REVIEW ARTICLE

Wetland reserves in New Zealand: the status of protected areas between 1990 and 2013

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Abstract: The extent and integrity of wetland ecosystems in New Zealand has declined. Only an estimated 10% of the historic (pre-European) extent of inland palustrine wetlands now remains. A key mechanism for conservation of wetlands is inclusion within the protected area network, including both public and private protected areas. Review of progress in wetland reservation enables evaluation of the success of land purchase, land tenure review and other initiatives to address gaps in the national reserve system. I present the first national assessment of changes in wetland reservation between 1990 and 2013. Potential biases in wetland protection were identified by comparing differences in reservation across wetland type, wetland size, biogeographical region, and altitudinal range. At the national scale 63% of palustrine wetlands are now within protected areas, but this represents only 6% of the historical extent. Between 1990 and 2013 the extent of current wetlands protected in conservation land administered by the Department of Conservation increased from 48% to 60%, a net gain of 29 000 ha. Much of the increase in wetland reservation has occurred in the South Island, partly due to tenure review of high country land (>500 m a.s.l.). There are inconsistencies in reservation between wetland types, with lower coverage of protected areas for swamps, fens and marshes. There are also inadequacies in the completeness of wetland reserves, with a number of wetlands only partially contained within reserve boundaries. I propose a number of options for improving the reservation status of wetlands in New Zealand that will contribute to a more comprehensive, adequate and representative network of freshwater protected areas.

Keywords: conservation areas; representation; reservation; wetland type

Introduction

The establishment and management of protected areas is a fundamental mechanism for the conservation of biological diversity in New Zealand (DOC & MfE 2000), and internationally (Saunders et al. 2002; Strayer & Dudgeon 2010; Kingsford et al. 2011). The value of protected areas in providing ecosystem services to society is increasingly recognised (Balmford et al. 2011; Palomo et al. 2011). International conventions and multi-lateral agreements, such as the Convention on Biological Diversity (CBD 1992) and the Ramsar Convention on Wetlands (Ramsar Convention 2005), to both of which New Zealand is a signatory, have sought global recognition of the importance of protected areas for freshwater management. In New Zealand the Conservation Act 1987 and Reserves Act 1977 outline the provisions for establishing conservation areas and reserves for the management of natural heritage. The Reserves Act, for example, states that one of its general purposes is *the preservation of representative samples of all classes of natural ecosystems and landscape which in the aggregate originally gave New Zealand its own recognisable character* (section 3(1)). The Department of Conservation Statement of Intent 2013–2017 similarly has as a core goal to ensure the *full range of New Zealand's ecosystems is conserved to a healthy functioning state* (DOC 2013). The Statement of Intent identifies specific actions to increase the extent of marine reserves, but less attention has been directed towards wetland reserve establishment. This may be partially due to the absence of analytical information to determine the state of wetlands in the current network of protected areas. However, there is recognition in national policy documents of the need to protect wetlands that have become uncommon due to human activity (e.g. MfE & DOC 2007).

The principles for systematic conservation planning described by Margules and Pressey (2000) and applied by other authors (e.g. Fitzsimons & Robertson 2005; Herbert et al. 2010) recognise the importance of the comprehensiveness, adequacy and representativeness (CAR) of the network of protected areas. This includes consideration of the potential biases in reservation between biogeographical regions. Development of the national reserve system in New Zealand has been comprehensive, with over 30% of the land mass in public conservation land; however, it has not been representative (Craig et al. 2000; Molloy & McSweeney 2011) or necessarily adequate to mitigate key threats to natural heritage. Establishment of protected areas in New Zealand was often limited to land unsuitable for other land uses. Fertile areas such as lowland wetlands were typically modified for agricultural use and are likely to be under-represented in protected areas (Craig et al. 2000; Ausseil et al. 2011).

In a review of wetland protection in Victoria, Australia, Fitzsimons and Robertson (2005) identified significant biases in the reservation of wetlands, with systems more readily converted to pasture, such as shallow freshwater marshes, being poorly protected relative to other wetland types. Similarly, in the boreal region of Canada, while 12% of wetlands are within protected areas, there is a bias towards low productivity wetlands (Andrew et al. 2014). A review of the adequacy of international approaches to freshwater protected areas was undertaken by Linke et al. (2011), who observed that wetlands

are often omitted from freshwater conservation planning due to a focus on rivers.

This paper focuses on the reservation of inland palustrine wetland ecosystems in New Zealand. Inland palustrine wetlands were defined as freshwater wetlands fed by rain, groundwater or surface water, but not directly associated with estuaries, lakes or rivers (Johnson & Gerbeaux 2004). The majority of freshwater wetlands in New Zealand are palustrine and encompass a broad range of landforms, plant communities and wetland soil types (Johnson & Gerbeaux 2004; McGlone 2009; Singers & Rogers 2014). While New Zealand has an international reputation for the conservation of biological diversity, inland palustrine wetlands have not fared as well as other ecosystem types due to a combination of drainage, catchment deforestation, increased nutrients and human-induced burning (McGlone 2009). It has been estimated that only 10% of palustrine wetlands now remain (Ausseil et al. 2011) and there is some evidence that wetland loss is still occurring, despite the introduction of the Resource Management Act in 1991 that seeks to preserve the natural character of wetlands. Recent intensification of agriculture, for example, has continued wetland loss in areas such as Southland where restiad-dominated bogs and other wetlands continue to be converted to pasture (Ledgard 2013).

Current initiatives to improve the conservation of wetland ecosystems include land tenure review (LINZ 2014), covenanting of private land (QEII National Trust 2013), the purchase of high priority habitat to establish new reserves through the Nature Heritage Fund (Molloy & McSweeney 2011), improvements to planning rules (Myers et al. 2013) and on-ground restoration (Robertson & Suggate 2011). However, there has been no comprehensive review of progress in wetland reservation across New Zealand. The degree that investment in conservation has benefited wetlands to date and the future priorities for wetland conservation are currently unclear.

