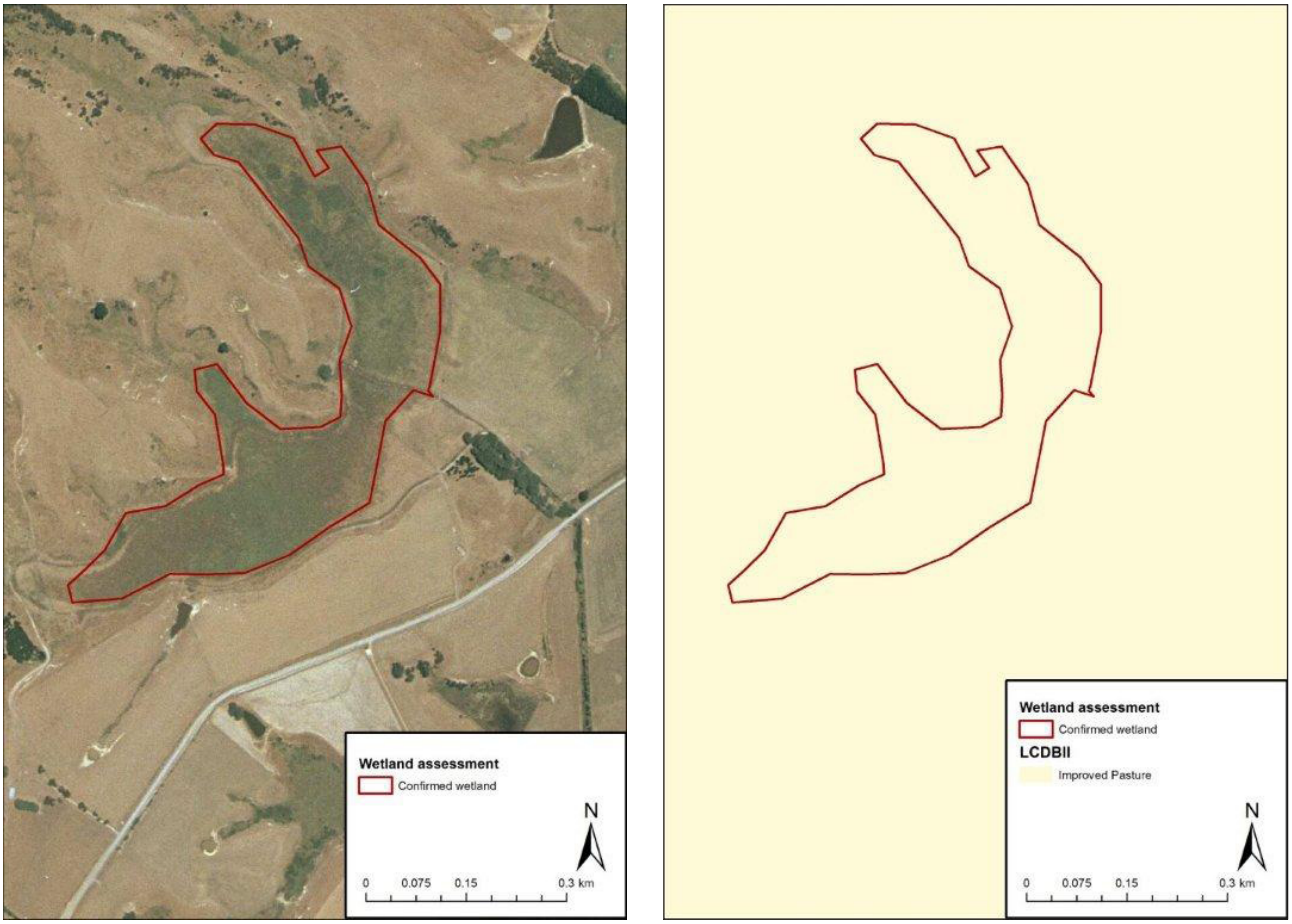

Figure A3.7. SR10—A. Aerial photograph and B. LCDB2 map. This 13.2-ha wetland supports a combination of sedges, rushes, willow weed and exotic grasses. The entire wetland is classified as high-producing exotic grassland by LCDB2.

