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3.4.7 Curlew sandpiper (*Calidris ferruginea*)

Between 5 and 63 curlew sandpipers (*Calidris ferruginea*) were counted each summer (Fig. 27), and 0–20 (12%) remained over winter (Table 13). Results from sites with comparative data indicated a 49% decline in numbers between 1983–1994 and 1994–2003, with the greatest decline at the Firth of Thames (74%). The only site where numbers increased was Manukau Harbour, which has become the second most important site after Lake Ellesmere (Te Waihora) (Table 20), even though birds were not sufficiently common here in 1984–1994 to be listed by Sagar et al. (1999). Lake Ellesmere (Te Waihora) and Manukau Harbour were the only sites that consistently supported curlew sandpipers; single counts of 30 birds in the Firth of Thames in 1994, 22 at Parengarenga Harbour in 1995 and six at Wairoa Estuary in 1998 have contributed markedly or entirely to the higher average counts at these sites.

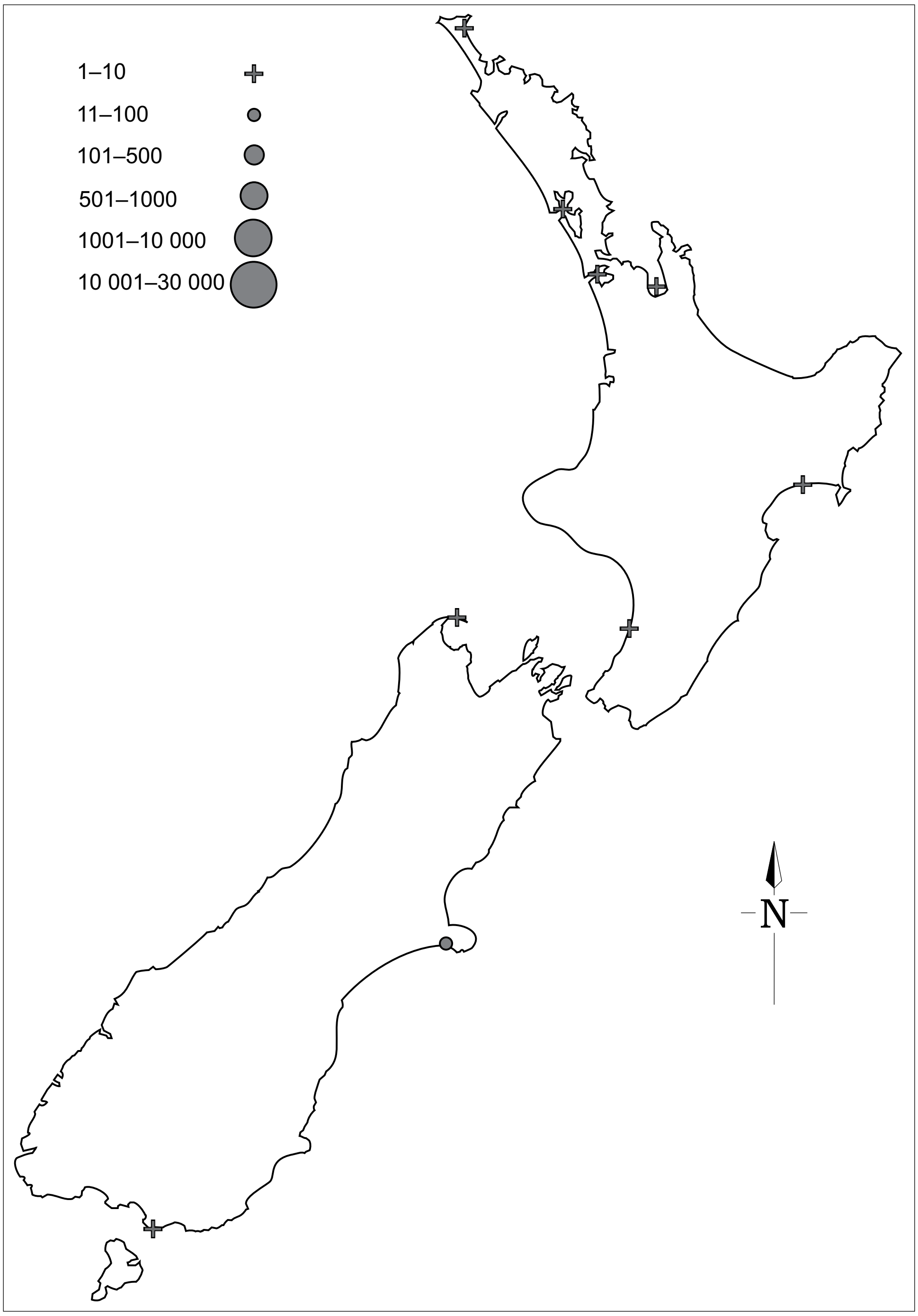
Relatively few birds (0%–8%) overwintered at most sites (Table 20). Manukau Harbour was the prime site for curlew sandpipers over winter, with 33% of the summer flock remaining there. In 1995, more birds overwintered at Manukau Harbour than were present there in summer. It is possible that the extra birds moved across from the Firth of Thames, where 30 had been counted in summer, but none had remained in winter.