The aim of this study was to quantify changes in wetland reservation over the past two decades through the establishment and expansion of protected areas, and to ascertain whether systems that are a priority for increased protection were in fact the target of investment. For the purposes of this paper, a broad definition of 'protected area' is applied, referring to the full range of conservation land in New Zealand, including all types of conservation land administered by the Department of Conservation (DOC), conservation parks and reserves administered by councils, covenants, and other private protected areas.

Methods

A prerequisite for national assessment of the status of protected areas was geospatial (GIS) data on the extent and types of wetland ecosystems and their level of reservation. The Freshwater Ecosystems of New Zealand (FENZ) is a GIS database that maps wetland, lake and river systems (Leathwick et al. 2010) and provided the base wetland layer for analysis. The wetland types applied were limited to the inland palustrine wetlands, as defined by Johnson and Gerbeaux (2004); swamp, marsh, fen, bog, inland saline, pakihi, and gumland. The wetland types are differentiated by substrate, water regime, nutrient status, and pH. While 'swamp' is a general term and can have various interpretations (McGlone 2009), in this classification, swamps are defined as wetlands that have a combination of mineral and peat substrate, a water table usually permanently above the ground surface, nutrient-enriched soils and that support a variety of vegetation forms (e.g. forest, shrub, tall herb and sedges (Johnson & Gerbeaux 2004). FENZ maps both the current and historic extent of wetlands. It was recognised there are classification errors for some wetland types, such as differentiating swamps from marshes (Ausseil et al. 2008). The current wetland extent layer in FENZ was derived from satellite images 1999–2003 supplemented with wetland mapping resources obtained from councils (Ausseil et al. 2008). The historic extent relates to the pre-European extent of wetlands, as modelled using landform and soils information (Ausseil et al. 2008). That Maori settlement in New Zealand and corresponding land use change is likely to have increased the extent of wetlands in some regions also needs to be taken into account (McGlone 2009). GIS data on the extent of conservation land administered by DOC at c. 1990 were obtained from geospatial information held by DOC (D. Brown, DOC, pers. comm.). The analysis used 1990 as a baseline as this relates to the establishment of the Resource Management Act (RMA) in 1991 and the Department of Conservation in 1987. Data on the current (2013) extent of conservation areas were obtained from the geospatial layers held in the national information system, known as NATIS, including DOC-administered conservation land and private land conservation areas, such as QEII covenants, Nga Whenua Rahui and DOC covenants. Protected areas administered by local and regional authorities were not included in the analysis.

Spatial analysis tools in ArcGIS 10.2 were used to calculate the extent of wetlands within (i) DOC-administered land in 1990, (ii) DOC-administered land in 2013, and (iii) other protected areas in 2013, and followed methods previously applied by Fitzsimons and Robertson (2003). No information on the extent of other protected areas in 1990 was available for this study. Differences in reservation across wetland types, wetland size, biogeographic region and altitude were examined. These attributes were derived from the FENZ database for each wetland polygon. This study applied the FENZ biogeographical regionalisation scheme that divides New Zealand into 29 bioregional units based on the physical-chemical and biological dissimilarity of riverine catchments (Leathwick et al. 2010).

Results were summarised as the area (ha) of wetlands within protected areas at 1990 and 2013. Biases in wetland reservation were examined by calculating the proportion of wetlands within protected areas across wetland type, wetland size and for different bioregions. The percentage (%) of each individual wetland (polygon) that is within a protected area was calculated to assess the adequacy of reserve boundaries in covering the total wetland extent. The ecological integrity (EI) of wetlands added to the reserve network was assessed using the EI score for each individual wetland from the FENZ database (Leathwick et al. 2010). The EI score is on a scale from 0 to 1, with scores >0.75 representing good condition wetlands (Ausseil et al. 2008). Summary statistics on the extent of wetlands in different types of protected areas (e.g. scientific reserve, stewardship land) were also derived. The various conservation reserve categories in New Zealand were also assigned to the seven internationally recognised IUCN categories for protected areas as defined in Dudley (2008): Category Ia (Strict nature reserve), Category Ib (Wilderness area); Category II (National park); Category III (Natural monument or feature); Category IV (Habitat/species management area); Category V (Protected landscape/seascape); and Category VI (Protected area with sustainable use of natural resources).

Results

Status of wetland protected areas

Of the approximately 250 000 ha of inland palustrine wetlands that remain in New Zealand, over 157 000 ha (63%) occurred on land that is primarily managed for the conservation of natural heritage. The relatively high level of wetland reservation was partly due to the contribution of large wetland sites such as the Awarua wetland (12 000 ha), Kopuatai peat dome (10 000 ha), and Whangamarino wetland (6000 ha). Land administered by DOC contributed the most to wetland protection (150 300 ha), but other conservation areas, such as QEII covenants (>5000 ha), also contributed to the network of wetland reserves (Table 1).

Between 1990 and 2013 an additional 29 000 ha of wetlands were legally protected within DOC-administered conservation land. This represented an overall increase in wetland reservation from 48% of the current wetlands in 1990 to 60% in 2013 (Table 1). The majority of the additions occurred in the South Island. Changes in land status were often the result of land purchase or tenure review, such as for the Hakatere region of the Ashburton Basin, which resulted in 780 ha of wetlands being designated as a Conservation Park in 2007. When compared with the historic extent of wetlands in New Zealand,

Table 1. Summary of wetland protection in New Zealand (1990–2013) relative to the current and historic extent of inland palustrine wetlands. PCL is Public Conservation Land administered by DOC. PCL + Other includes PCL and other types of conservation areas, including covenants.

