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Bird populations in nine braided rivers of the Upper Waitaki Basin, South Island, New Zealand: changes after 30 years.

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ABSTRACT

Sections of nine rivers in the Upper Waitaki Basin were surveyed between 1991 and 1994 and these surveys were compared with counts completed in 1962, 1965 and 1968. A systematic account of 27 wetland birds is given. Densities (number of birds km^{-1}) of birds were compared between the two periods. Species that increased in density were mainly common generalists, whereas species that decreased in density were endemic river breeding specialists. Densities of Wrybills (*Anarhynchus frontalis*), Spur-wing Plovers (*Vanellus miles*), Canada Geese (*Branta canadensis*), and Grey Teal (*Anas gracilis*) were higher in the 1990s than in the 1960s, whereas densities of Banded Dotterels (*Charadrius bicinctus*), waterfowl and shags, Black-billed Gulls (*Larus bulleri*), South Island Pied Oystercatchers (*Haematopus ostralegus*), Black-backed Gulls (*L. dominicanus*) and Black-fronted Terns (*Sterna albostriata*) were lower in at least one river in the 1990s compared to the 1960s. Estimated minimum populations of river birds published for the Ahuriri River (surveyed in 1982) and the Cass River (surveyed in 1979 and 1982) were usually intermediate to those recorded in equivalent 1960s and 1990s surveys. Four mechanisms that explain changes in braided river bird populations are suggested.

KEY WORDS: comparative survey, braided river, birds, density, Upper Waitaki Basin

INTRODUCTION

More than 20 species of wetland bird have been recorded on braided rivers in New Zealand, and six of these (Wrybill, Black Stilt, Banded Dotterel, South Island Pied Oystercatcher, Black-fronted Tern, and Black-billed Gull; latin names in the results section) breed predominately in braided river beds and associated habitats (O'Donnell and Moore 1983, Robertson *et al.*, 1983, Maloney *et al.*, 1997). Wrybill, Black-fronted Tern and Black Stilt are globally vulnerable or endangered species

(Bell 1986, IUCN 1988). In New Zealand, braided rivers are found mainly in the South Island, on the eastern flanks of the Southern Alps. Braided rivers are characterised by high spring-summer flows, rapid and frequent flooding and low water clarity. Several birds of braided rivers have evolved adaptations to cope with these factors, such as the ability to lay repeat clutches, short inter-lay intervals between clutches, specialised feeding behaviours (e.g., Black Stilt; Pierce 1986a) and morphological adaptations (e.g., Wrybill; Pierce 1979, Hay 1984).

Habitat quantity and quality in braided river systems has undoubtedly declined over the last 100 or more years, as mainly European plant species and introduced predatory mammals have increased in range and density (Balneaves and Hughey 1989, King 1990). The effects of vegetation invasion and of human management and control of rivers can be clearly seen in declines in the range and abundance of many wetland birds (e.g., Pierce 1984, Hughey 1985, O'Donnell unpubl. Department of Conservation Report 1992, Maloney *et al.*, 1997). Reductions in the range and abundance of wetland birds are most obvious in lowland Canterbury where rivers such as the Hurunui, Opihi and Lower Waimakariri have limited habitat for wetland birds compared with rivers that are comparatively free from vegetation invasion (O'Donnell and Moore 1983).

Today, rivers of the Upper Waitaki Basin may provide close to 50 % of remaining suitable braided river habitat for birds in the South Island (Maloney *et al.*, 1997), as the spread of introduced plant species has affected lowland reaches of most Canterbury rivers (Balneaves and Hughey 1989). In the Upper Waitaki Basin major human influences in braided rivers have apparently been limited to post 1960s hydro-electric development and continued river control works. All rivers now have some form of river control project in one or more river sections, but in contrast to lowland Canterbury rivers, only two rivers (Ahuriri and Tekapo) are affected by large-scale vegetation invasion. Therefore, rivers of the Upper Waitaki catchment offer an opportunity to examine bird population changes over a long time period and in the absence of major vegetation invasion effects. Using survey data from two studies conducted in the 1960s and the 1990s, I compare the density and minimum abundance of braided river birds in nine rivers of the Upper Waitaki Basin.

METHODS

River surveys

Surveys were undertaken in nine rivers (Tasman, Godley, Hopkins, Ahuriri, Tekapo, Cass, Lower Ohau, Pukaki, and Upper Ohau; Fig. 1) during two periods. In the 1960s (1962, 1965 and 1968) surveys were carried out by the New Zealand Wildlife Service investigating effects of the creation of Lakes Benmore and Aviemore on braided river birds (Bell unpubl. Wildlife Service Report, 1969). Surveys in the 1990s (from 1991 to 1994) were undertaken by Project River Recovery staff of the Department of Conservation, as part of a long-term monitoring programme of