TABLE 20. TEN-YEAR AVERAGES OF CURLEW SANDPIPER (*Calidris ferruginea*) COUNTS.

Data are presented for New Zealand sites where more than 1 bird on average was counted in summer between 1994 and 2003, or that had comparative data in Sagar et al. (1999). Summer counts are compared with those from the previous decade (Sagar et al. 1999); * = $P < 0.05$. n = the number of counts from which the average was calculated, SEM = standard error.

SITE	WINTER 1995–2003			SUMMER 1994–2003			SUMMER 1983–1993		
	COUNT	SEM	*n*	COUNT	SEM	*n*	COUNT	SEM	*n*
Lake Ellesmere (Te Waihora)	1	1	6	13	3	8	30*	5	11
Manukau Harbour	3	2	9	9	1	10			
Parengarenga Harbour	0	0	2	7	7	3	14	5	9
Firth of Thames	0	0	9	4	3	10	15*	3	11
Wairoa Estuary	0	0	3	3	4	2			
Awarua Bay	0	0	2	1	1	3	10*	3	11
Farewell Spit	0	0	3	1	1	10	3*	1	11

Figure 27. The distribution and abundance of curlew sandpipers (*Calidris ferruginea*) in New Zealand during summer between 1994 and 2003. Only sites with more than one bird, on average, are shown.



3.4.8 Sharp-tailed sandpiper (*Calidris acuminata*)

Between 8 and 37 sharp-tailed sandpipers (*Calidris acuminata*) were counted each summer (Table 13; Fig. 28). Comparisons of average counts with those reported at important sites by Sagar et al. (1999) indicate a decline of 71% in the numbers occurring in New Zealand (Table 21). Even the maximum count recorded during 1994–2003 was below the mean for the previous 10 years. Peak counts of 34 and 37 in 1994 and 2001, respectively, were followed by declines; in the remaining years, up to 17 birds were recorded.