	Extent (ha)	Proportion of wetlands in protected area (%)		
		PCL 1990	PCL 2013	PCL + Other 2013
Current wetlands	250 000	48	60	63
Historic wetlands	2 471 000	5	6	6

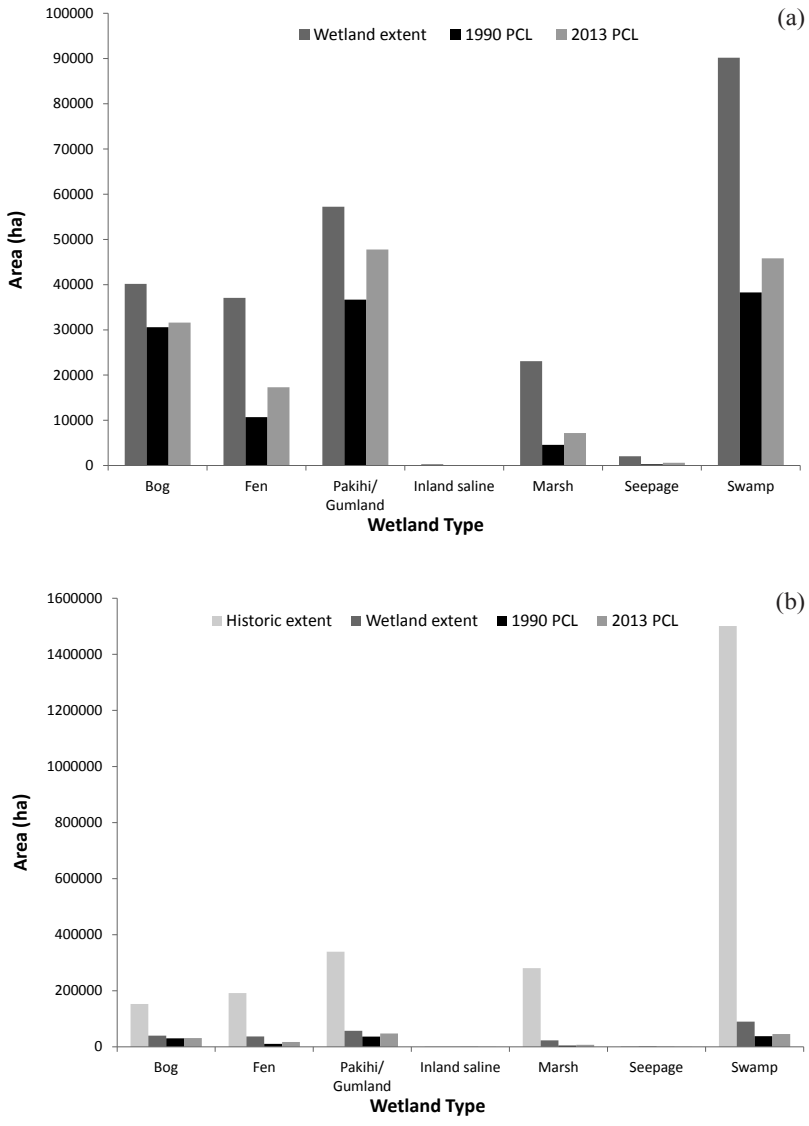

Figure 1. Change in wetland protection in New Zealand for different wetland types (a) relative to current extent, and (b) relative to historic extent. PCL is Public Conservation Land administered by DOC.

the increase in the extent of wetlands in protected areas since 1990 was relatively insignificant. The 2013 level of wetland reservation relative to the historical extent of wetlands extent was 6% compared with 5% in 1990 (Table 1).

Wetland type

Since 1990 all wetland types across New Zealand have increased their extent of legal protection in conservation land administered by DOC (Fig. 1a). The largest increase in reservation was for the Pakihi/Gumland wetland types (11 000 ha added). Swamps also experienced a significant increase in legal protection (7500 ha). Ombrotrophic systems, such as the rain-fed bogs, have experienced lower rates of wetland reservation since 1990. Relative to their current extent, bogs have comprehensive coverage within protected areas, whereas fens and marshes have a lower level of reservation (Fig. 1a). Relative to historic extent (Fig. 1b), the different wetland types have between 2% and 21% coverage within conservation land. The swamp and marsh wetland types were the most under-represented wetland types in New Zealand compared to their historic extent.

Elevation

Wetlands across all elevation classes showed similar levels of reservation in 2013, relative to the current extent of wetlands (Fig. 2). Substantial increases in wetland protection >100 m a.s.l. were evident between 1990 and 2013, but there was relatively little change in areas protected in the 50–100 m a.s.l. elevation class. The relatively high amount of legal protection for lowland wetlands (<50 m a.s.l.) was likely to be due to a few very large (>5000 ha) wetland systems and does not take into account the historical loss of lowland wetlands (mainly swamps) due to drainage and land clearance (Fig. 1b).

Wetland size

Biases in wetland reservation were observed in terms of wetland size. Only 29 % of wetlands less than 100 ha were within protected areas, compared with 70% of wetlands larger than 100 ha. Between 1990 and 2013 additions to protected areas were also biased toward larger wetlands (Fig. 3). However, a number of small wetlands (<100 ha) are likely to be within private protected areas (e.g. QEII covenants), which were not assessed in this study.

Ecological integrity

The condition (ecological integrity) of wetlands within DOC-administered conservation land was also examined (Figure 4).

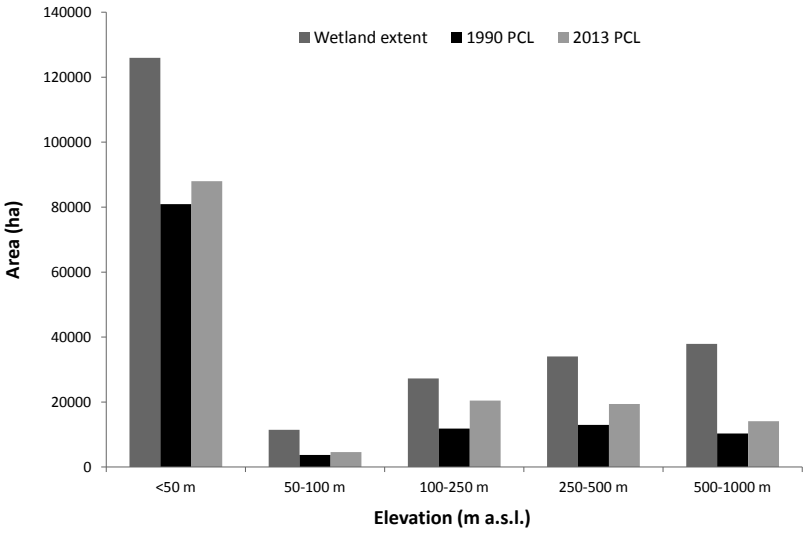

Figure 2. Change in wetland protection in New Zealand relative to altitudinal range. PCL is Public Conservation Land administered by DOC.

