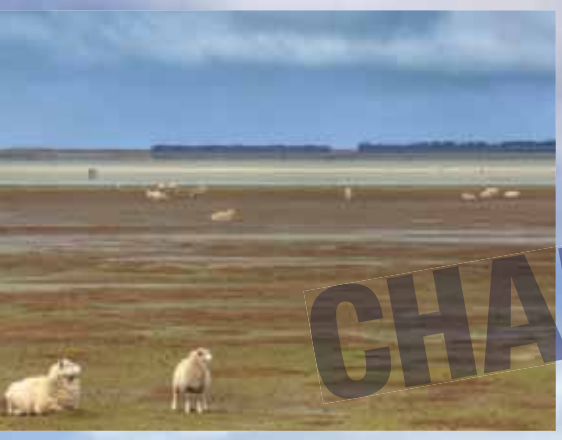
TE WAIHORA/LAKE ELLESMERE
State of the Lake and Future Management

Edited by **KENNETH F.D. HUGHEY** and **KENNETH J.W. TAYLOR**



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Edited by **KENNETH F.D. HUGHEY** and **KENNETH J.W. TAYLOR**
Lincoln University Environment Canterbury

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Waihora Ellesmere Trust
PO Box 116,
Lincoln,
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Phone:+64 (03) 353 9712
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SHUTTERSTOCK

01 INTRODUCTION

KENNETH F.D. HUGHEY Lincoln University **KENNETH J.W. TAYLOR** Environment Canterbury

Te Waihora/Lake Ellesmere[1] is a large coastal lake, intermittently open to the sea. It is highly regarded for its conservation and related values, some of which are of international significance. Its function as a sink for nutrients from its large predominantly agriculturally based catchment, currently undergoing accelerated intensification, is also recognised, at least implicitly. It is the resulting conflict from these value sets which is mainly responsible for the ongoing debate about the future of the lake, a debate long fuelled by rhetoric and informed by a body of science which highlights the lake's complexity as a biophysical system, but has many gaps. It is a debate that now has substantial statutory implications, arising from factors which include:

- the requirements of conservation, and indigenous needs and entitlements which are growing in prominence and statutory (including property rights based) legitimacy;
- public interest in legal processes associated with further major intensification of agriculture planned for the catchment;
- a recent Environment Court decision in which serious questions about the overall biological health of the lake were raised; and
- the consequences arising from the need for Environment Canterbury to obtain resource consents for the lake operating regime.

In addition, in recent times the Waihora Ellesmere Trust (WET), a community based group advocating for improved management of the lake, has been established. It is within these diverse contexts that this State of Te Waihora/Lake Ellesmere report has been prepared—it results from the 2007 Waihora/Ellesmere Living Lake Symposium, held from 31 October-3 November 2007 at Lincoln University, Canterbury. The symposium was initiated and organised by the WET (see www.wet.org.nz).

The Living Lake Symposium had several key objectives:

- To determine the overall state of the lake, by first defining the key value sets, and indicators that could be reported against;
- To suggest future management actions that would address key issues affecting the defined values;
- To provide a forum within which lay individuals, scientists and managers could openly debate issues; and
- To provide a launching pad for integrated and focused future management of the lake and its environs.

The programme incorporated three keynote speakers: Dr Larry Hildebrand from Environment Canada, Dr Hamish Rennie from Lincoln University, and Dr Bryan Jenkins from Environment Canterbury—their addresses made a major contribution to the symposium although none are included in this report, because it is focused primarily on the science and the management options associated with the lake.

The format of this report is designed to be readily updateable. Ten of the principal presentations in the main sessions of day two of the symposium are included in this report—two Power Point presentations (both regarding water quantity and related issues) are provided as appendices to improve completeness. Over time, however, topic areas not available as full papers for this report, e.g., surface water quantity, will be written up and included in detail. Similarly, the papers herein will themselves be updated as new and significant data become available. Each subject area will be reconsidered within the same structure and context as has been provided here. One paper, 'Te Waihora/Lake Ellesmere: An integrated view of the current state and possible futures', was presented on the final formal day of the symposium and it is included as the concluding chapter of this report.

Finally, the Waihora Ellesmere Trust and many of the others attending the symposium saw merit in reconvening the event around two years after the initial symposium, to report on progress with management, indicator monitoring, scientific understanding and other matters. We support that suggestion.

In terms of report format it is important that readers note the following:

- All authors were provided with 'briefs of work' and were requested to contextualise their work with that contained within the Taylor (1996) report on the lake—this was more easily achievable for some than others. Given some lack of consistency between symposium presentations and final papers it is our intention that a revised set of agreed indicators will be considered and included in any follow-up symposium and associated reports—some considerable work will be required in some areas to achieve this objective;
- Only the wildlife and integration papers included in this report have been formally peer reviewed; and
- All other papers have been standardised and style edited-some changes have been suggested by the report editors and made by the paper authors.

Finally, an attempt has been made to present the papers in a logical sequence of 11 chapters: chapter 1 sets the scene; chapters 2-7 cover the biophysical science dimensions (groundwater, water quality, native vegetation, native fisheries, trout, wildlife); chapters 8-10 deal with the human dimensions (Ngāi Tahu, recreation, economics); and chapter 11 deals with integration of the findings from the previous chapters and setting the scene for future management.

[1] Note that the Geographic Place Names Board has defined the name as Lake Ellesmere (Te Waihora). It is not our intention to debate the nomenclature, but rather to put the focus where we consider it should lie, within the lake's initial historical and cultural context for indigenous Maori.

07

BIRDLIFE of the lake

COLIN HILL

KENNETH F.D HUGHEY Lincoln University **COLIN F.J O'DONNELL** Department of Conservation

Te Waihora/Lake Ellesmere is a large brackish and low-lying lake in Canterbury. It is widely regarded as a wildlife habitat of national and international importance with the highest recorded bird diversity of any location in New Zealand. Apart from the diverse range of habitats and species characterising the lake there are very large numbers of some species including those of conservation concern such as banded dotterel and Australasian bittern. The lake and its environs are hugely modified with habitat loss still occurring. A range of indicators of change in the state of wildlife of the lake have been identified. Evaluation of changes to these indicators, especially over the last 10-20 years indicates that some indicators are healthy and some likely suffering slow decline. Four principal outcomes and 10 core management actions are proposed in order to safeguard the wildlife features of the lake and its environs. The outcomes are associated with maintaining species diversity, enhancing the populations of key conservation and taonga species, sustainably managing harvest species for both recreational and Ngāi Tahu reasons, and providing an appropriate habitat mix for all of the above. Key management actions related to these outcomes are associated with lake level operating regimes and targeted habitat protection.

7.1 Introduction and aims

Te Waihora/Lake Ellesmere is widely considered one of the most important wetlands in NZ, especially for its wildlife (see O'Donnell 1985, Taylor 1996). In this assessment we consider:

- The context of, and knowledge base for, management of the wildlife of Te Waihora/Lake Ellesmere, including an assessment against relevant material from the Taylor (1996) Natural Resources of Lake Ellesmere (Te Waihora) and its Catchment report (Section 7.2);
- An approach to defining draft wildlife outcomes and proposed indicators of change (Section 7.3);
- Key values, important habitats and some proposed wildlife outcomes reflecting future management goals (Section 7.4);
- Key indicators of the ongoing change, related to the proposed outcomes and reflecting bicultural views, of the state of Te Waihora/Lake Ellesmere wildlife (Section 7.5);
- The changing state of Te Waihora/Lake Ellesmere wildlife (and its proposed indicators), from pre-Maori times to the present (Section 7.6);
- The relationship of indicator change to lake level and other forms of management, i.e., the key drivers of wildlife change (Section 7.7); and given the above;
- Ongoing management requirements, including specific projects, benefits and costs, in priority order (Section 7.8).

Finally, a short discussion precedes a set of conclusions which in turn are followed by overall report recommendations.