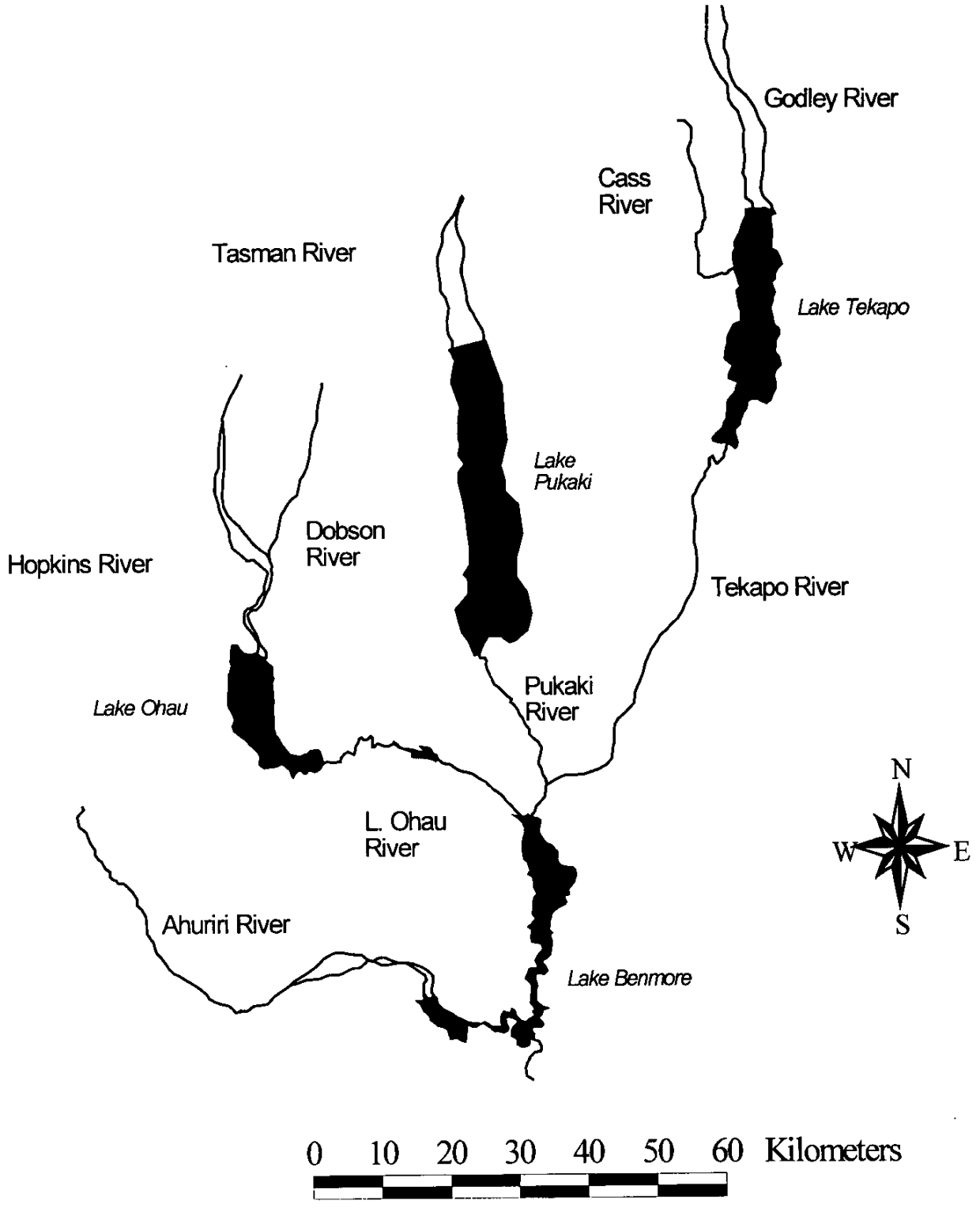

FIGURE 1 - Locations of Upper Waitaki Basin rivers surveyed for birds. Note that the boundaries of the rivers indicate bed width. Only a small proportion of the bed is covered by water during normal flows.

TABLE 1- Description of the lengths of rivers surveyed in the 1960s (1962, 1965, 1968) and the 1990s (1991 - 1994), and the number of surveys completed in each decade. Rivers are ordered from largest to smallest on the basis of river length surveyed in the 1990s. Full descriptions of survey routes used in the 1990s are held by Department of Conservation, Twizel Area Office.

	Length (km)		Number of surveys		General description
River	1960s	1990s	1960s	1990s	
Ahuriri	65.0	62.7	3	4	Birchwood Station to Lake Benmore
Tekapo	53.0	46.3	3	4	Lake Tekapo to Lake Benmore
Pukaki	19	12.5	3	4	Lake Pukaki to the Tekapo River confluence
Hopkins	8	12	3	2	Huxley Gorge Station to Lake Ohau
L. Ohau	15	11.6	3	4	Lake Ruataniwha to Lake Benmore
U. Ohau	16	10.3	3	4	Lake Ohau to Lake Ruataniwha
Tasman	13	9.9	3	3	1960s from Glentanner Station to Lake Pukaki. 1990s from Fred's Stream to Lake Pukaki
Godley	8	5.5	3	2	Confluence of MacAulay River to Lake Tekapo
Cass	5.1	5.1	3	4	Godley Peaks bridge to Lake Tekapo