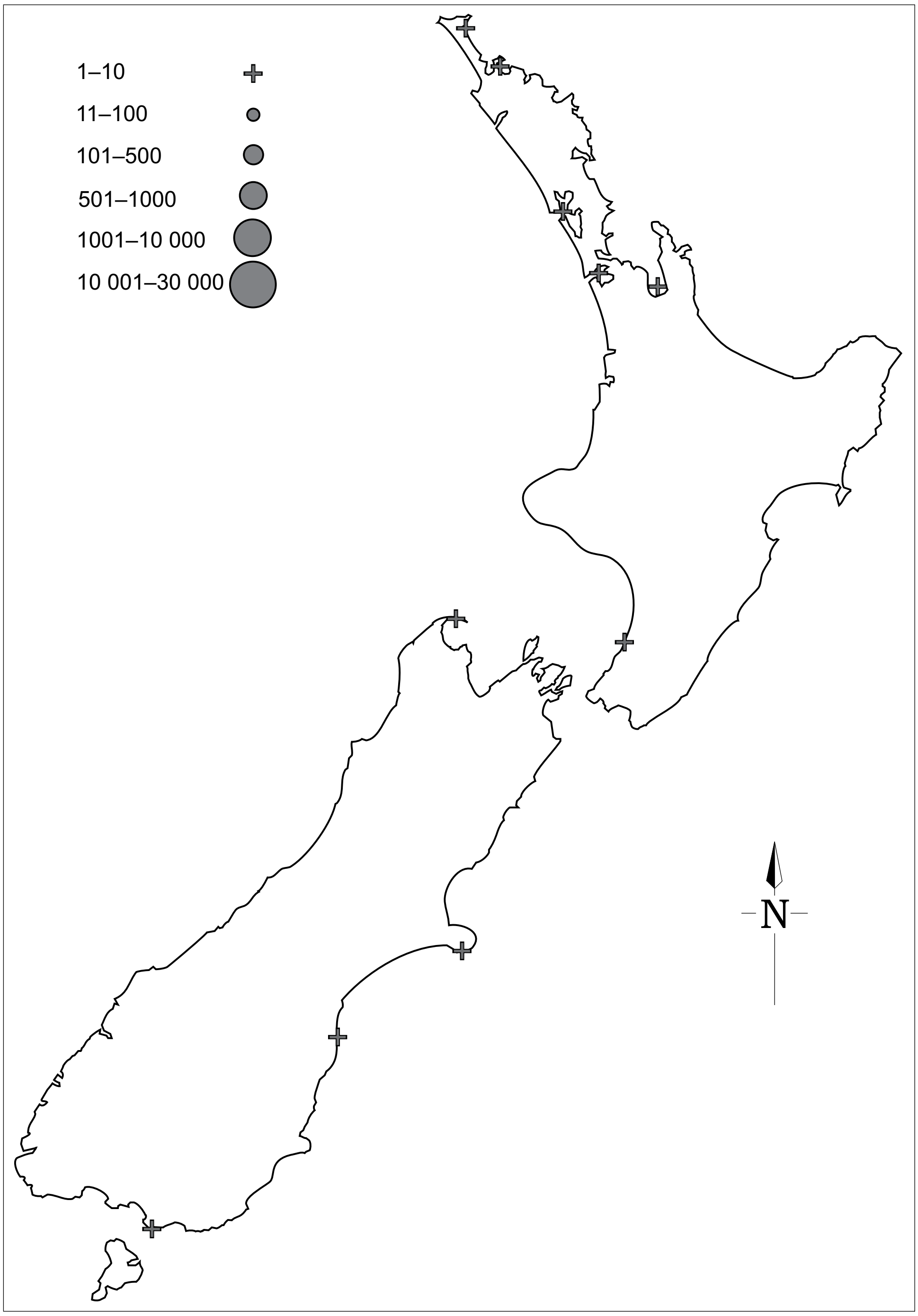
Sharp-tailed sandpipers seldom overwinter in New Zealand. Only one case was recorded: a flock of 12 birds at Parengarenga Harbour in 1997 (Table 13). Similarly, in most years Sagar et al. (1999) found that no birds overwintered, but in a single year (1992) 9 of the 15 birds they listed during summer were recorded.

TABLE 21. TEN-YEAR AVERAGES OF SHARP-TAILED SANDPIPER (*Calidris acuminata*) COUNTS.

Data are presented for New Zealand sites where more than 1 bird on average was counted in summer between 1994 and 2003, or that had comparative data in Sagar et al. (1999). Summer counts are compared with those from the previous decade (Sagar et al. 1999); * = $P < 0.05$. n = the number of counts from which the average was calculated, SEM = standard error.