7.2 The context of, and knowledge base for, wildlife

Much has been published about the wildlife of Te Waihora/Lake Ellesmere (e.g., Stead 1932, O'Donnell 1985, Taylor 1996, Sagar *et al.* 2004) and there is much related ongoing 'research' (e.g., biannual Ornithological Society of NZ (OSNZ) wader counts since Nov-Dec 1983), Fish and Game North Canterbury, and now Christchurch City Council, surveys). Probably the most integrated publication covering all this work is that of Taylor (1996). That work reported and summarised the following:

- Species presence and habitat needs, including a summary of bird population characteristics, organised by waterfowl, waders, swamp birds and other species. Data in the report are however dated, i.e., it relied on work undertaken and reported on between 1985-87. In summary it was noted that 161 species (as of 1987) have been observed at the lake or in its immediate environs (DoC 1987), with around 80 species being regular inhabitants (O'Donnell 1985).
- Habitats and values, organised around geographical segments of the lake and its environs (including Kaitorete Spit) (see Figure 1).
- The significance of Te Waihora/Lake Ellesmere - that report summarised the recommendation for designating Te Waihora/Lake Ellesmere as a wetland of international importance (IUCN 1981) but noted that further progress would not occur until Crown and Ngāi Tahu Treaty negotiations had been completed. With the establishment of the Joint Management Plan between Ngāi Tahu and DoC it might be envisaged that some progress will shortly occur in this area.

Implications for management, particularly in relation to lake level changes, eutrophication, foreshore erosion, recreation and drainage and foreshore development, were also given. The report summarised the purpose and implications of the current lake operating regime, including the Water Conservation Order (Lake Ellesmere) 1990 provisions.

Apart from the ongoing bird survey work we are aware of only one new study (Sagar *et al.* 2004) that provides additional habitat related management information post Taylor (1996). This work reports primarily on the feasibility of re-establishing the macrophyte beds in the lake but also notes a possible and relatively recent change in the food chain of the lake, notably the shift from an invertebrate fauna where aquatic snails

Photo ***Large flocks of 50-150 of Royal Spoonbills are now a relatively common sight.*** *Photography* ***Colin Hill.***

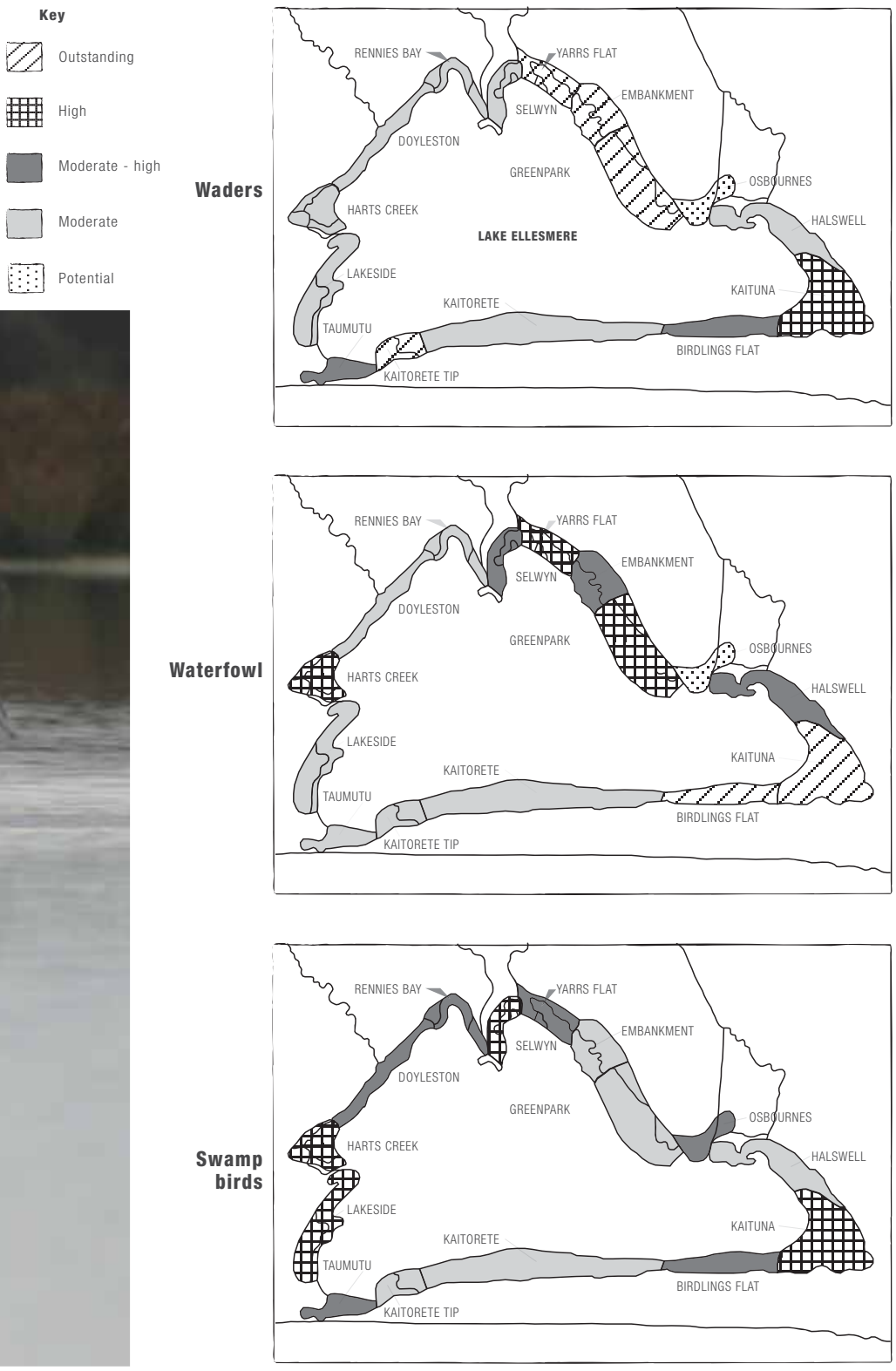

FIGURE 1. Wildlife values[1] and key habitat areas around Te Waihora/Lake Ellesmere. Source (O'Donnell 1985).

[1] During the late 1970s and early 1980s the New Zealand Wildlife Service undertook the first national inventory of habitats of significance to wildlife, termed Sites of Special Wildlife Interest (SSWIs). Habitats were rated as being of "Outstanding", "High", "Moderate-high", "Moderate", or "Potential" value for species protected by the Wildlife Act 1953. Sites were assessed according to 16 criteria. The criteria used were based on criteria used by the International Ramsar Convention for identifying Wetlands of International Importance at the time, for which New Zealand has been a contracting party since 1976. The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an inter-governmental treaty which provides the framework for national action and international co-operation for the conservation and wise use of wetlands and their resources.

were very important to one dominated by chironomids. Little is understood about the dynamic variability in production of chironomids and how this might be affected by changes in lake management, especially around for example, salinity.

Bearing these issues and findings in mind an assessment of the information available, as summarised above, in association with relevant expert knowledge and discussions with the tangata whenua and other expertise should suffice in defining preliminary desired management outcomes for the wildlife of Te Waihora/Lake Ellesmere.

Photo ***Godwits, while present in most years at the lake, visit only in relatively low numbers.*** *Photography* ***Colin Hill.***

7.3 Approach to defining outcomes and indicators of change

Overall, the quality of information about Te Waihora/Lake Ellesmere wildlife is very high (see Section 7.2). Published and unpublished data have been relied upon with no new field work undertaken. Fortunately the Ornithological Society of NZ (OSNZ) and Fish and Game North Canterbury (for game bird species) undertake frequent surveys of the lake's wildlife and these resources are heavily relied on for this report; additionally, since 2006 the Christchurch City Council has begun annual surveys of the lake wildlife. Discussions have occurred with key wildlife scientists who have had long associations with wildlife surveys of the lake (e.g., B. Ross of Fish and Game North Canterbury and P. Sagar of NIWA), with representatives of Ngāi Tahu about key species and changes over time, and with Colin Hill a landowner with long-running interest in wildlife conservation. All of these discussions have also focused on the choice of 'desired outcomes for wildlife' and the subsequent selection of a range of ongoing wildlife-related indicators for future monitoring of change related to key management objectives, and ultimate reporting thereon. The framework for the report is therefore as follows:

SECTIONS AND STEPS		METHODS/PROCESS
Section 7.4-7.6		
Outline the wildlife values of the lake and proposed desirable outcomes	>>	Review literature; gather unpublished data from agencies and experts; discussions
Identify indicators of change	>>	Review literature, discuss with agencies and experts; but also selected against SMART criteria
Using the indicators evaluate the state of wildlife at the lake	>>	Use literature and any available data
Section 7.7		
Identify the key drivers of change to these indicators	>>	Literature review; discussion with experts
Section 7.8		
Suggest interim management actions that reflect measures to achieve the outcomes and which can be reported against using the indicators	>>	Liaise with Ngāi Tahu, DoC and Fish and Game, discuss with experts, consult with other stakeholders

7.4 Wildlife values, key habitats and proposed desired wildlife outcomes

Values and habitats

From the key literature (e.g., O'Donnell 1985, Taylor 1996) it is clear that the key scientific 'values' of the lake's wildlife are:

- A very high level of species diversity (N=110 indigenous bird species that use the lake and its riparian margins for feeding or breeding), represented within a range of guilds[2], including international migratory species. Sagar *et al.* (2004: 38) note that the total number of species recorded at the lake is 167 species - given a total number of extant bird species in New Zealand of 324 recorded in 1996 then at least 50% have been recorded from the lake. This proportion is far more than for any other site in New Zealand;
- Very large numbers of birds (up to 98,000 recorded at one time), especially waterfowl;
- Comparatively large numbers of some species which rely on the lake for particular life stages (e.g., southern crested grebe, bittern, banded dotterel);
- Comparatively large proportions of the numbers of some species using New

[2] A guild is defined as a community of (in this case bird) species with similar habitat requirements (Verner 1984).

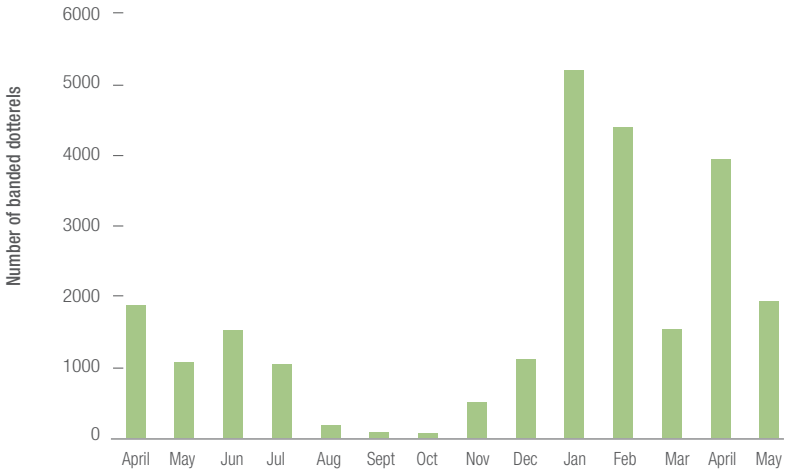

FIGURE 2. An annual cycle of banded dotterel at Te Waihora/Lake Ellesmere: 1986–87.

Zealand wetlands as over-wintering sites during migration (e.g., wrybill, pied stilt).

These values contribute to the lake being considered as nationally important for wildlife (O'Donnell 1985) because:

- A very large number of birds occur there at all times
- There is a very high species diversity across a wide range of guilds
- There are significant proportions of New Zealand populations of around 20 bird species present
- Significant areas of habitat exist for birds with restricted distributions
- Habitats for indigenous species that are migratory in New Zealand exist.

In addition the lake meets multiple criteria under the Ramsar Convention on Wetlands of International Importance. A summary of these and other forms of recognition are given in Te Rūnanga o Ngāi Tahu (2005: 69-71).

Underpinning these values is the diversity of different microhabitat types that provide a wide range of foraging and breeding opportunities (Figure 1). The list of indigenous species found on the lake, their guilds, conservation status and population characteristics, is provided in Appendix A (for information purposes Appendix B lists key exotic species). Figures 2-4 also demonstrate the typical annual cycles of use for some of the key species and groups of interest. While the data are dated (1980s), they

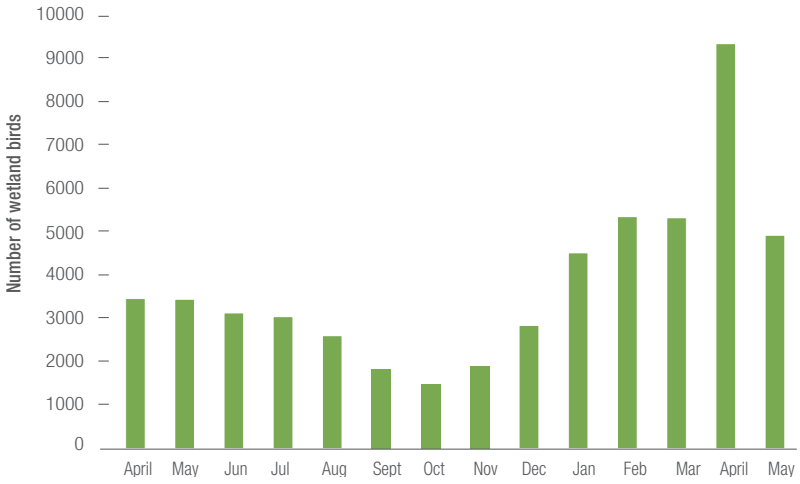

FIGURE 3. The total wetland bird cycle of numbers for Te Waihora/Lake Ellesmere: 1986–87.

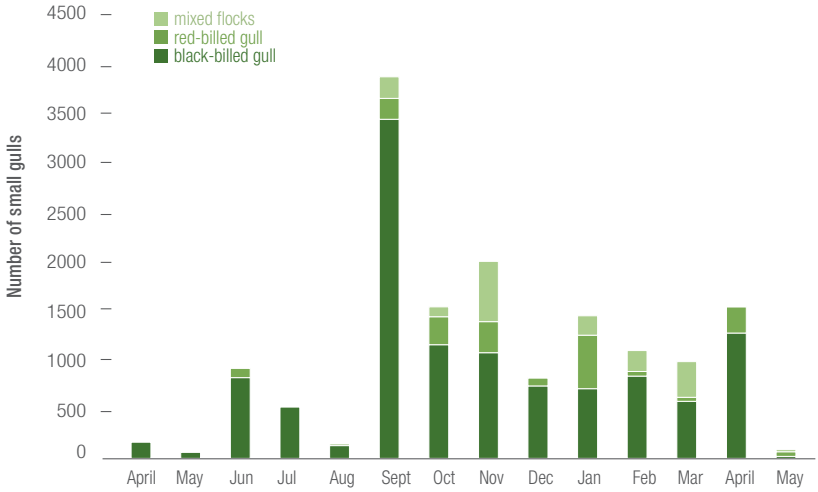

FIGURE 4. Annual cycle of 'small gull species' at Te Waihora/Lake Ellesmere: 1986–87.

Photo ***Sharp-tailed Sandpiper - the lake is a New Zealand stronghold for this international migrant wader.*** *Photography* ***Colin Hill.***

do represent the most detailed monitoring effort ever undertaken for the lake, and are likely still relevant in terms of the cyclic patterns shown.

It is also very clear that the lake has high cultural and recreational values with respect to wildlife and that these have varied hugely over time, e.g., some bird species such as brown teal that were harvested by the Tangata Whenua in the past are now locally extinct, and while game bird shooting is very important so too now is bird watching. In relation to all of the above it is clear that a diverse range of habitats occur around the lake and these are strongly influenced by seasonal lake level management, by riparian management practices, and by other human induced pressures, e.g., mammalian predation.

Proposed desirable wildlife outcomes

Based on the above and discussions with 'key contacts' the following outcomes for wildlife are proposed for the lake:

- Species diversity should be maximised with a target average level of 50 indigenous species from seven guilds recorded per annum: composed of 40 'core' (those expected to occur at the lake on an annual basis) and 10 regular migrant or vagrant species (from guilds 1, 2, 3 or 6);
- Enhance populations of species whose total populations are at defined conservation risk (see Hitchmough *et al.* 2007) and which rely on the lake for critical life stage requirements, e.g., Australasian bittern, banded dotterel, Caspian tern and grey teal;
- Sustainably[3] manage harvestable species, e.g., black swan (including their eggs), Canada goose and mallard duck, while also managing for their interactions with other sensitive ecosystem components and socio-economic considerations (e.g., some species like Canada goose are both resource and pest);
- Provide the optimised range of habitat conditions to provide for all of the above, especially in terms of lake level management, water quality, and riparian management.