river birds in 11 rivers of the Upper Waitaki Basin (Maloney *et al.*, 1997). Only the 1990s data from the same or equivalent sections of the nine rivers that were surveyed in the 1960s by the Wildlife Service are presented here. Each river was divided into short sections that related to access and river crossing points, or to landscape features such as gorges, wide braided sections and river deltas. Survey methods used in the 1990s are described in Maloney *et al.*, (1997). Briefly, observers walked downstream at a standard 3 km h^{-1} pace, spaced evenly across the width of the riverbed, and counted all birds that flew upstream and passed them. Survey sections, numbers of observers, exact walking routes and times are poorly documented in archived files for the 1960s data, but methods were similar to those in the 1990s. Surveys in the 1960s were undertaken by Wildlife Service, OSNZ and Acclimatisation Society personnel, walking downstream either alone or in pairs. In both periods rivers were divided into short sections, including river deltas. In 1962 rivers were surveyed on one day in October, except in the Tekapo and Ahuriri Rivers which were both surveyed over three days. Survey dates in 1965 and 1968 are unknown, but surveys occurred in spring. In the 1990s rivers were surveyed on a single day during the spring breeding season (October to December), except the Ahuriri River which was surveyed over two days. As most river bird species are present on their breeding grounds from September to December monthly variation is probably low (although this assumption has not been tested). All wetland birds were counted. Other birds not dependent on water environs were recorded as present or absent. River lengths, numbers of surveys and general descriptions of the survey areas are given in Table 1.

Data analyses

Comparison of river bird densities

Because river sections described in the 1960s data give only the river length (as opposed to area) surveyed, all bird densities were calculated as the number of birds per kilometre of river length. Bird densities were calculated using the lengths of rivers as described for the 1960s and 1990s data separately (Table 1). Except for the following four cases, sections were the same in both periods. In the Tasman River one 1960s section was flooded when Lake Pukaki was raised in 1977 (Martin 1991), so in the 1990s an equivalent length of river upstream of that section was used in comparisons. Data from 1960s surveys were not included for 4 km of the Upper Ohau, 8.5 km of the Tekapo and 6.5 km of the Ahuriri Rivers, which were surveyed but subsequently flooded (by rising lake levels or lake creation). Data sets are essentially paired in comparisons between 1960s and 1990s bird counts because the same sections of river were used in both periods. Therefore, densities (means of the once per yearly counts in the 1960s and in the 1990s for each of the nine rivers separately) for each of seven river bird species (Wrybill, Banded Dotterel, Pied Oystercatcher, Black-fronted Tern, Black-billed Gull, Pied Stilt and Black-backed Gull), and for a combined waterfowl and shag group were compared using paired t-tests. Data for Caspian Tern, Black Stilt and all miscellaneous species were not analysed as numbers in most rivers were too few for comparisons. Data were square-root transformed where variances were unequal, and because multiple tests were performed for seven species and one group of species among the rivers I divided the significance level ($P = 0.05$) by the number of pair-wise comparisons ($N = 8$ species and groups) using the Dunn-Bonferroni procedure (Marascuilo and McSweeney 1977). Thus the adjusted significance level was $P = 0.006$.

Comparison of minimum numbers of river birds

Standardised bird surveys also recorded the minimum counts of birds present in a river system for each survey period (counts were a minimum estimate because not all habitats were surveyed). For two rivers where surveys at intermediate times were made I compared the highest minimum count per river obtained in any year in the 1960s and in the 1990s with data from surveys given in two previously published accounts, the Cass River from 1979 to 1982 (Pierce 1983), and the Ahuriri River from 1982 to 1983 (Robertson *et. al.*, 1983). As both studies surveyed river birds using broadly similar techniques, I used the highest minimum count for each species as reported; from mid-October 1979 or 1982 in Table 1 of Pierce (1983), and from the "Spring 4" count of 22 - 29 November 1982 in Appendix C of Robertson *et. al.*, (1983). Comparisons of counts of nine river birds between the three survey years for each river were made using Kruskal-Wallis tests.

TABLE 2 - Mean (standard error) number of birds per km for nine species, for waterfowl / shags combined, and for all other miscellaneous species, in nine Upper Waitaki Rivers surveyed in the 1960s (1962, 1965, 1968) and 1990s (1991 to 1994). For distances surveyed (km) per river see Table 1. Species codes are: DOT = Banded Dotterel, WRY = Wrybill, BS = Black Stilt, PS = Pied Stilt, SPO = Pied Oystercatcher, BFT = Black-fronted Tern, BIL = Black-billed Gull, CT = Caspian Tern, BBG = Black-backed Gull, WAT = waterfowl and shags, MISC = Miscellaneous species. * $P < 0.006$, ** $P < 0.001$ for within species T-test comparisons between 1960s and 1990s data.