SITE	SUMMER 1994–2003			SUMMER 1983–1993		
	COUNT	SEM	*n*	COUNT	SEM	*n*
Manukau Harbour	5	1	10	9*	2	11
Lake Ellesmere (Te Waihora)	5	2	8	11*	4	11
Wainono Lagoon (Lake Ki-Wainono)	3	1	8			
Farewell Spit	3	1	10			
Firth of Thames	3	1	10	13*	4	11
Kaipara Harbour	2	1	10			
Parengarenga Harbour	2	2	3			
Manawatu Estuary	2	0	1			
Kaituna Cut/Maketu Estuary	0	0	6	5*	1	11

Figure 28. The distribution and abundance of sharp-tailed sandpipers (*Calidris acuminata*) in New Zealand during summer between 1994 and 2003. Only sites with more than one bird, on average, are shown.



3.4.9 Eastern curlew (*Numenius madagascariensis*)

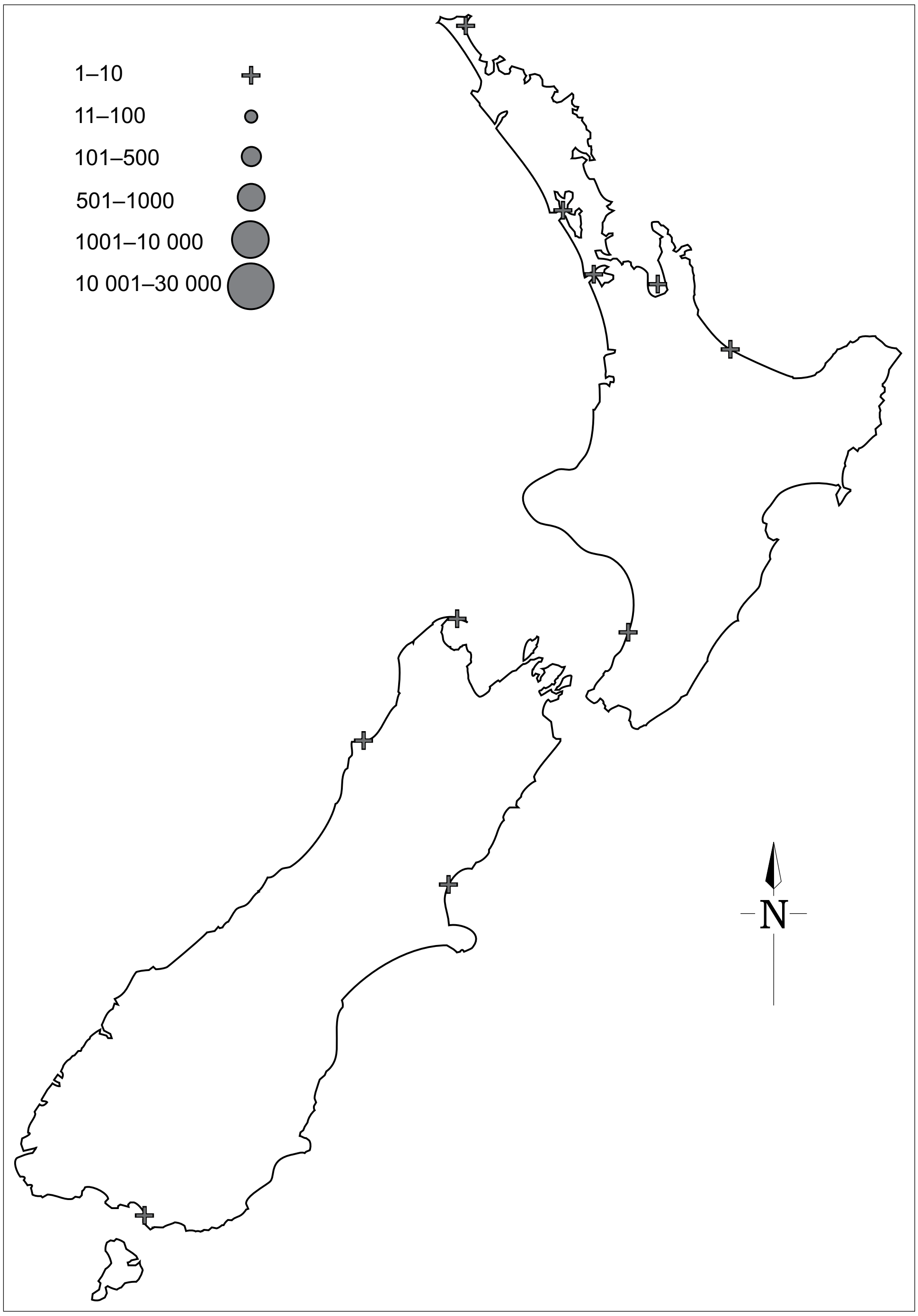
Between 11 and 28 (average 18) curlews (*Numenius madagascariensis*) were counted in summer (Fig. 29), and 1–24 in winter (Table 13). Comparison of specific sites suggests that there has been an 11% decline since 1983–1994 (Table 22). However, numbers seem to have remained more or less constant throughout the 1994–2003 period (Table 13), suggesting that the decline in numbers reaching New Zealand (Sagar et al. 1999) may have ended. The longer series of counts from the Firth of Thames and Manukau Harbour between 1960 and 2003 shows that there has been little overall change in total number at these sites, but a steady local decline at the Firth of Thames and a corresponding increase at Manukau Harbour (Veitch & Habraken 1999). There may be a continuing local trend of increase at Manukau Harbour at the expense of the Firth of Thames, but the combined average count for the last 5 years of this survey period (mean = 6, SEM = 1) is only half that recorded during the first 5 years (mean = 13, SEM = 3; $t = 4.7$, df = 4, $P < 0.01$). The proportion of the population that overwintered (23%) was quite large compared with other Arctic migrants. Sagar et al. (1999) and Veitch & Habraken (1999) also found a high proportion of birds overwintering (25% and 27%, respectively). Presumably, many of the curlews in New Zealand have not yet reached breeding age. In 1995, more birds were counted in winter ($n = 25$) than in the previous summer ($n = 17$) (Table 13).