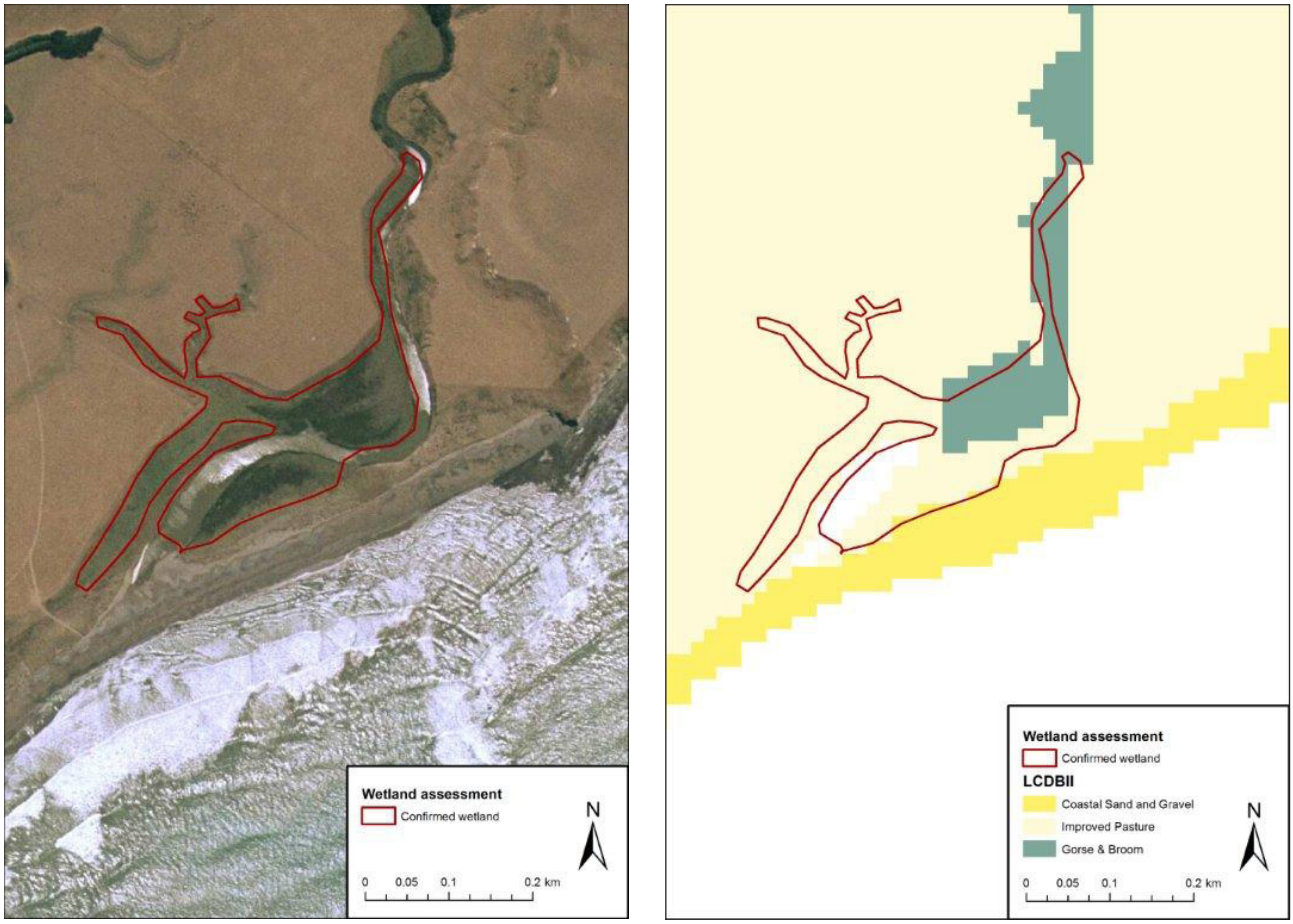

Figure A3.8. GW165—A. Aerial photograph and B. LCDB2 map. This 5.2-ha wetland is characterised by *Carex geminata*, *Cyperus ustulatus*, sea rush (*Juncus kraussii* var. *australiensis*) and three square. It is misclassified by LCDB2 as a combination of high-producing exotic grassland, broadleaved indigenous hardwoods, and gorse and broom.