Species	Year	Ahuriri	Tekapo	Pukaki	Hopkins	L. Ohau	U. Ohau	Tasman	Godley	Cass
DOT	1960s	8.50 (0.52)	13.5 (1.78)	5.53 (1.42)	13.1 (3.15)	12.6 (5.01)	4.21 (0.76)*	11.0 (0.73)	11.8 (2.92)	47.9 (8.2)
	1990s	4.85 (0.43)	7.93 (0.99)	1.41 (0.59)	4.4 (1.01)	10.9 (3.32)	0.96 (0.28)	25.8 (2.06)	28.0 (5.43)	35.5 (4.24)
WRY	1960s	0.2 (0.02)	1.55 (0.26)	0.18 (0.09)	3.0 (0.95)	0.27 (0.20)	0.08 (0.08)	6.66 (3.04)	5.29 (0.68)	5.3 (2.04)
	1990s	0.87 (0.16)	0.63 (0.02)	0.02 (0.02)	3.9 (0.85)	1.35 (0.45)	0.16 (0.08)	6.79 (0.75)	13.8 (0.35)*	7.54 (1.45)
BS	1960s	0.46 (0.06)	0.07 (0.06)	0.04 (0.04)	0.33 (0.33)	0.13 (0.08)	0.21 (0.08)	0.50 (0.27)	0.04 (0.04)	0.13 (0.22)
	1990s	0.16 (0.05)	0.05 (0.03)	0.02 (0.02)	0.17 (0.01)	0.41 (0.09)	0 (0)	0.14 (0.08)	0 (0)	0.19 (0.08)
PS	1960s	2.08 (0.05)	0.51 (0.16)	0 (0)	1.75 (0.14)	0.11 (0.02)	0.11 (0.06)	1.81 (0.43)	0.50 (0.19)	0.19 (0.33)
	1990s	1.62 (0.31)	1.27 (0.30)	0.52 (0.14)	1.48 (0.38)	3.42 (1.12)	0.19 (0.14)	0.69 (0.14)	0 (0)	2.79 (1.11)
SPO	1960s	5.16 (0.4)*	4.07 (0.79)	0.44 (0.15)	5.67 (2.110	2.35 (0.58)	0.69 (0.09)	1.89 (0.66)	4.58 (2.24)	11.9 (1.61)*
	1990s	3.21 (0.20)	1.51 (0.28)	0.28 (0.23)	3.30 (0.93)	1.63 (0.43)	0.14 (0.11)	1.99 (0.48)	3.11 (0.52)	4.41 (0.36)
BFT	1960s	10.8 (1.19)	17.1 (4.85)	14.4 (6.24)	15.9 (1.8)	7.38 (2.91)	8.39 (0.70)	8.93 (1.39)	7.09 (0.99)	42.2 (6.55)*
	1990s	8.30 (0.71)	10.8 (2.23)	1.50 (0.76)	3.43 (1.57)	30.6 (11.7)	10.1 (3.83)	5.97 (1.57)	10.9 (8.45)	11.7 (10.2)
BIL	1960s	9.19 (1.04)	2.52 (0.94)	1.05 (0.56)	11.1 (1.21)*	2.16 (0.73)	5.96 (5.12)	6.04 (2.89)	8.13 (3.07)	3.9 (3.18)
	1990s	3.68 (1.16)	0.47 (0.15)	0.04 (0.04)	0.26 (0.26)	2.21 (1.9)	0.03 (0.02)	0.66 (0.42)	0.69 (0.17)	4.36 (4.23)
CT	1960s	0.02 (0.02)	0.16 (0.07)	0 (0)	0.04 (0.04)	0.02 (0.02)	0 (0)	0 (0)	0.08 (0.08)	0.52 (0.40)
	1990s	0.09 (0.02)	0.17 (0.06)	0 (0)	0.25 (0.08)	0.25 (0.15)	0 (0)	0.12 (0.01)	0.69 (0)	0.19 (0.11)
BBG	1960s	2.23 (0.17)	6.07 (2.62)	0.79 (0.14)	7.63 (1.68)	2.16 (0.73)	1.02 (0.15)	5.16 (1.47)	6.25 (1.72)	113.2 (24.9)
	1990s	8.09 (1.05)	26.2 (3.53)	1.98 (0.79)	6.69 (0.67)	0.8 (0.26)	0.50 (0.29)	15.7 (3.78)	7.94 (0.35)	1.76 (0.55)*
WAT	1960s	9.55 (0.08)	21.6 (2.0)**	45.7 (17.2)	426 (30.4)*	52.7 (9.84)	27.3 (8.25)	313.0 (25.0)	162.7 (34.7)	100.0 (13.8)
	1990s	11.1 (0.67)	6.59 (0.89)	1.36 (0.32)	20.6 (7.58)	7.95 (1.39)	0.84 (0.37)	16.8 (0.88)	72.9 (55.5)	2.79 (0.86)
MISC	1960s	0.41 (0.12)	0.70 (0)	0 (0)	3.0 (1.53)	4.33 (2.03)	2.0 (1.53)	2.0 (0)	2.33 (1.33)	0.67 (0.33)
	1990s	1.83 (0.25)	1.11 (0.25)	0.32 (0.13)	8.47 (0.59)	1.94 (0.14)	0.45 (0.15)	4.32 (3.41)	0.43 (0.26)	4.51 (0.79)

RESULTS

Density estimates

In eight comparisons of densities of five species in five rivers, bird densities were significantly greater in the 1960s than in the 1990s, whereas for one comparison (Wrybills in the Godley River, paired t-test, $P<0.006$) densities were greater in the 1990s than in the 1960s (Table 2).