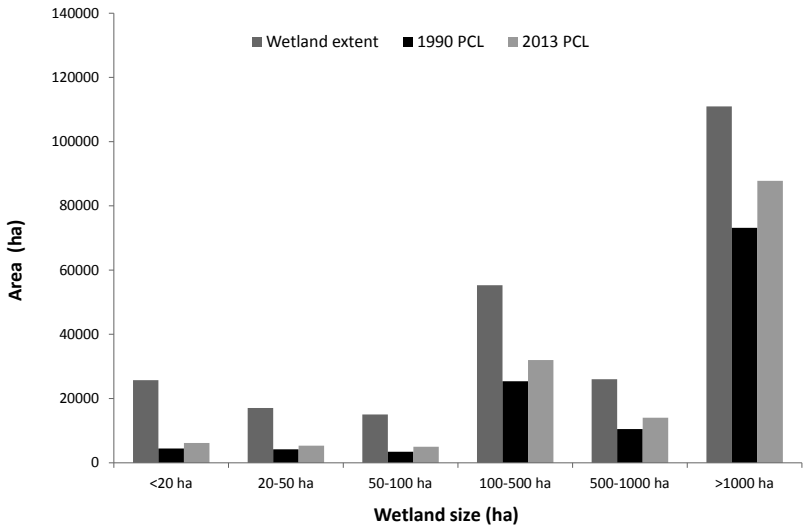

Figure 3. Change in wetland protection in New Zealand relative to wetland size. PCL is Public Conservation Land administered by DOC.

Between 1990 and 2013 most wetlands added to protected areas had relatively high ecological integrity (>0.75 EI). Of the 29,000 ha of wetlands transitioning into protected status since 1990, less than 300 ha were in poor condition (<0.25 EI).

Proportion of wetland in reserve

The proportion of each individual wetland within DOC-administered conservation land was calculated to evaluate how well the reserve configuration encapsulated the full extent of each wetland. Most wetland reserves covered >80% of the wetland area (Fig. 5); however, a number of wetlands were only partially protected (<80% of wetland area within reserve). Between 1990 and 2013 there was a notable improvement in reserve design, as indicated by the reduced area of incomplete wetland reserves (Fig. 5).

Reserve type

The types of reserves and conservation areas applied across New Zealand were also assessed to evaluate the adequacy of protected areas. Over 20 different reserve types are applied to wetlands nationally. A significant amount of the wetland protected area was classified as Stewardship Land (63 500 ha), accounting for 40% of all wetland reserves. National Park, Government Purpose Reserve and Ecological Area were the next most common reserve types used to protect wetlands (Fig. 6). As different legislation (e.g. National Parks Act, Reserves Act, Conservation Act) governs different reserve types in New Zealand, the IUCN protected area categories were applied to compare the degree of legal protection (Fig. 6). Only 3% of wetlands in protected areas were aligned to the IUCN status of a Strict Nature Reserve (category IA). The majority of wetland protected areas were in category III, which still indicates a focus on conservation of natural features. Private protected areas, such as QEII covenants, also contribute to wetland reservation (Fig. 6). Government Purpose Reserves are used at some internationally significant Ramsar sites in New Zealand (e.g. Whangamarino Wetland); however, it was not possible to align this reserve type to one of the IUCN categories.

FENZ biogeographical regions

Wetland reservation, as at 2013, was not consistent across the North and South Island, or the 29 biogeographical units (Table 2). Fen and seepage wetland types, for example, had considerably lower reservation levels in the North Island. Some biogeographical units had very high areas of wetlands

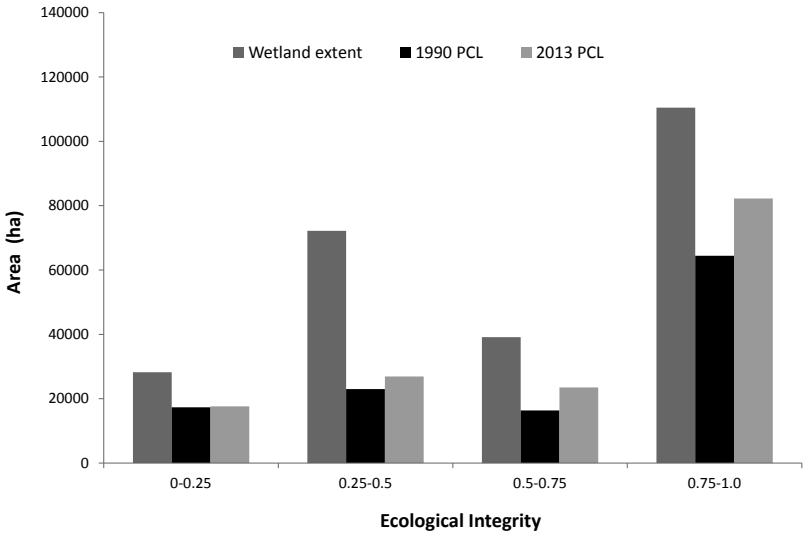

Figure 4. Change in wetland protection in New Zealand relative to wetland condition (Ecological Integrity). High Ecological Integrity (0.75–1.0) corresponds to wetlands in better condition, as indicated in FENZ (Freshwater Ecosystems of New Zealand; Leathwick et al. 2010).