7.5 Indicators to measure the changing state of wildlife against the proposed desired outcomes

Much has been written about how to choose indicators of environmental change and in New Zealand there was a process led by Ministry for the Environment (MfE), the Environmental Performance Indicator programme, which attempted to define a core set of indicators for New Zealand - that process has had limited success. More recently, Hamill (2006) has reported a snapshot of lake water quality in New Zealand. Notably, while ecological condition trends were reported for key North Island lakes (e.g. Taupo), no similar information was reportable for Te Waihora/Lake Ellesmere. In addition, the Department of Conservation (DOC) has reviewed the need for indicators of 'ecological integrity' (Lee *et al.* 2005). DOC has developed a draft list of indicators that it is now beginning to assess in terms of their usefulness in the field.

There is no planning document that brings an integrated view of the overall state of a lake in terms of a broad range of interests. With respect to Te Waihora/Lake Ellesmere only Taylor (1996) presents an integrated report on the lake, albeit without the necessary outcome targets against

[3] Including consideration of the potentially detrimental effects of some species if present in very large numbers, i.e., black swan and Canada goose.

which reporting should proceed. Given the above and the proposed outcomes for wildlife (section 3) it is now necessary to formulate indicators to help bridge this gap in knowledge about the lake. The following two sections identify indicator selection criteria and present a proposed set of indicators.

Key principles in indicator selection

Te Waihora/Lake Ellesmere is a complex system. In these sorts of systems linear causes and effects are atypical (see Hughey *et al.* 2009). Nevertheless managers and others require indicators that show changes to the state of the wildlife (and other values of importance).

Global Environment Forum projects and programmes, and many others as well, typically incorporate indicators chosen against SMART criteria[4]:

- **Specific:** Related to achieving a specific objective/outcome
- **Measurable:** ALL parties agree on the indicator, what it covers and there are practical ways of measuring the indicator and reporting the results
- **Achievable and Attributable:** There is a known cause and effect link so that if the indicator changes to an undesired level then an intervention can be undertaken
- **Relevant and Realistic:** ALL stakeholders must buy into the indicators
- **Time-bound,** timely, trackable and targeted.

An additional criterion, based on the integrated nature of this work, can be proposed:

- **Already in use for** related purposes, e.g., Fish and Game annually monitors Canada goose numbers and these same data can be used for a sustainable harvest indicator.

We now use these criteria as a basis for developing wildlife indicators for the lake.

The proposed indicators

Based on the SMART(A) criteria and the proposed outcomes the indicators suggested or appropriate for wild life of Te Waihora/Lake Ellesmere are shown in Table 1 and expanded on in Table 2.

7.6 The current state of wildlife of Te Waihora/Lake Ellesmere

The following outlines the state of the lake's wildlife and habitat using the indicators suggested above, and where possible an attempt is made to report trends against the following timeline:

- pre Maori (<1000AD)
- Maori (1000AD-1820)
- early European development of the lake and its environs (1820-1877)

TABLE 1. **Outcomes and indicators for wildlife.**

Proposed outcome	Suggested indicator (see also Table 2)	How measured
Species diversity should be maximised with a target average level of 50 indigenous species from 7 guilds recorded per annum. The 50 is further subdivided into: 40 'core' (those expected to occur at the lake on an annual basis) and 10 regular migrant or vagrant species (from guilds 1,2,3 or 6) – see Appendix A for the 'core' 40 list.	Maintenance or improvement of the representative range of indigenous species and guilds recorded at the lake	Number of guilds and number of indigenous species recorded annually
		Diversity of foraging guilds/yr
		Diversity of migrant waders/yr
		Percentage of species that are long-distance migrants
		Number of 40 'core' species recorded annually
Enhance the populations of **conservation and taonga** species whose total populations are at some defined conservation risk (see Hitchmough *et al.* 2007) and which rely on the lake for critical life stage requirements, e.g., Australasian bittern (matuku), banded dotterel, Caspian tern (tara) and grey teal (tete);	Trend in numbers of breeding pairs of Australasian bitterns	Frequency of occurrence of acutely and chronically threatened species/yr
	Trend in numbers of post-breeding banded dotterels	Annual index counts of bittern in breeding season
	Trend in numbers of breeding pairs of Caspian terns	February and June census of dotterels annually
	Trend in number of grey teal over-wintering	Annual count of Caspian terns in breeding season
		Annual census of grey teal in April
Sustainably manage[5] harvestable species, e.g., black swan (and their eggs), Canada goose and mallard duck;	Trend in black swan numbers	Annual census in June
	Trend in Canada goose numbers	
Provide the **optimised range of habitat conditions** to provide for all of the above, especially in terms of lake level management, water quality, and riparian management.	Trend in areas of habitat areas seen as critical to meet the needs of 1, 2 and 3 above	Critical habitats identified and mapped using remote sensing techniques as a baseline
	Increase in areas of priority habitat through restoration efforts	Remapping of critical habitats occurs at 5-yr intervals
	Maintenance of populations of species representative of each foraging guild present on the lake	Annual census of little shag (October breeding census), NZ shoveler, NZ scaup (April), pied stilt (February and June), banded dotterel, black swan (June), black-billed gull (June) and bittern (July)

[4] See: http://gefweb.org/MonitoringandEvaluation/MEPoliciesProcedures/MEPIndicators/mepindicators.html accessed 8 Feb 2007

[5] Including consideration of the potentially detrimental effects of some species if present in very large numbers, i.e., black swan and Canada goose.

TABLE 2. **Bird populations of Te Waihora/Lake Ellesmere for seven guilds and key species therein to be used as indicators (modified and updated from Taylor (1996)).**

Guild	Key Species common name	Scientific name	Maori name	Justification	Relationship to other resources/ indicators
Open water divers	Little shag	*Phalacroxorax melanoleucos*	Kawaupaka	Representative of guild. Most numerous cormorant and local breeding species. Needs healthy small fish and crustacean populations for foraging. Requires fresh waters for feeding	Relies on fish for feeding
	NZ Scaup	*Aythya novaeseelandiae*	Papango		Diving feeder
Deep water waders	Pied stilt	*Himantopus leucocephalus*	Poaka	Representative of guild. Most numerous wader; needs extensive and healthy saltmarshes with variable water levels Taonga	Invertebrate feeder
	White heron	*Egretta alba*	Kotuku		Relies on fish for feeding
Shallow water waders	Banded dotterel	*Charadrius bicinctus bicinctus*	Tuturiwhatu	Representative of guild. Needs extensive and healthy saltmarshes that are frequently exposed and inundated	Invertebrate feeder
Dabbling waterfowl	Black swan	*Cygnus atratus*	Wani	Representative of guild. Cultural and recreational importance	Submerged microphyte feeder; recreation
	Canada goose	*Branta Canadensis*		Recreational importance	Recreation, farming
	NZ shoveler	*Anas rhynchotis*	Kuruwhengi Pateke	Representative of guild. Most important habitat in NZ. Requires brackish open waters for feeding. Recreational importance	Filter feeder
Aerial hunting gulls and terns	Black-billed gull	*Larus bulleri*	Tarapunga	Representative of guild. Endangered species.	Invertebrate feeder
	Caspian tern	*Sterna caspia*	Tarā nui	Threatened species breeding at lake	Fish feeder
Swamp specialists	Australasian bittern	*Botaurus stellaris poiciloptilus*	Matuku	Threatened species – one of largest populations on eastern SI. Representative of guild. Needs healthy small fish for foraging	Positive correlation with eel abundance (see Self 2005)

- European-driven lake opening regime (1877-1947)
- present day formal regime including the Wahine storm event, a major storm event that occurred into 1968 and was considered to have severely damaged the lake's weed beds.