Specifically, lower densities were recorded in the 1990s compared with densities in the 1960s for Banded Dotterels in the Upper Ohau River ($P<0.006$), Pied Oystercatchers in the Ahuriri ($P<0.006$) and Cass ($P<0.006$) Rivers, Black-billed Gulls in the Hopkins River ($P<0.006$), Black-fronted Terns in the Cass River ($P<0.006$), Black-backed Gulls in the Cass River ($P<0.006$) and waterfowl and shags in the Tekapo ($P<0.001$) and Hopkins ($P<0.002$) Rivers. Densities did not differ between the 1960s and 1990s for any species in three rivers (Tasman, Lower Ohau and Pukaki; Table 2). Distribution and trends for 27 wetland bird species are presented in a systematic account below.

Minimum population estimates of birds per river

Overall changes in total combined population size of all species were not detected in the Cass and Ahuriri Rivers (K-W tests, $H = 0.17$, $H = 1.03$, respectively, both $P > 0.5$). Although individual species did vary greatly, the absence of an overall trend was because the degree and direction of change in population size from the 1960s to the 1990s were not consistent among the rivers for any of the species. In four comparisons in the Cass River there was a consistent decline in numbers of birds recorded, whereas in six comparisons there were either more (five species) or less (one species) birds surveyed in 1979/1982 than in the 1960 or 1990s. No birds showed constant increases in numbers over the three surveys (Table 3). In the Ahuriri River four species increased in number, three declined and four (one lower and three higher) were at intermediate levels (Table 3).

Systematic account of species recorded during 1960s and 1990s surveys

Black Shag *Phalacrocorax carbo*: Recorded in all rivers. Numbers decreased between the 1960s and 1990s in five rivers and increased in three. Largest apparent decreases were in the Hopkins (2.38 to 0.38 birds km^{-1}, from 1960s to 1990s) and Cass Rivers (4.45 to 0.13). Highest densities in the 1990s were in the Godley (1.09 birds km^{-1}) and Lower Ohau River (0.91).

Little Shag *P. melanoleucos*: Uncommon on braided rivers. Recorded in six rivers in 1960s surveys (Cass, Ahuriri, Pukaki, Tekapo, Upper and Lower Ohau) and on only four upland rivers in the 1990s (Tasman, Ahuriri, Hopkins, Godley). In the 1990s was most common on the Tasman and Ahuriri Rivers (both 0.09 birds km^{-1}).

TABLE 3 - Highest number of wetland birds recorded in any year in the 1960s, 1990s and in two intermediate periods in river surveys of the Ahuriri and Cass Rivers. Trends in counts are indicated by (+), where 1990s values are higher, (-) where 1990s counts are lower, and (0) where no pattern is discernible compared with previous surveys. Sources for data are: 1960s from Bell (unpublished Wildlife Service Report 1969); 1979/82 Cass River data from Table 1 of Pierce (1983); 1982 Ahuriri River data from Robertson *et. al.*, (1983).

	Cass River				Ahuriri River			
Species	1960s	1979/82	1990s	Trend	1960s	1982	1990s	Trend
Banded Dotterel	391	563	216	0	586	530	377	-
Wrybill	39	87	54	0	12	77	81	+
Black Stilt	2	N/A	2	0	34	28	19	-
Pied Stilt	3	53	25	0	148	208	142	0
Pied Oystercatcher	71	53	27	-	358	262	231	-
Black-fronted Tern	250	147	215	0	779	888	622	0
Black-billed Gull	36	153	87	0	664	101	447	0
Caspian Tern	5	3	2	-	2	7	10	+
Black-backed Gull	127	52	24	-	745	389	791	+
Waterfowl & shags	440	N/A	14	-	195	1089	683	0
Miscellaneous spp.	1	39	21	0	34	146	147	+

White-faced Heron *Ardea novaehollandiae*: Uncommon and in low densities. Recorded in eight rivers in 1960s (not Pukaki) and in six rivers in 1990s (Tasman, Ahuriri, Pukaki, Tekapo, Upper and Lower Ohau). Highest density in the 1990s was 0.86 birds km^{-1} in the Lower Ohau River, but always less than 0.16 birds km^{-1} in other rivers.

Australasian Bittern *Botaurus poiciloptilus*: One sighted during river surveys in the 1960s in each of the Godley and Ahuriri Rivers.