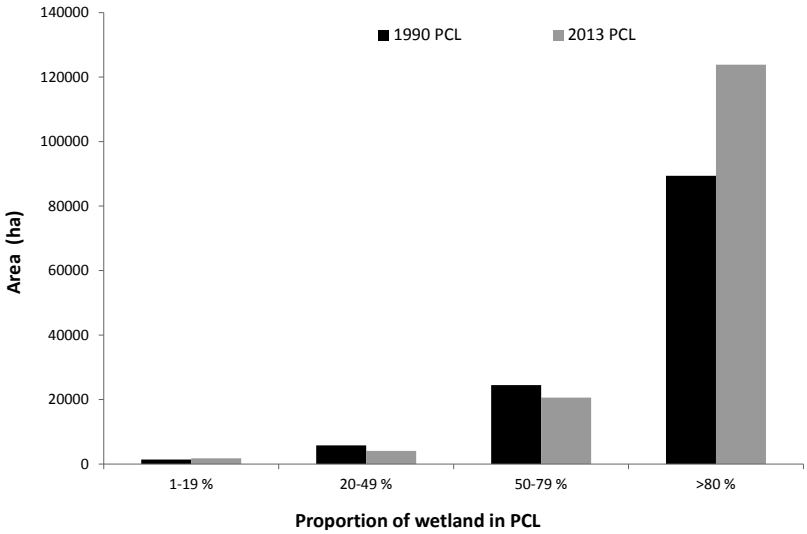

Figure 5. Change in wetland protection in New Zealand relative to the proportion of wetland within PCL. PCL is Public Conservation Land administered by DOC.

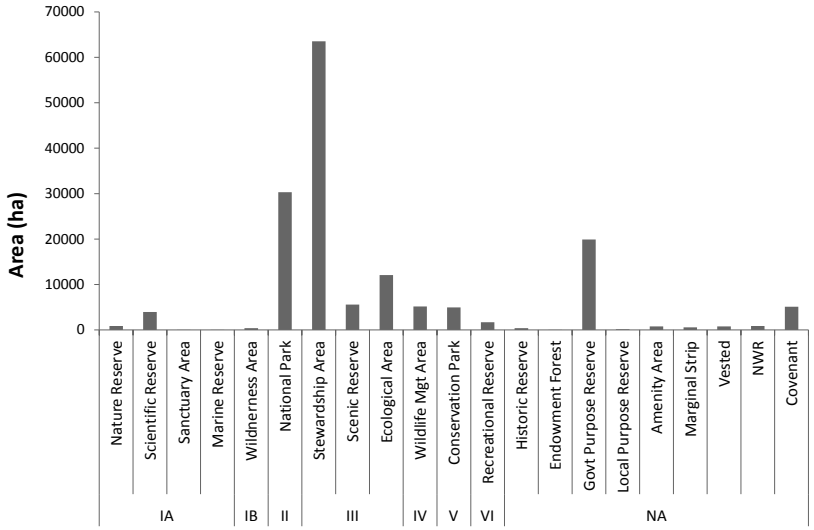

Figure 6. Extent of wetland protected on Public Conservation Land (PCL) in New Zealand in 2013 in relation to the type of conservation area or reserve. Relevant IUCN protected area status indicated (I-VI). NWR refers to Maori owned land under Ngā Whenua Rāhui covenant; Mgt is abbreviation for Management.

Table 2. Wetland protection in DOC-administered PCL across 29 FENZ (Freshwater Ecosystems of New Zealand, Leathwick et al. 2010) biogeographical units. Percentage of current wetlands in protected areas for each biogeographical unit at 2013 and relative to historic wetland extent (in parentheses). Note the protected area calculations do not include regional parks, e.g. Auckland biogeographical unit.

FENZ	Wetland Type						
Biogeographical Unit	Bog	Fen	Pakihi/ Gumland	Inland saline	Marsh	Seepage	Swamp
Northland – northern	51.1 (4.1)	32.8 (0.3)	59.1 (3.0)		83.4 (83.4)		63 (29.6)
Northland – eastern	43.3 (1.3)	66.6 (0.7)	54 (1.6)		17.2 (0.3)	13.3 (na)	35 (1.8)
Northland – western	25.8 (0.5)	0 (0)	67.4 (3.4)		23.3 (0.47)	1.7 (1.7)	53.2 (2.1)
Auckland	2.5 (0.1)	0 (0)	0 (0)		1.7 (0.2)	1.5 (1.5)	9.6 (0.19)
Coromandel		0.2 (0.1)			44.8 (23.3)	61.4 (25.8)	45.5 (0.9)
Waikato	81.3 (15.4)	2.2 (0.1)	0 (0)		11.1 (0.6)		48.5 (3.4)
Bay of Plenty	0 (0)	0 (0)	0 (0)		8.3 (3.9)	2.4 (na)	29.3 (2.1)
Mokau	0.6 (0.1)	0.5 (0.1)			22.3 (1.1)	0 (0)	52.3 (2.6)
East Cape	0 (0)	5.3 (0.1)	96.3 (39.5)		5.5 (0.1)	1.4 (1.4)	10.1 (0.2)
Taranaki	100 (100)	69 (5.5)			72.8 (21.1)	16.7 (16.7)	1.8 (0.1)
Wanganui-Rangitikei		38.5 (17.3)			29.5 (2.7)	1.7 (1.7)	20.3 (0.4)
Hawke's Bay		0 (0)			6.2 (0.2)	11.2 (11.2)	0 (0)
Manawatu-Wairarapa	0 (0)	35.2 (0.4)			12.4 (0.2)	23.5 (23.5)	43.2 (0.4)
Palliser-Kidnappers					1.2 (0.1)	0 (0)	0 (0)
Wellington		0 (0)			21.7 (18.7)		14.3 (2.3)
Northwest Nelson	29.7 (1.2)	86.5 (86.5)	82.9 (29.0)		76.3 (8.4)	80.8 (80.8)	49.7 (7.5)
Motuekā-Nelson		89.9 (na)			30.3 (7.9)	34.2 (17.8)	36.6 (0.7)
Marlborough		93.3 (4.7)			44.9 (17.1)	31.6 (28.8)	40.9 (3.3)
Grey-Buller	8.7 (0.1)	90.3 (90.3)	88.3 (18.5)		47.4 (6.2)	83.7 (83.7)	60.0 (10.8)
Canterbury		16.1 (7.9)			26.9 (8.3)	14.0 (14.0)	20.1 (0.8)
Banks Peninsula					21.1 (10.8)	0 (0)	92.3 (2.8)
Westland	97.4 (36.0)	99.6 (53.8)	84.4 (16.9)		72.7 (4.4)	97.3 (97.3)	86.8 (26.9)
Waitaki		19.5 (9.9)			21.7 (10.9)	14.7 (3.2)	10.3 (2.8)
Clutha	35.9 (16.9)	11.9 (4.5)		0 (0)	9.8 (1.6)	39.8 (13.5)	13.6 (1.6)
Taieri	3.3 (0.7)	34.3 (23.0)		11.7 (4.6)	9.3 (0.9)	20.2 (8.9)	20.1 (4.8)
Otago Peninsula					78.4 (na)	81.7 (60.5)	12.7 (3.9)
Fiordland		99.6 (5.0)	100 (0.1)			100 (100)	100 (100)
Southland	73 (26.3)	44.7 (4.5)	59.8 (10.2)		38.6 (1.2)	20.7 (13.9)	60.2 (2.4)
Stewart Island	87.5 (87.5)	100 (100)					100 (100)
NEW ZEALAND	78.7 (20.6)	46.7 (9.0)	83.5 (14.0)	8.8 (1.6)	31.1 (2.6)	29.2 (19.9)	50.8 (3.0)