Naturally, most of the evidence of trends in condition for the period prior to even as recently as the 1980s will be qualitative, to an extent anecdotal and in places highly speculative, but where possible based on known habitat condition and its relation to species presence, and to habitats and their use by wildlife, elsewhere. We know that pre Maori the lake was young and its associated wetlands were very large (2-3 times its current area). We can also surmise that wildlife was prolific, and likely highly diverse (see Holdaway *et al.* 2001). This is likely because habitats would have been dominated by largely open water and swamp edges, favouring the following guilds:

- Open water divers
- Deep water waders
- Dabbling waterfowl, including black swan
- Aerial hunting gulls and terns
- Swamp specialists
- Riparian wetland species.

It is possible that shallow water waders (high level of current species diversity) were few in number and diversity given likely lake conditions at the time (i.e., lack of extensive mud flat areas). On the other hand some species that became extinct in Maori (moa) and European (brown teal and fernbird) times would have been present in large numbers, therefore representing high levels of diversity.

Maori (1000AD-1820)

Maori were the first to undertake any management of lake openings, but at much higher levels than in 'modern' European times. As a consequence it is likely some of the geographical patterns of the lake changed substantially and led for example to formation of areas like the Greenpark Sands. Some species around the lake became extinct during this period (moa and black swan, plus other waterfowl?) but overall abundance and species diversity would

Contribution to trial national level indicators (see Lee *et al.* 2005)	Origin and breeding status at the lake	Typical numbers at one time (peak season)		Maximum percentage of national population using the lake per year (Appendix A)	
		1985-88	2006-07	1985-88	2007
5.1.2 Demography of widespread animal species 5.1.4 Representation of animal guilds	Native; Breeding	100-500	18	<1	<1
5.1.2 Demography of widespread animal species	Native; Breeding	10000	2937	33%	?
5.1.4 Representation of animal guilds;	Native	1-5	1-5	20%	15%
4.3.2 Security of chronically threatened taxa under active management;	Native; Breeding	1000+3000	1000-2000	10%	4%
5.1.2 Demography of widespread animal species	Native; Breeding	6000-13000	up to 10651	25%	?
8.1.3 Impacts on ecological integrity of land used for recreation	IIntroduced				
5.1.2 Demography of widespread animal species	Endemic; Breeding	500-15000	up to 3405	10%	2%
4.2.3 Security of acutely threatened taxa under active management	Endemic	500-3000	up to 1592	10%	3%
4.2.4 Demographic response to management for selected taxa	Native; Breeding	10-40	up to 63	2%	2%
4.2.3 Security of acutely threatened taxa under active management	Native; Breeding	20	n.c.	3-5%	unknown

have been very high, perhaps even higher than in pre Maori times, i.e., it might be postulated that the increase in habitat diversity with occasional lake openings would have increased species diversity at a rate greater than the number of local extinctions. Seven guilds would have been represented, all in high diversity and abundance. It is possible, however, that shallow water waders may have had only occasional use given the lake was opened very infrequently, i.e., it seems maybe on average around one opening every two-three years.

Early European development of the lake and its environs (1820-1877)

There are records that "the Maoris used to let the lake out every two or three years and since the arrival of the Canterbury Colonists they are known to have let it out in the years 1852, 1854, 1861, 1863, 1865 and 1867. In 1868 it was let out by Chapman and since then it has been let out every year by white man. The Maori interest in lake heights was due to lake water threatening the Taumutu Pa" (A report to the Canterbury provincial Government on the drainage of Lake Ellesmere by Mr W.B. Bray, April 1875) (Harris 1947, cited in Reid and Holmes 1996: 51). During this time period swamplands were beginning to be drained, introduced mammalian predation began, and recreational hunting would have pressured some bird species-in combination these activities would have threatened some species, e.g., brown teal. Overall then abundance and diversity would still have been high, indeed likely higher in terms of diversity of shallow water waders as annual conditions might have been more suitable for this guild.

European-driven lake opening regime (1877-1947)

Glennie and Taylor (1996) note that Selwyn County Council took the first steps in controlling lake levels in 1877 by letting tenders for the opening of the lake. While initial openings were based around ratepayer 'agitation' (Bowden *et al.* 1983; cited in Glennie and Taylor 1996: 10) they latterly developed into a pattern of summer 1.05 m and winter 1.13 m openings. Wildlife were abundant around the lake at this time as is evidenced

Photo ***Black swan and cygnets is a very common native species of waterfowl.*** *Photography* ***Colin Hill.***

by recreational hunters and Maori taking a wide range of species, including both deep and shallow water wading birds. Wetlands were greatly drained over this period and several species became locally extinct, i.e., fernbird and brown teal. Others, including bittern, were likely hugely decreased in numbers. Overall though, abundance was high and diversity high.

Present day formal regime including the Wahine storm event

One single event, the 1968 Wahine storm, characterises the most significant changes to have occurred to the lake and its wildlife over this period (see Gerbeaux 1993). The storm destroyed the lake's weedbeds (although there is evidence they had been in declne for some time) and they have never recovered. As a result some aspects of water quality have changed, black swan numbers have declined, etc. Other habitat changes have occurred as a result of a more formal lake level management regime and the National Water Conservation Order-it is unknown how much either or both have influenced total species diversity, although the existence of a variable lake level management regime seems likely to enhance diversity.

The other major change in this period has been the growing interest in bird watching as a recreational activity which in Canterbury is heavily focused on the lake. One result of this interest has been the ever increasing number of 'new' species recorded on the lake, thus increasing recorded total diversity of the lake and its environs.

Specific changes in state related to the indicators in this period are:

- Since later Maori and certainly early European occupation an ongoing total increase in the **diversity** of species recorded at the lake with an underlying level of 'core' diversity that declined and now appears to be remaining static.

  Evidence:
  Based on reports over time the overall species list for the lake is increasing and the annual number of indigenous species presence is remaining static.

  Prognosis for this indicator:
  healthy

- Slow declines in some **conservation species which** are likely to mirror national level declines, e.g., Bittern and Caspian tern.

  Evidence:
  All New Zealand tern species in New Zealand are in decline. The extent to which Te Waihora/Lake Ellesmere is contributing to, or reflecting this decline is unknown. It is also likely that conditions are worsening for bittern, and numbers may be in decline, but there is insufficient monitoring to determine.

  Prognosis for this indicator:
  Static to unhealthy

- In terms of **sustainable harvest species** there was a rapid decline in black swan in the 1960s and 1970s and a fluctuating above target number of Canada geese until recent times (Figures 5 and 6). The lake should be supporting more swans, and geese should be under the target level.

  Evidence:
  There are considerable data for swans and geese. Estimated swan numbers around the time of the Wahine storm are 70000, now around 4000.

  Prognosis for this indicator:
  unhealthy

- **Habitat availability** and quality varies greatly and is poorly managed, e.g., willow growth in Harts Creek might be negatively influencing bittern numbers, long periods of low lake levels (summer of 05-06) disastrous for many species as essential riparian habitats become dessicated. There is anecdotal evidence that these trends may be worsening.

  Evidence:
  Although monitoring of, for example, bitterns is not occurring we know they require large areas of habitat, but that the area of suitable habitat is declining (Grove and Pompei 2008). Records of lake level opening periods show the

extended low lake levels in the 05-06 opening, which were likely to have adverse impacts of swampbird habitat.

Prognosis for this indicator:
Static to unhealthy

A summary of the present day trends is given in Table 3. Only one indicator is healthy, i.e., diversity - this indicator is probably remaining this way because habitat diversity is being maintained (albeit with some declines in quality) and the indicator is not dependent on population size criteria. The status of some conservation and taonga species is clearly likely in decline as habitat conditions deteriorate, e.g., willow invasion is likely reducing habitat for bittern at Harts Creek, while declines of other genera, e.g., terns, is a nation-wide phenomenon. Sustainable harvest species present a 'mixed bag'. From 2000 to 2005 Canada geese numbers were maintained below target levels with only 2006 in recent years being negative. Conversely, black swan numbers are well below likely desirable levels, probably as a result of the loss of the weed beds before, during and after the 1968 Wahine storm. As noted already there is deterioration of habitat occurring in Harts Creek and other areas as a result of willow invasion. Poorly controlled grazing, inappropriate lake level management and other human-induced influences are contributing to an ongoing net decline in habitat condition. Overall then while wildlife values are clearly high there is cause for concern with several key indicators in decline.