TABLE 22. TEN-YEAR AVERAGES OF EASTERN CURLEW (*Numenius madagascariensis*) COUNTS.

Data are presented for New Zealand sites where at least 1 bird on average was counted in summer between 1994 and 2003, or that had comparative data in Sagar et al. (1999). Summer counts are compared with those from the previous decade (Sagar et al. 1999); * = $P < 0.05$. n = the number of counts from which the average was calculated, SEM = standard error.

SITE	WINTER 1995–2003			SUMMER 1994–2003			SUMMER 1983–1993		
	COUNT	SEM	*n*	COUNT	SEM	*n*	COUNT	SEM	*n*
Farewell Spit	1	0	3	8	3	3	8	1	11
Manukau Harbour	1	1	9	6	1	10	9*	1	11
Invercargill Estuary	1	1	2	3	1	3			
Firth of Thames	1	0	9	3	1	10	4*	1	11
Kaipara Harbour	1	1	9	3	0	10			
Parengarenga Harbour	0	0	2	3	3	3	2	0	8
Mouth of the Ashley River/ Rakahuri	0	0	6	2	0	8	1	0	10
Whangarei Harbour	0	0	9	0	0	10	1	1	11
Manawatu Estuary	0	0	0	1	0	1			
Orowaiti Lagoon	0	0	0	1	0	1			

Figure 29. The distribution and abundance of eastern curlews (*Numenius madagascariensis*) in New Zealand during summer between 1994 and 2003. Only sites with more than one bird, on average, are shown.



3.4.10 Pectoral sandpiper (*Calidris melanotos*)

Pectoral sandpipers (*Calidris melanotos*) were not common, but were recorded in all years but one. Up to 16 birds were recorded in summer counts (Fig. 30), but none were recorded in winter (Table 13). The main sites were Lake Ellesmere (Te Waihora) (average 3), Ahuriri Estuary (1), and Manukau Harbour (1). The overall numbers (average 5) were slightly higher than those from the previous decade (average 4; Sagar et al. 1999).