Black Swan *Cygnus atratus*: Recorded at low densities in five rivers (not Cass, Pukaki, Upper and Lower Ohau) in the 1960s and in four rivers in the 1990s (Godley, Pukaki, Upper Ohau, Tasman). Maximum densities in the 1990s of 1.06 and 0.37 birds km^{-1} in the Hopkins and Ahuriri Rivers, respectively.

Canada Goose *Branta canadensis*: Abundant and apparently increasing in density between the survey periods in four rivers (Godley now 65.82 birds km^{-1}, Tasman 18.01, Tekapo 3.15 and, Ahuriri 5.53), but decreasing in the Cass (from 9.47 to 0.26 birds km^{-1}) and Hopkins Rivers (from 15.71 to 9.32).

Paradise Shelduck *Tadorna variegata*: Recorded commonly on braided rivers at moderate densities. Apparent declines in the Hopkins River (from 26.5 to 7.80 birds km^{-1}), otherwise densities were similar between the two survey periods. In the 1990s highest densities were on the Hopkins (7.83 birds km^{-1}), whereas densities were < 1.5 birds km^{-1} on other rivers.

Mallard Duck *Anas platyrhynchos*; Grey Duck *A. superciliosa*; "Duck spp": Mallard and Grey Ducks were recorded in both survey periods either separately by species, or were grouped into a joint category ("Duck spp"). Where identified, Grey Ducks were recorded on all rivers, but have apparently declined from 2.3 -

3.9 birds km^{-1} in the 1960s to 0.2 - 0.9 birds km^{-1} in the 1990s in five rivers (Cass, Godley, Hopkins, Tasman and Ahuriri). Mallard Duck densities showed apparent increases in two rivers (Cass, Godley), and decreases in two rivers (Hopkins, Tasman). Overall, both species were less common in the 1990s than in the 1960s, with 1990s densities ranging from highs of 8.30 birds km^{-1} (Godley) and 2.70 (Lower Ohau) to lows of 0.10 birds km^{-1} in the Pukaki River and 0.46 birds km^{-1} in the Upper Ohau River.

Grey Teal *A. gracilis*: Recorded only on the Godley River in the 1960s, but recorded on six rivers (Cass, Godley, Lower Ohau, Hopkins, Tekapo and Ahuriri) in the 1990s, indicating a substantial range increase. Always in low densities (highest was 0.71 birds km^{-1} in the Lower Ohau).

New Zealand Shovelor *A. rhynchotis*: In 1960s recorded on six rivers (Tasman, Godley, Cass, Tekapo, Ahuriri and Hopkins), and in 1990s on five rivers (Cass, Tekapo, Pukaki, Lower Ohau, and Ahuriri). Recorded in the 1960s in the Godley (1.08 birds km^{-1}), Tasman (1.38) and Hopkins (0.79) but completely absent from these rivers in the 1990s. As with Grey Teal, highest densities in the 1990s were in the Lower Ohau River (0.52 birds km^{-1}).

New Zealand Scaup *Aythya novaeseelandiae*: A bird of still waters; a few individuals were recorded on the Godley, Tasman, Tekapo and Ahuriri Rivers in either the 1960s or 1990s. A high density of birds (2.33 birds km^{-1}) was recorded on the Godley River in 1960s, but no birds were recorded on this river in the 1990s.

Pukeko *Porphyrio porphyrio*: Uncommon on braided rivers. Recorded on a few occasions from the Tekapo River in the 1960s and the Ahuriri River in both periods.

South Island Pied Oystercatcher *Haematopus ostralegus*: A common species in all rivers except the Pukaki and Upper Ohau. Numbers have declined significantly in two rivers (Ahuriri and Cass), with apparent declines in the Tekapo, Upper Ohau, Hopkins, Godley and Lower Ohau Rivers. Populations in the 1990s are now only 30 to 90 % of those recorded in the same river sections in the 1960s, with highest densities on the Cass (4.36 birds km^{-1}), Hopkins (3.30) and Ahuriri (3.12).

Pied Stilt *Himantopus himantopus*: Highest densities in the Cass (2.79 birds km^{-1}) and Lower Ohau (3.42) Rivers in the 1990s, and in the Ahuriri, Tasman and Hopkins Rivers (1.75 to 2.08 birds km^{-1}) in the 1960s. Apparent increases in densities in four rivers (Cass, Lower Ohau, Tekapo and Pukaki) and decreases in the Ahuriri and Tasman Rivers, but much variation between years within each of the periods.

Black Stilt *H. novaezelandiae*: Black Stilt densities were low in both periods. 1960s densities were greatest in the Ahuriri (0.46 birds km $^{-1}$), Hopkins (0.33) and Tasman (0.50) Rivers. In the 1990s densities were highest in the Lower Ohau (0.41 birds km^{-1}), but in no other river were densities during the 1990s greater than 0.2 birds km^{-1} (i.e., less than one Black Stilt for every 5 km of river length surveyed).