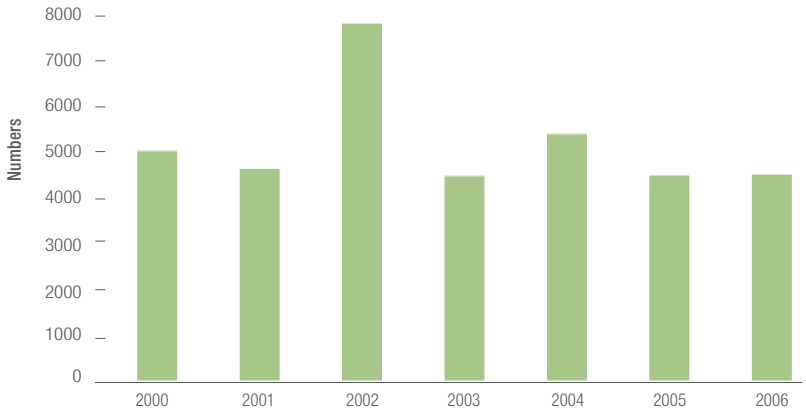

FIGURE 5. Black swan trend counts for Te Waihora/Lake Ellesmere (June aerial surveys) (Source: B. Ross, Fish and Game, 2007, draft report).

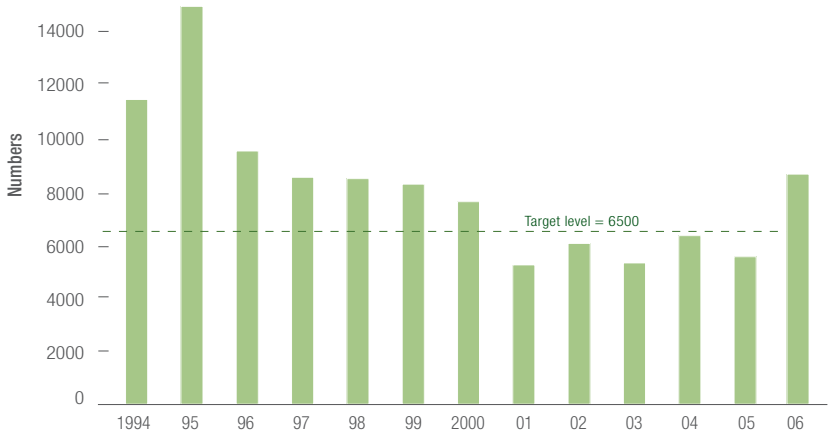

FIGURE 6. Canada goose trend counts for Te Waihora/Lake Ellesmere (June aerial surveys)(Adapted from Ross, 2007, draft report). Note the target level represents the maximum number for the lake under the Canada goose management plan (see Fish and Game 2000).

TABLE 3. **Summary of wildlife state and indicator trends for Te Waihora/Lake Ellesmere.**

Indicator	State	Trend
Diversity	Healthy	Stable
Conservation and taonga species status	Static to unhealthy	Declining
Sustainable harvest species	Unhealthy	Stable
Habitat availability	Static to unhealthy	Declining

7.7 The relationship of indicator change to lake level and other human-related drivers of change

Water level management

There is no one lake level management regime that if implemented would benefit all wildlife on Te Waihora/Lake Ellesmere-and, there has never been one. Rather, different regimes will suit different guilds of birds in different ways, sometimes at the expense of other guilds. These effects are most obviously related to the lake level management regime. Thus, recommending a lake level management regime for wildlife is about maximising average benefits to desirable wildlife, e.g., a more-or-less permanently high lake level would benefit many guilds but effectively destroy the exposed mud and turfland flats exploited by the deep and shallow water waders. Table 4 gives an indication of the extremes of these regimes. An optimum (implying the obvious tradeoffs are considered and balanced by conservation managers) water regime will ensure that there is sufficient open water for species that prefer that zone, but will also ensure a general lowering of levels in spring so that saltmarshes become exposed and wind action ensures regular temporary re-watering of some of those saltmarshes and also some of the swampland areas.

Grazing

Grazing destroys swamp and saltmarsh vegetation and stock can trample or disturb nesting birds. Grazing needs to be managed in some habitats and excluded from others. Grazing in key habitats at key times, e.g., swan nesting along the shore of Kaitorete Spit or wet saltmarshes, should be avoided.

Eutrophication

Impacts are largely unknown for the wildlife although if water quality degrades to a 'tipping point' level where there is a significant reduction in invertebrate food production, the impacts could be catastrophic. There is insufficient information to enable an informed evaluation of the current situation or trends.

Recreation

As a general rule recreational vehicles should be prohibited from venturing into key habitats where they can destroy habitat and disturb wildlife. Exceptions for essential works and for managed tourism and recreation may be possible.

Weeds, e.g., grey willow

The proliferation of grey willow in Harts Creek needs to be reversed as it will likely lead to a long term reduction in bittern and other bird and fish habitat.

Predation

Mammalian predators are likely abundant around the lake. No research has been undertaken into their significance; however, introduced predators cause significant impacts on indigenous birds in all habitat types studied to date in New Zealand (see Dowding and Murphy 2001). The suite of predators present is typical of that in coastal areas and braided rivers, where impacts are catastrophic. Some predator management is desirable and potentially could follow designs currently being implemented in the Whangamarino and Awarua Plains wetlands

7.8 Identification of management interventions

The state of Te Waihora's wildlife is mixed, although overall only species diversity is considered healthy with the other indica-

TABLE 4. **Generalised relationships between wildlife guilds and variation in lake level.**

Guild	Example Species (common name)	Lake level regime that would most benefit this guild	Lake level regime that would be most harmful to this guild
Open water divers	Little shag	High lake permanently	Low lake level permanently
Deep water waders	Pied stilt	Seasonally adjusted levels including moderate to low levels in spring and autumn	High lake permanently
Shallow water waders	Banded dotterel	Seasonally adjusted levels including moderate to low levels in spring and autumn	High lake permanently
Dabbling waterfowl	Black swan	High lake permanently	Low lake level permanently
	Canada goose	High lake permanently	Low lake level permanently
Aerial hunting gulls and terns	Black-billed gull	High lake permanently	Low lake level permanently
Swamp specialists	Australasian bittern	High lake permanently	Low lake level permanently
Riparian wetland species	Kingfisher	High lake permanently	Low lake level permanently

TABLE 5. **Proposed outcomes and suggested management actions for wildlife of Te Waihora/Lake Ellesmere.**

Proposed outcome	Suggested management actions related to indicator trend
Species diversity should be maximised with a target average level of 50 s pecies (40 of which are 'core') from 7 guilds recorded per annum;	Implement the lake closing regime as per the Water Conservation Order, but subject to key management and ecological criteria
	Implement specific management techniques outlined below.
Enhance the populations of **conservation and taonga species** whose total populations are at some defined conservation risk (see Hitchmough *et al.* 2007) and which rely on the lake for critical life stage requirements, e.g., Australasian bittern, banded dotterel, Caspian tern and grey teal;	Key conservation species management areas to be identified, e.g., Harts Creek and Kaituna Lagoon for bittern, Greenpark Sands for banded dotterels and other waders;
	Active management for conservation species be undertaken in these key management areas, e.g., willow control and water level management in Harts Creek and Kaituna lagoon.
	General predator control.
	No further loss of emergent 3-tier swamp vegetation, and restoration at key sites, particularly along the western shores of the lake.
Sustainably[6] manage harvestable species, e.g., black swan, Canada goose and mallard duck;	Reduce Canada goose numbers to meet CG management plan requirements;
	Explore the potential to re-establish brown teal, ultimately for cultural harvest?
Provide the **optimised range of habitat conditions** to provide for all of the above, especially in terms of lake level management, water quality, and riparian management.	Map extent of microhabitat types using remote sensing and ground truthing.
	Maintain the extent of key microhabitats through active wetland management and statutory and non-statutory advocacy and education.
	Implement the lake closing regime as per the Water Conservation Order.
	Manage grazing regimes along shoreline habitats.
	Manage recreational activities that may degrade habitats.

[6] Including consideration of the potentially detrimental effects of some species if present in very large numbers, i.e., black swan and Canada goose.

tors ranging from static to unhealthy. Given this state what management actions could be undertaken to improve the situation (see Table 5)?