in conservation land because of expansive National Parks, such as Rakiura National Park and Fiordland National Park. Conversely, units such as East Cape, Hawke's Bay and the Bay of Plenty had reservation levels less than 3% for a number of different wetland types (Table 2). These biogeographical units also have fewer large wetland sites.

Target 11 of the CBD is that by 2020, at least 17% of 'inland water areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures' (CBD 2010). If applying a target of at least 17% of the current extent for each wetland type in a protected area, for each biogeographical unit, the majority of units where the threshold was not achieved occurred in the North Island (Fig. 7a). In the South Island, the east coast units generally failed to meet the 17% target. However, if applying the 17% target relative to the historic extent of each wetland type in a protected area then the majority of New Zealand failed to meet this objective (Fig. 7b).

Discussion

Progress in wetland reservation since 1990

Reporting on long-term changes in the status of New Zealand's indigenous ecosystems is fundamental to determining whether investment in conservation has achieved the objectives set out in national (e.g. DOC 2013) and regional conservation strategies. This assessment of changes in the levels of wetland reservation between 1990 and 2013 represents the first analysis of its type in New Zealand. Improvements in wetland reservation were observed over 20 years, which coincides with a period of increased awareness of the values of natural landscapes and environmental protection.

Over the past two decades there have been large-scale additions to public conservation land that included 29 000 ha of wetland ecosystems. The majority of change occurred in the South Island as a result of tenure review and land purchase in areas such as the Ashburton Basin and St James Station. Since 1990 there has been increased reservation of under-represented wetland types (e.g. swamps, fens), large wetlands (>100 ha) and wetlands that occur above 100 m a.s.l. Wetlands that were added to conservation land also generally had high ecological integrity (>0.75 EI). In 2013 there were a number of biogeographical units that had high levels of wetland reservation relative to the current extent of wetlands in those regions (Table 2). Development of private protected areas, although not directly assessed, has also contributed to wetland reservation. For example, there are now over 5000 ha of wetlands managed through covenants.

Based on current wetland extent, over 60% of inland palustrine wetlands in New Zealand are within protected areas, compared with 48% in 1990. However, many international