Banded Dotterel *Charadrius bicinctus*: An abundant braided river species, with high densities in the 1990s on the Cass (35.5 birds km^{-1}), Godley (28.0), Tasman (25.9) and Lower Ohau (10.9) Rivers, and more than 3.0 birds km^{-1} on all but the Upper Ohau River. However, densities were lower in the 1990s than 1960s in the Ahuriri, Cass, Hopkins, Tekapo, Pukaki, Upper and Lower Ohau Rivers. Banded Dotterel densities in the 1990s were only 20 to 70% of 1960s values.

Black-fronted Dotterel *C. melanops*: One recorded in the Lower Ahuriri (near Chain Hills) in November 1992.

Wrybill *Anarhynchus frontalis*: In the 1990s highest densities were recorded on the larger upland rivers; Tasman (6.79 birds km^{-1}), Godley (13.8), Cass (7.54) and Hopkins (3.90) Rivers. Densities have increased significantly in the Godley River, but otherwise comparisons of densities between the two periods were similar.

Spur-wing Plover *Vanellus miles*: The only species showing a consistent increase in range and densities in all rivers. In the 1960s on five rivers (not Cass, Pukaki, Lower Ohau, or Tasman) at very low densities (0.08 - 0.14 birds km^{-1}). By the 1990s recorded in all rivers at densities ranging from 0.18 (Pukaki) to 8.51 (Hopkins) and populations of more than 1.0 bird km^{-1} on the Tasman, Ahuriri, Cass, Hopkins, Lower Ohau and Tekapo Rivers. Undoubtedly the increase in abundance and distribution between the periods reflects the continued population increase and range expansion of this recent Australian arrival.

Eastern Curlew *Numenius madagascariensis*: One recorded on the Cass River delta in November 1994.

Black-backed Gull *Larus dominicanus*: Densities of this species have increased in three rivers (Ahuriri from 2.20 to 8.10 birds km^{-1}, Tekapo from 6.10 to 26.2, and Tasman from 5.20 to 15.7) and decreased in the Cass River (from 113.2 to 1.80). Overall densities of Black-backed Gulls appear to have increased markedly, and Black-backed Gulls are the most numerous species on the Tekapo, Ahuriri and Pukaki Rivers.

Black-billed Gull *L. bulleri*: Densities of this species are much reduced from 1960s levels in six rivers, with significant declines in two of these (Ahuriri and Hopkins). Six rivers (Tasman, Godley, Hopkins, Tekapo, Pukaki and Upper Ohau) have lost all breeding colonies and in the 1990s only the Ahuriri (50 - 150 pairs), Cass (30 - 40 pairs) and Lower Ohau (10 pairs) regularly had breeding birds.

White-winged Black Tern *Chlidonias leucopterus*; Three recorded in the 1965 surveys, in the lower reaches of the Godley, Cass and Tekapo Rivers. One in the Upper Ahuriri River (near Ben Avon) in December 1994, and one in the Lower Cass River in November 1994.

Black-fronted Tern *Sterna albostriata*: Common in rivers of the Upper Waitaki Basin in the 1960s and in the 1990s, with mean densities of around 10 birds km^{-1} in most rivers. There were declines in four rivers (Hopkins, Tekapo, Cass and Pukaki), and this was significant in the Cass River.

Caspian Tern *Sterna caspia*: Densities were very low in all rivers, with nesting pairs being associated with and restricted to Black-backed Gull colonies (usually

only one pair per colony). Densities were highest in the Cass River (0.89 birds km^{-1}) in the 1960s, and in the Godley River (0.69 birds km^{-1}) in the 1990s.

Arctic Tern *Sterna paradisaea*; A first record for the Upper Waitaki Basin. One on the Cass River delta in November 1994.

A total of 27 other birds were recorded during the surveys, and for completeness these were as follows: Harrier (*Circus approximans*), New Zealand Falcon (*Falco novaeseelandiae*), Californian Quail (*Callipepla californica*), Chukar (*Alectoris chukar*), Rock Pigeon (*Columbia livia*), Shining Cuckoo (*Chysococcyx lucidus*), Long-Tailed Cuckoo (*Eudynamys taitensis*), Little Owl (*Athene noctua*), Kingfisher (*Halycon sancta*), Rifleman (*Acanthisitta chloris*), Skylark (*Alauda arvensis*), Pipit (*Anthus novaeseelandiae*), Dunnock (*Prunella modularis*), Blackbird (*Turdus merula*), Thrush (*T. philomelos*), Grey Warbler (*Gerygone igata*), Fantail (*Rhipidura fuliginosa*), Tomtit (*Petroica macrocephala*), Silvereye (*Zosterops lateralis*), Yellowhammer (*Emberiza citrinella*), Chaffinch (*Fringilla coelebs*), Greenfinch (*Carduelis chloris*), Goldfinch (*C. carduelis*), Redpoll (*C. flammea*), House Sparrow (*Passer domesticus*), Starling (*Sturnus vulgaris*) and Australasian Magpie (*Gymnorhina tibicen*). Twenty five of these were recorded in at least one river in the 1960s (not Fantail or Rifleman), whereas 20 species were recorded in the 1990s (not Little Owl, Kingfisher, New Zealand Falcon, Chukar, Long-Tailed Cuckoo, Tomtit or Australasian Magpie).