7.9 Discussion and conclusions

Te Waihora/Lake Ellesmere, despite all the largely detrimental changes over the last 100 or so years, remains a wetland of national and international importance for wildlife-specifically it contains very large numbers of birds representing a wide range of guilds and species living in a wide range of habitats. Despite these levels of importance some habitats associated with the lake are declining in value and so too are the species and guilds linked to these habitats. Overall then while the state of wildlife can be considered in 'reasonable health', the trend is probably a slow decline in value for wildlife. To reverse this trend, and secure the 'health' of the lake's wildlife, a range of management actions needs to be taken. These actions range from immediate work on willow control to improvements in lake level (linked to the water conservation order provisions) and riparian management-some of these are urgent, some are more strategic, but all are necessary.

7.10 Acknowledgements

We thank the following for wildlife data: Brian Ross (Fish and Game North Canterbury) for gamebirds, and Andrew Crossland (Christchurch City Council) for organising the 2006 and 2007 February waterbird censuses and provision of information from these. Others who have provided helpful advice include Colin Hill, Paul Sagar, and Jason Arnold. We also thank Paul Sagar for reviewing the paper and making many helpful suggestions for improvement.

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7.12 Appendices

Appendix A

Indigenous bird species, guilds and estimated population sizes for all species recorded at Te Waihora/Lake Ellesmere from c.1900–present.

Nomenclature from Heather and Roberston (1996)

The list includes species that use the lake and its wetland margins. It excludes oceanic species and vagrants that occur at sea off the Kaitorete Spit, penguins that may moult along the Kaitorete Spit, introduced species, and extinct species.

Key	
B	**Breeding** species,
F	Uses the lake for **feeding** only,
M	Regular international **migrants** that occur most years,
V	Vagrants, i.e., species that occur only **very rare**ly on the lake
X	Locally **extinct** post European arrival (but still occur elsewhere in New Zealand)
Outlined rows	The '**core' 40 species** for monitoring species diversity on an annual basis

Species common name, by guild	Maori name	Scientific name	Origin and breeding status	New Zealand wide conservation status - 2007
1. Open water divers				
Australasian crested grebe	Puteketeke	*Podiceps cristatus*	B	Acutely threatened
NZ dabchick	Weweia	*Poliocephalus rufopectus*	X	Chronically threatened
Australasian gannet	Takapu	*Morus serrator*	V	
Australian pelican		*Pelecanus conspicillatus*	V	
Black shag	Kawau	*Phalacrocorax carbo*	B	Chronically threatened
Little shag	Kawaupaka	*P. melanoleucos*	B	
Pied shag	Karuhiruhi	*P. varius*	F	
Little black shag		*P. sulcirostris*	V	Chronically threatened
Spotted shag	Parekareka	*Stictocarbo puncatatus*	F	
NZ scaup	Papango	*Aythya novaeseelandiae*	B	
Australian coot		*Fulica atra*	V	
White-eyed duck		*A. australis*	V	
2. Deep water waders				
White heron	Kotuku	*Egretta alba*	F	Acutely threatened
Intermediate egret		*E. intermedia*	V	
Little egret		*E. garzetta*	M	
Reef heron	Matuku moana	*E. sacra*	V	Acutely threatened
White-faced heron		*Ardea novaehollandiae*	B	
Royal spoonbill	Kotuku ngutu-papa	*Platalea regia*	F	
Nankeen night heron		*Nycticorax caledonicus*	V	
Glossy ibis		*Plgadis falcinellus*	M	
Australian white ibis		*Threskiornis molucca*	V	
Finsch's oystercatcher[9]	Torea	*Haematopus finschi*	F	
Variable oystercatcher	Toreapango	*H. unicolor*	F	
Pied stilt	Poaka	*Himantopus himantopus*	B	
Black stilt	Kaki	*Himantopus novaezelandiae*	B	Acutely threatened
Australian red-necked avocet		*Recurvirostra novaehollandiae*	V	
Banded stilt[10]		*Cladoryhnchus leucocephalus*	V	

[9] Also referred to as South Island pied oystercatcher (SIPO).

[10] Although not formerly recognised on the New Zealand bird species list, there is a specimen from Lake Ellesmere in the Canterbury Museum (Tunniclife 1977), and Cayley (1961) cites this species as straggling to New Zealand.


Photo ***The Pied Stilt is a very common sight around the lake.*** *Photography left* ***Shutterstock*** *right* ***Colin Hill.***

Typical numbers at one time 1985 and 1988[11],[12]	Typical numbers at one time 2000-2007	Max at one time (1980-present)	National population (year estimated in) and approx. proportion of national total present at lake at one time (%)[13]
0-1	10-20	32	400 (2004) (8%)
-	-	-	
0	0	1	
0	0	1	
100-200	250	500	5-10000 pairs (3%)
400-500	500	500	5-10000 pairs (5%)
0	10-20	24	5-10000 pairs (<1%)
0	0	6	
1-100	<200	20	10-50000 pairs (<1%)
0	100-200	235	20000 (1990s) (<1%)
0	0	3	
0	0	0	
1-15	1-15	19	100-120 (2000) (19%)
0	0	1	
0-1	0-1	2	<50 (4%)
0	0	0	
100-200	100-200	421	Widespread & common
0-2	70-120	199	610 (1995) (30%)
0	0	0	
0	0	2	Frequent vagrants
0	0	0	
80	20-75	143	85000 (1995) (<1%)
0	<5	4	
1000-3000	Up to 2937	10000	30000 (1993) (33%)
1-4	2	4	89 (2007) (4%)
0	0	0	
0	0	0	

[11] Bird data for this period was collated from O'Donnell (1985) and NWASCA (1988), as reported in Taylor (1996: 191).
[12] Data from DoC unpubl reports, Ornithological Society of NZ unpubl. reports and A. Crossland, Christchurch City Council, from the February 2006 survey, and from the February 2007 survey.
[13] Data from Heather and Robertson (1996) unless otherwise noted.

Species common name, by guild	Maori name	Scientific name	Origin and breeding status	New Zealand wide conservation status - 2007
Eastern curlew		*Numenius madagascariensis*	V	
Whimbrel		*N. phaeopus*	V	
Bar-tailed godwit	Kuaka	*Limosa lapponica*	M	
Black-tailed godwit		*Limosa limosa*	V	
Hudsonian godwit		*L. haemastica*	V	
Siberian tattler		*Tringa brevipes*	V	
Greenshank		*T. nebularia*	V	
Lesser yellowlegs		*T. flavipes*	V	
Marsh sandpiper		*Tringa stagnatilis*	V	
Stilt sandpiper		*Micropalama himantipus*	V	
3. Shallow water waders				
NZ dotterel	Tuturiwhatu	*Charadrius obscurus*	V	Acutely threatened
Banded dotterel	Tuturiwhatu	*C. bicinctus*	E, B	Chronically threatened
Red-capped dotterel		*C. ruficapillus*	V	
Black-fronted dotterel		*C. melanops*	F	
Large sand dotterel		*C. leschenaultii*	V	
Mongolian dotterel		*C. mongololus*	V	
Oriental dotterel		*C. veredus*	V	
Wrybill	Ngutu parore	*Anarhynchus frontalis*	F	Acutely threatened
Pacific golden plover		*Pluvialis fulva*	M	
Spur-winged plover		*Vanellus miles*	B	
Turnstone		*Arenaria interpres*	M	
Lesser knot	Huahou	*Calidris canutus*	M	
Great knot		*C. tenuirostris*	V	
Sanderling		*C. alba*	V	
Curlew sandpiper		*C. ferruginea*	M	
Sharp-tailed sandpiper		*C. acuminata*	M	
Pectoral sandpiper		*C. melanotos*	M	
Red-necked stint		*C. ruficollis*	M	
Little stint		*Calidris minuta*	V	
Long-toed stint		*C. subminuta*	V	
Broad-billed sandpiper		*Limicola falcinellus*	V	
Ruff (Reeve)		*Philomachus pugnx*	V	
Little whimbrel		*Numeniusminutus*	V	
Terek sandpiper		*Tringa terek*	V	
Grey phalarope		*Phalaropus fulicarius*	V	
Red-necked phalarope		*Phalaropus lobatus*	V	
Wilson's phalarope		*Phalaropus tricolor*	V	
4. Dabbling waterfowl				
Black swan[14]	Wani	*Cygnus atratus*	B	
Cape Barren goose*		*Cereopsis novaehallandiae*	V	
Paradise shelduck	Putangitangi	*Tadorna variegata*	B	
Chesnut-breasted shelduck		*T. tadornoides*	V	
Grey duck	Parera	*Anus superciliosa*	B	Acutely threatened
Australasian shoveler	Kuruwhengi, Pateke	*A. rhynchotis*	B	
Brown teal	Pateke	*A. aucklandica*	X	Acutely threatened
Grey teal	Tete	*A. gracilis*	B	
Mixed shoveler/ teal				

[14] Black swans and Cape Barren geese are generally considered introduced species. However, Worthy (1998) found that bones of the 'extinct' New Zealand swan were identical to those of the introduced Australian species. The 'New Zealand goose' is in a similar position with the Cape Barren goose. Thus, it appears that these species are indigenous species that were inadvertently re-introduced to New Zealand.