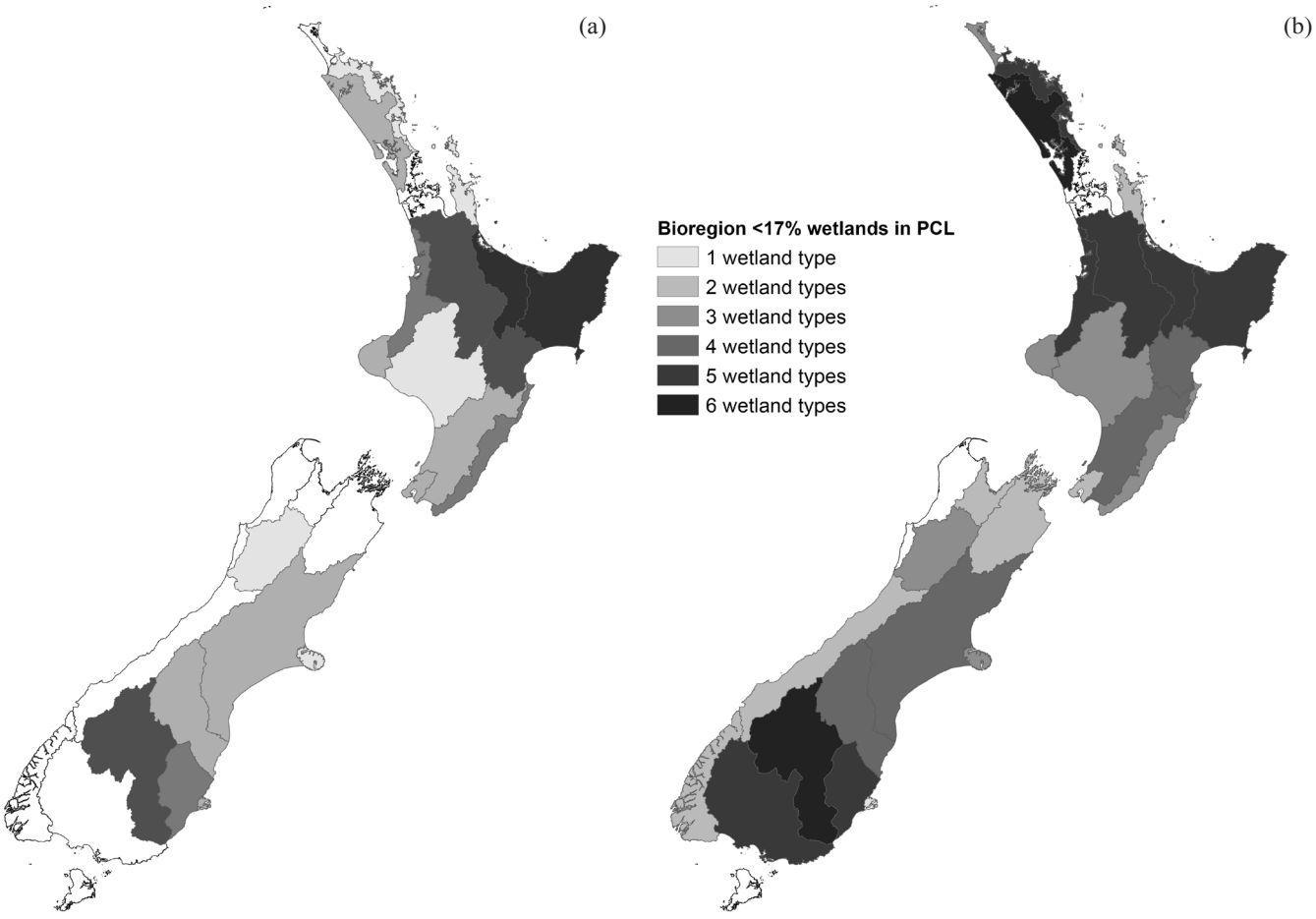

Figure 7. Biogeographical units in New Zealand with <17% of at least one wetland type protected within PCL in 2013: a) relative to current wetland extent, and b) relative to historic wetland extent. PCL is Public Conservation Land administered by DOC.

conventions base protection targets on the land mass of the biogeographical region in terms of the natural extent of ecosystems (e.g. National Reserve System Task Group 2010). Relative to the historic extent of wetlands in New Zealand, only 6% of wetlands are within protected areas, a figure below the 17% target set by the Convention on Biological Diversity (CBD) and government agencies in other countries. The National Reserve System (NRS) programme in Australia, for example, has committed to the CBD goal and currently 54 of the 89 bioregions in Australia have achieved at least 10% protection (National Reserve System Task Group 2010). Although, legal protection of wetlands in some regions of Australia remains less than 5% (Kingsford et al. 2004), which is similar to New Zealand.

Biases in the coverage of protected areas

This analysis aimed to identify biases in the reserve system to help direct future priorities. Between 1990 and 2013, additions to the protected area network often included under-represented wetlands, but there remained differences in levels of reservation between wetland types and biogeographical regions. The wetland types with low levels of reservation were swamps, marshes, and fens, compared with both their current and historic extent. Lowland ecosystems are a priority for reservation, given the significant loss of wetlands due to drainage and land conversion in the past. In regions such as Hawke's Bay, Manawatu, and Canterbury, lowland wetlands cover less than 5% of their original extent. However, since 1990 there has been limited progress in wetland reservation for DOC-administered land in the 50–100 m altitudinal range, and only moderate progress in the 0–50 m range. McGlone (2009) noted that many of the lowland swamps and fens have only been in their current state, in terms of ecological processes and biological composition, for a relatively brief geological period due to anthropogenic influences, and noted that swamps often have a high abundance of exotic species. Ideally, the prioritisation of under-represented wetland types should take into account ecological integrity, their restorability (for highly depleted wetland types), and the value of a site for preserving natural and cultural heritage.

While at a national level wetlands may appear to have high levels of legal protection (>60%), substantial biases are apparent at the biogeographical scale for different wetland types. In the Bay of Plenty, for example, five wetland types have less than 10% of their current extent in conservation land administered by DOC. The East Cape and many other areas of the North Island also have low levels of reservation for remaining wetlands (Fig. 7). Some wetland types have no (0%) coverage in DOC-administered land within a number of biogeographical units (Table 2) and consequently should be a priority for preserving natural heritage in those regions. The Natural Heritage Fund (NHF) of New Zealand aims to target under-represented habitats, such as wetland ecosystems (Molloy & McSweeney 2011), and information presented here may assist future NHF assessments.

Many of the wetlands not within protected areas are small (<100 ha). These small wetlands often occur on agricultural land, within gullies and other low depressions adjacent to streams. Increased reservation of small wetlands through private land conservation mechanisms such as covenants, or through improved regional plan rules, provides an opportunity to improve catchment management as these wetlands can perform important ecosystem functions such as limiting downstream transport of sediment and nutrients (Zedler & Kercher 2005). Reviews of biases in wetland protected areas in other countries have also examined landscape connectivity between terrestrial, freshwater and coastal ecosystems (Pringle 2001; Roux et al. 2008; Nel et al. 2009; Herbert et al. 2010). Addressing biases in wetland reservation for New Zealand should also occur within a broader framework of freshwater protected areas.

Standard methodological approaches and data availability

Information on progress in wetland reservation and identification of remaining gaps are critical for investment decisions. National and bioregional statistics highlight the contribution of new reserves to conservation of freshwater biodiversity. Monitoring of wetland reservation also provides the context for restoration initiatives, such as the Arawai Kākāriki wetland restoration programme (Robertson & Suggate 2011) and community-led projects to protect and restore wetlands (e.g. QEII National Trust 2013). A monitoring framework, based on the change (in hectares) of wetland reservation in terms of wetland type, bioregion, size, ecological integrity, altitude, and reserve type, was applied that is suitable for repeated assessments of changes in legal protection of wetlands in New Zealand. Assessments similar to that presented here should be more commonplace and applied to other ecosystem types, such as estuaries and grasslands.

Some regions of the world have comprehensive mapping programmes to assist in reporting on wetland conservation. For example, Dahl (2011) produced a detailed report on changes in wetland extent in the USA for the period 2004–2009. However, lack of adequate spatial data on wetland location, type, and condition is an impediment to conservation assessment in many countries (Davidson & Finlayson 2007). Advances in remote sensing now enable rapid approaches to wetland inventory (Bwangoy et al. 2010; Klemas 2011) but uptake of such technology remains limited. In New Zealand, the FENZ geospatial database provided the means to undertake national reporting on wetland reservation. Standardisation of spatial data on protected areas within NATIS will ensure future changes in protected areas and land tenure are captured. These resources provide the basis to evaluate progress towards establishing a comprehensive, adequate, and representative (CAR) network of wetland protected areas.