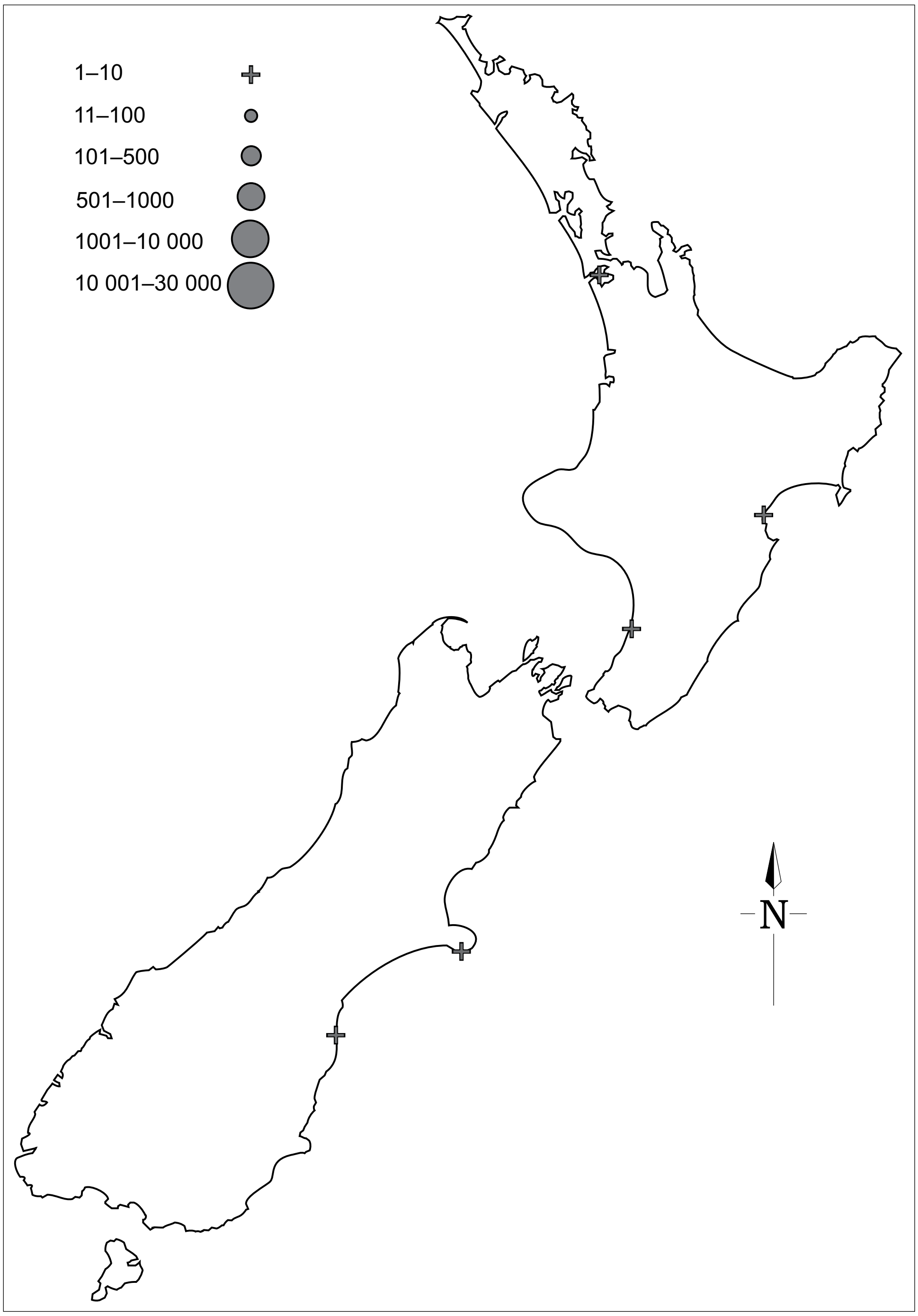


Figure 30. The distribution and abundance of pectoral sandpipers (*Calidris melanotus*) in New Zealand during summer between 1994 and 2003. Only sites with more than one bird, on average, are shown.

3.5 RARE WADERS

Nineteen other species of waders and one hybrid taxon were recorded during counts. For each of these, totals for the decade were less than 25 birds (Table 23). Since the count methodology clearly emphasised the common species of wader, rare species will often have been missed, especially when they were difficult to identify.