DISCUSSION

The results of these surveys provide evidence for declines in densities of four of six braided riverbed bird species in the Upper Waitaki Basin over the last 30 years; Banded Dotterel in seven rivers, Pied Oystercatcher in five rivers, Black-fronted Tern in four rivers and Black-billed Gull in six rivers. Only one river bird species (Wrybill) increased in density, in one river. Densities of black stilts were similar across decades. Where there were declines, these occurred in the Cass and Hopkins Rivers (five species each) - both rivers with low levels of vegetation encroachment, low water flow modification, and with only low or moderate levels of river protection work development.

Of the other wetland bird species surveyed, four species (Canada Goose, Grey Teal, Spur-wing Plover, Black-backed Gull) increased markedly in density and in range, while Grey Ducks (throughout their range) and Mallard Ducks (in two of four rivers) decreased. Numbers of the remaining 15 species surveyed were generally low in all rivers, and trends over time could not be determined.

It should be expected that comparison of two survey points, 30 years apart, will provide a simplistic view of population trends. In the two cases where intermediate survey data were available, in the Ahuriri and Cass Rivers, most species were either more abundant than in either the 1960s and 1990s or were intermediate between the two decades, implying that populations have both increased and declined over a relatively short period of time. It could be that cyclic changes in abundance may be a normal integral part of braided river ecology, hidden from the view of researchers

by a lack of comparative data, and therefore, a cautious, conservative approach to interpreting trends and identifying patterns from these survey data is required.

Is there a common pattern that can explain changes in numbers over time? Species that increased were few, and increases were recorded in only some rivers. Often these species were nationally common, generalist type species. However, species that decreased did so across many rivers, and were mainly endemic river breeding specialists (e.g. Black-fronted Tern), or species with a large proportion of their national populations breeding in braided river systems (e.g. Banded Dotterel).

Specifically, overall increases in densities were recorded in very few rivers, and in only five species. Three of these species were: Spur-wing Plover, an aggressive coloniser with a rapidly expanding range; Canada Goose, a recognised pest species; and Black-backed Gull, an opportunistic species that has benefited from increased agricultural land development. The other two (Wrybills in the Godley River) and Grey Teal, are endemic species with low and threatened national populations. Possibly Grey Teal have benefited from the creation of new lake delta habitat following the creation of Lake Benmore which may explain the increased densities in the Tekapo, Ohau and Ahuriri Rivers, but this does not fit with observed increases in the Cass, Godley and Hopkins Rivers, where the amount and quality of habitat has remained constant. Similarly, habitat suitable for Wrybills on the Godley River is apparently similar in the 1990s to the 1960s; apart from observer error in counting this difficult species, no simple explanation of the observed increase in Wrybill densities in this river is apparent.

In comparison, decreases in densities occurred across a wide range of rivers for four species, and for a combined waterfowl and shag group. All four species were endemic wetland birds, two of which (Black-billed Gull, Black-fronted Tern) are listed as threatened species (Tisdall 1994). Reduction in Black-billed Gull numbers in the Tekapo, Lower Ohau and Pukaki Rivers may be correlated with the de-watering of these rivers after the 1960s surveys were completed, but hydro-electric development works does not explain the reduction in numbers in the Hopkins or Ahuriri Rivers. Similarly, Black-fronted Terns declined in two de-watered rivers (Tekapo and Pukaki) but also from the relatively unmodified Cass and Hopkins Rivers.

Post hoc explanations for changes in abundance of river bird populations will always be speculative. While increasing vegetation encroachment into some braided rivers and the de-watering and flooding of others because of hydro-electric development result in habitat loss, and are probable causes of bird population decline (e.g., O'Donnell and Moore 1983, Robertson *et al.*, 1983, Balneaves and Hughey 1989), other factors (e.g., differential predation rates, food supply, disease) are required to explain declines recorded in unmodified rivers such as the Cass or Hopkins Rivers.

Clearly, the cause of change in population size of an individual species is complex, and perhaps not related to a change in a single environmental variable. It is more likely that a combination of regional and local scale forces are shaping population size and distributions of river birds, and I suggest that four such mechanisms act

simultaneously on braided river bird populations to determine species abundance and distribution. These are: (1) *Population shift*; changes in numbers on one river are caused by migration of local populations to other rivers within the Upper Waitaki Basin, or elsewhere, (2) *Habitat change*; populations change as habitat changes, and usually from an unmodified to a modified state, (3) *Predation*; pressure from predators causes a decline in population size and, (4) *Wintering ground effects*; changes in numbers are related to habitat conditions in wintering areas (e.g., the reduction in food supply or loss of roosting habitat in northern estuaries). Detailed research on a species by species basis, or using a wider community-based approach are needed to test predictions based on these general hypotheses.

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