Typical numbers at one time 1985 and 1988[11,12]	Typical numbers at one time 2000-2007	Max at one time (1980-present)	National population (year estimated in) and approx. proportion of national total present at lake at one time (%)[13]
0	0	1	
0	0	0	
0-50	20-80	325	85-105000 (1995) (<1%)
0	0	13	
0	0	1	
0	0	1	
0	0	1	
0	0	0	
0	0	2	
0	0	1	
0	0	0	
1000-3000	1000-2000	4846	50000 (1995) (10%)
0	0	0	
0	0	2	
0	0	1	
0	0	1	
0	0	1	
50-200	50-200	459	4500 (2004) (10%)
50-70	122	122	600-1200 (1995) (10-20%)
100-500	100-200	1052	Abundant & widespread
0-10	0-10	34	5-7000 (1995) (<1%)
5-90	10-35	85	50-70000 (1995) (<1%)
0	0	1	
0	0	3	
5-70	10-20	86	50-150 (1995) (60%)
10-25	10-25	33	50-200 (1995) (17%)
1-3	0-6	10	<20 (1995) (50%)
200	Up to 63	220	150-300 (1995) (70%)
0	0	1	
0	0	1	
0	0	1	
0	0	2	
0	0	2	
0	0	4	
0	0	1	
0	0	0	
0	0	2	
6000-13000	Up to 10651	16000	63000 (1980) (25%)
0	2	2	
10-400	100-500	1635	120000 (1981) (1%)
0	2	2	13 (2007) (15%)
<100	?	?	<500000 (1995)
500-15000	Up to 3405	>15379	150000 (1980s) (10%)
-	-	-	
500-7000	Up to 10979	10979	>50000 (1995) (22%)
5000-10000	Up to 1260	27166	

Species common name, by guild	Maori name	Scientific name	Origin and breeding status	New Zealand wide conservation status - 2007
5. Torrent specialists				
None present				
6. Aerial hunting gulls & terns				
Brown skua	Hakoakoa	*Catharacta skua*	V	Acutely threatened
Antarctic skua		*C. maccormicki*	V	
Arctic skua		*Stercorarius parasiticus*	M	
Pomarine skua		*S. pomarinus*	M	
Black-billed gull		*Larus bulleri*	F	Acutely threatened
Red-billed gull	Tarapunga	*L. scopulinus*	F	Chronically threatened
Black-backed gull	Karoro	*L. dominicanus*	B	
Caspian tern	Taranui	*Sterna caspia*	B	Acutely threatened
White-fronted tern	Tara	*S. striata*	F	Chronically threatened
Black-fronted tern	Tarapiroe	*S. albostriatus*	F	Acutely threatened
White-winged black tern		*Chlidonias leucopterus*	M	
Arctic tern		*S. paradisaea*	V	
Fairy tern		*S. nereis*	X	Acutely threatened
Little tern		*Sterna albifrons*	M	
7. Swamp specialists				
Banded rail	Moho-pereru	*Rallus philippensis*	X	Chronically threatened
Spotless crake	Puweto	*Porzana tabuensis*	B	Chronically threatened
Marsh crake	Koitareke	*Porzana pusilla*	B	Chronically threatened
Pukeko	Pukeko	*Porphyrio porphyrio*	B	
Australasian bittern	Matuku	*Botaurus poiciloptilus*	B	Acutely threatened
Painted snipe		*Rostratula benghalensis*	V	
Japanese snipe		*Gallinago hardwickii*	V	
Fernbird	Matata	*Bowdleria punctata*	X	Chronically threatened
8. Riparian wetland species				
Kingfisher	Kotare	*Halcyon sancta*	B	
Welcome swallow		*Hirundo tahitica*	B	
Cattle egret		*Bubulcus ibis*	M	
Australasian harrier hawk	Kahu	*Circus approximans*	B	
NZ falcon	Karera	*Falco noveseelandiae*	V	Chronically threatened
Weka	Weka	*Gallirallus australis*	X	
NZ pigeon	Kereru	*Hemiphaga novaeseelandiae*	F	
Kea	Kea	*Nestor notabilis*	V	Acutely threatened
Shining cuckoo	Pipiwharauroa	*Chalcites lucidus*	F	
Long-tailed cuckoo	Koekoea	*Eudynamys taitensis*	V	
Black-faced cuckoo shrike		*Coracina novaehollandiae*	V	
Silvereye	Tauhou	*Zosterops lateralis*	B	
Grey warbler	Riroriro	*Gerygone igata*	F	
NZ pipit	Pihoihoi	*Anthus novaeseelandiae*	B	
Fantail	Piwakawaka	*Rhipidura fuliginosa*	F	
Bellbird	Korimako	*Anthornis melanura*	F	

Appendix B

Introduced species of importance at Te Waihora/Lake Ellesmere.

Dabbling waterfowl			
Mute swan	*Cygnus olor*	I, B	Protected
Canada goose	*Branta canadensis*	I	Game bird
Mallard duck	*Anas platyrhynchos*	I, B	Game bird

Typical numbers at one time 1985 and 1988[11],[12]	Typical numbers at one time 2000-2007	Max at one time (1980-present)	National population (year estimated in) and approx. proportion of national total present at lake at one time (%)[13]
0	0	1	
0	0	0	
0	0	6	
0	0	2	
500-3000	Up to 1592	5000	<50000 (2007) (10%)
10-500	Up to 59	544	100000+ (2000) (<1%)
500-1000	Up to 648	1561	Abundant & widespread
10-40	Up to 63	70	3000 (1995) (2%)
0-100	Up to 169	204	30000 (2000) (<1%)
0-50	54	58	5000 (1995) (1%)
0	0	4	<10 (1995) (40%)
0	0	1	
-	-	-	
0-1	0	11	
-	-	-	
?	n.c.	5	?
?	n.c.	26	?
250-500	Up to 28	502	Abundant
20	n.c.	20	580-725 (3-5%)
0	0	1	
0	0	1	
-	-	-	
10-50	n.c.	20	
100+	n.c.	514	
10-30	<10	94	<1000(10%)
?	58+	58+	Widespread & common
0	0	1	
-	-	-	
0	0	1	
0	0	1	
?	?	?	
0	0	1	
0	0	0	
?	?	?	
?	?	?	
?	?	?	
?	?	?	
?	?	?	

			National population and % of 2007 popn using the lake per year
40-50	10-20		100 (1990s) (50%)
7000-16000	6000-8000		50000 (30%)
500-9000	Up to 1388		3 million (1995)

Te Waihora/Lake Ellesmere is a large coastal lake, intermittently open to the sea. It is highly regarded for its conservation and related values, some of which are of international significance. Its function as a sink for nutrients from its large predominantly agriculturally based catchment, currently undergoing accelerated intensification, is also recognised, at least implicitly. It is the resulting conflict from these value sets which is mainly responsible for the ongoing debate about the future of the lake.

This book serves to quantify the nature of this debate by documenting changes to lake values, both over time and spatially. It provides a standardised approach to reporting these changes, set against indicators that are value-specific. Ultimately, it provides a template for thinking about future management scenarios for the lake and its environs. Given this approach the book ultimately serves as a resource for helping understand the ever-changing and current and possible future states of the lake, under a variety of management requirements and implications.