TABLE 23. NUMBERS OF RARE WADERS COUNTED IN NEW ZEALAND BETWEEN NOVEMBER 1994 AND JUNE 2003.

SPECIES	MEASURE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	TOTAL
American golden plover*	Winter count		0	0	0	0	0	0	0	0	0	0
	Summer count	0	0	0	0	0	0	0	0	0	1	1
Black-tailed godwit	Winter count		1	1	0	0	0	0	2	0	2	6
	Summer count	0	2	0	1	0	2	0	1	1	1	8
Broad-billed sandpiper	Winter count		0	0	0	0	0	1	0	0	0	1
	Summer count	1	0	0	0	0	1	1	0	1	0	4
Dunlin	Winter count		0	0	0	0	0	0	0	0	0	0
	Summer count	1	0	0	0	0	0	0	0	0	0	1
Great knot	Winter count		1	0	0	0	0	0	0	0	0	1
	Summer count	0	0	0	0	0	0	0	0	0	0	0
Grey plover	Winter count		0	1	0	0	0	0	0	0	0	1
	Summer count	0	1	0	0	0	0	0	1	4	0	6
Grey-tailed tattler	Winter count		0	1	0	1	0	0	0	0	0	2
	Summer count	3	1	4	0	4	1	0	3	2	3	21
Hudsonian godwit	Winter count		0	0	0	0	0	0	0	0	0	0
	Summer count	0	0	0	0	0	0	0	1	0	0	1
Large sand dotterel	Winter count		0	0	0	0	0	0	0	0	0	0
	Summer count	1	0	0	1	1	1	0	1	0	0	5
Least sandpiper*	Winter count		0	0	0	0	0	0	0	0	0	0
	Summer count	0	0	0	0	0	0	0	1	0	0	1
Little whimbrel	Winter count		0	0	0	0	0	0	0	0	0	0
	Summer count	0	0	0	0	0	0	0	2	0	1	3
Marsh sandpiper	Winter count		3	0	0	0	0	4	1	0	0	8
	Summer count	1	2	0	0	4	0	4	0	0	1	12
Mongolian dotterel	Winter count		0	0	0	0	0	0	0	0	2	2
	Summer count	1	2	0	2	2	2	1	1	0	1	12
Oystercatcher hybrid	Winter count		0	0	0	0	0	0	0	0	7	7
	Summer count	0	0	0	0	0	0	0	0	0	0	0
Red-necked phalarope	Winter count		0	0	0	0	0	0	0	0	0	0
	Summer count	0	0	0	0	0	0	1	0	0	0	1
Ruff	Winter count		0	0	0	0	0	0	0	0	1	1
	Summer count	0	0	0	0	0	0	0	0	0	0	0
Sanderling	Winter count		1	0	0	0	0	0	0	0	0	1
	Summer count	0	3	0	0	0	1	2	0	0	0	6
Shore plover	Winter count		0	0	0	0	0	0	0	0	0	0
	Summer count	0	0	1	0	0	0	0	0	0	0	1
Terek sandpiper	Winter count		0	0	2	0	0	0	0	0	0	2
	Summer count	0	0	3	1	1	2	2	1	2	1	13
Wandering tattler	Winter count		0	0	0	0	0	0	0	0	0	0
	Summer count	0	0	0	0	0	0	0	0	0	1	1

* Unconfirmed identification.

Several species of rare waders, such as marsh sandpipers (*Tringa stagnatilis*), appeared to be relatively common in winter. It is likely that great knots (*Calidris tenuirostris*) and black-tailed godwits (*Limosa limosa melanuroides*) were more easily found in the smaller winter flocks.