The selection of the ecosystem classification, biogeographical regionalisation scheme and other attributes applied in analysis will impact on the reported reservation levels and subsequent conservation priorities. The classification applied here identified eight wetland types and a biogeographical regionalisation system of 29 units. As expected, the finer the level of resolution applied, the more accurate the identification of biases in wetland reservation (e.g. Table 2). For example, at a national scale fens are an under-protected wetland type, but in some biogeographical units, fens had relatively good coverage within protected areas (e.g. Stewart Island). Variation of biological diversity within wetland types can also be significant (e.g. Suren et al. 2008) and therefore, an even finer level of wetland classification may be needed to evaluate the priorities for legal protection. For example, while bogs appear to be relatively well represented in protected areas, finer classification of ombrotrophic wetlands may uncover unique forms with low reservation levels. There is a limit, however, to the degree to which finer scale classifications can be applied, as the classes selected need to be amenable to automated mapping procedures and suitable for national assessments.

The Annual Report of the Department of Conservation (DOC 2013) sets a framework for reporting on progress in conserving natural heritage. Information on the extent and condition of indigenous ecosystems is at the forefront of the framework. This will require maintaining national databases on wetland ecosystems for future reporting. FENZ will require updates of wetland mapping every 5–10 years to ensure that spatial information is reliable. Changes in the extent of wetlands are captured to some degree by revisions to the Land Cover Database (LCDB); however, there are some questions about the accuracy of LCBD to delineate some types of wetlands (Davis et al. 2013). Resources to maintain and regularly update and refine the FENZ database are therefore essential for future reporting on wetland reservation.

Adequate protection of wetlands

Determining what is meant by 'adequate' protection for ecosystems within a reserve network depends on the definition applied. Linke et al. (2011) noted adequacy deals with how a conservation area network should be designed to ensure persistence of all the biodiversity attributes, but commented it is the least well understood of the CAR principles.

For this study, three aspects of adequacy were assessed: reserve type, wetland condition, and the proportion of individual wetlands within reserves. Almost half of all wetlands in land administered by DOC are within Stewardship Land. Although for the purposes of this study Stewardship Land was included within the realm of a protected area, it offers low protection status relative to other reserve types such as Scientific Reserve or Ecological Area. A recent report by the Parliamentary Commissioner for the Environment also identified many areas of conservation significance currently classified as Stewardship Land (PCE 2013). Fitzsimons and Robertson (2005) observed that wetlands in Victoria, Australia, are often protected in reserve types that had lower legal protection status in the IUCN protected area framework (IUCN 1994).

Another measure of the adequacy of the protected area network is the condition, or ecological integrity (EI), of the wetlands within reserves. Additions to the protected area network should focus on wetlands in good condition to maximise conservation gains. The majority of wetlands within protected areas in New Zealand had high ecological integrity (>0.75 EI score) and since 1990, the reservation of wetlands focused on more intact sites (Fig. 4). This means new additions to public conservation land will not necessarily have high management costs.

Reserve design, particularly the configuration of the reserve boundary relative to wetland ecosystem boundary, also influences the adequacy of protected areas. Inadequate reserve design is especially relevant for wetlands due to the importance of the hydrological regime on ecological integrity (Mitsch & Gosselink 2007). Changes to wetland hydrology outside the reserve boundary can directly impact on the portion of the wetland that is legally protected. For example, the development of drains to enhance water runoff can alter the hydrological processes of a wetland managed for conservation (Sorrell et al. 2007). In this study, the degree to which wetlands were enclosed within a reserve was assessed. Wetlands with at least 80% of their area within conservation land were most common. There were a number of sites that were only partly reserved (<80%), but since 1990, an improvement in reserve design was observed. Further research is required to assess how the location of reserve boundaries impacts on wetland ecological function and the protection of threatened species.

In some landscapes management of ecological processes outside the reserve boundary may be more important than management within the reserve (Fitzsimons & Robertson 2005; Abell et al. 2007; Kingsford et al. 2011). This includes management of catchment processes, particularly water quality and environmental water allocations for wetlands. Recent freshwater reforms identify water quality limits to maintain the ecological health of river and lake ecosystems, and also recommend development of limits for wetlands (MfE 2013). Since the condition of wetlands within some protected areas is under threat (Robertson & Funnell 2012; Blyth et al. 2013), establishing land drainage, water level and water quality limits for catchment land use is needed to preserve the natural values of wetlands. Myers et al. (2013) called for wetland managers in New Zealand to apply national policies to prevent further loss, and regional and district authorities to implement regulations to maintain and enhance the natural features of wetlands.

Future development of freshwater protected areas

Due to the considerable loss of wetlands in New Zealand since European arrival and the associated decline of biological diversity, a systematic approach to wetland protection, management and restoration is required. This presents a challenge, as the extent of current wetlands within New Zealand, irrespective of tenure, represents only 10% of the historical extent. If a target of 17% of ecosystems protected is applied, following Target 11 of the CBD, then all remaining wetlands in New Zealand would rate as high priority for legal protection.

Future development of wetland protected areas is likely to be limited by available funding, which indicates the need for a national strategy to address conservation priorities. There are also only a limited number of large wetland ecosystems that remain under private ownership. A shift in focus to protect smaller wetlands may achieve protection targets (e.g. under-represented wetland types in specific biogeographic regions) most cost-effectively. These wetlands are often situated in low-lying areas of agricultural or forestry land and can be sites of high value for the conservation of threatened species (Richardson et al. 2015). Smaller size wetlands are likely to be less expensive to fence or purchase, although they may be exposed to more pressures and require greater management effort. Wetlands that are the priority for reservation are increasingly likely to be within landscapes that present few opportunities for changes in land tenure and are likely to be more suitable for private land conservation initiatives. Changes in land management arrangements through Treaty processes (e.g. Waikato River) also offer an opportunity to progress wetland conservation.

A scientific basis is proposed to progress the freshwater protected area network in New Zealand that takes into account five key principles:

i) Gap filling – focus on under-represented freshwater ecosystems, including wetlands, through application of a biogeographical framework;
ii) Adequate reserve design – aquatic ecosystem connectivity and terrestrial-aquatic linkages are considered in reserve design;
iii) Collaboration – opportunities for partnerships between government, iwi, non-government organisations, and other stakeholders are encouraged;
iv) Review of land tenure – assessment of wetlands and other freshwater ecosystems within land of lower protection status (e.g. Stewardship land) occurs;

v) Target-based – national and regional targets are established for public and private-land wetland reservation.

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