Although the majority of rare waders were Arctic migrants, two New Zealand breeding taxa were also recorded in low numbers. A shore plover (*Thinornis novaeseelandiae*) was seen at Waipu in November 1996, which probably originated from an unsuccessful attempt to re-establish the species in the Hauraki Gulf (Dowding & Murphy 2001). In addition, seven hybrid oystercatchers (*Haematopus ostralegus* x *unicolor*) were recorded from the mouth of the Ashley River/Rakahuri in June 2003. This reflects the small amount of interbreeding between variable and pied oystercatchers that has been recorded there in recent years (Andrew Crossland, OSNZ pers. comm.).

3.6 NEW ZEALAND COUNTS IN A FLYWAY CONTEXT

Recent population estimates for the East Asian Flyway and Australia in 1993 (Watkins 1993) and 2005 (Bamford et al. 2008) can be used to give an indication of how the counts from New Zealand reflect the wider context (Table 24). Comparing the average counts in New Zealand for 1983–1993 and 1994–2003 with the differences between single counts in 1994 and 2003 shows a broad agreement in terms of increases and decreases, but there is up to 50% variation in the amount of change indicated (Table 24). This result may be due to real differences in the datasets being compared, but may also be a consequence of the technique used: the difference between two points in fluctuating datasets is unlikely to provide a good representation of trends.

TABLE 24. POPULATION ESTIMATES AND TRENDS FOR THE WHOLE EAST ASIAN FLYWAY, AUSTRALIA AND NEW ZEALAND.

To make values comparable, the change in New Zealand has been recalculated using totals from all sites counted in both summer 1994 and summer 2003 (winter 1995 and winter 2003 for banded dotterel). The difference between counts is given as a percentage of the initial count. In addition, the percentage change between 10-year averages for 1983–1994 and 1994–2003 are given. Data for the East Asian Flyway and Australia are from Watkins (1993) and Bamford et al. (2008).

SPECIES	FLYWAY			AUSTRALIA			NEW ZEALAND			% CHANGE
	1993	2005	% CHANGE	1993	2005	% CHANGE	1994	2003	% CHANGE	1983–1994 TO 1994–2003
Banded dotterel*	50 000	50 000	0	30 000	N/A	N/A	7335	5406	–26	–16
Pacific golden plover	90 000	100 000–1 000 000	N/A	9000	N/A	N/A	231	229	–1	–50
Turnstone	28 000	35 000	+25	14 000	20 000	+43	3302	2314	–30	–46
Lesser knot	255 000	220 000	–14	153 000	135 000	–12	63 340	49 032	–23	–14
Curlew sandpiper	250 000	180 000	–28	188 000	118 000	–37	64	18	–72	–49
Sharp-tailed sandpiper	166 000	160 000	–4	166 000	140 000	–16	35	25	–29	–71
Red-necked stint	471 000	325 000	–31	353 000	270 000	–24	120	136	+13	+1
Eastern curlew	21 000	40 000	+90	19 000	28 000	+47	20	27	+35	–11
Whimbrel	40 000	100 000	+150	10 000	N/A	N/A	152	74	–51	–23
Bar-tailed godwit	330 000	325 000	–2	165 000	185 000	+12	105 560	83 001	–21	+9

* Banded dotterel population was assessed from winter counts, unlike other species.

Comparing the change in counts between 1994 and 2003 in New Zealand with those from Australia and the flyway in 1993 and 2005 probably does give a very general picture of population trends, however. There seem to be general declines in populations from all of the count units of lesser knots, curlew sandpipers and sharp-tailed sandpipers, suggesting that declines recorded in New Zealand reflect wider scale impacts. Bar-tailed godwit numbers may be approximately stable overall, as counts show either small increases or decreases. More interestingly, trends in New Zealand differ from those elsewhere for some species. Red-necked stints appear to have increased in New Zealand but declined elsewhere, while turnstones have declined in New Zealand despite numbers counted elsewhere having increased. Eastern curlews have also declined in New Zealand but not elsewhere (the suggestion of an increase between 1994 and 2003 is the result of unusually low counts returned in 1994). Also of interest is the apparently stable flyway population of banded dotterel, given the declines observed in New Zealand.

The ratio of first-year birds to older birds in canon net catches in Australia is also available for some species. In some cases, there are indications of a fairly simple relationship between the proportions of first-year birds and the numbers counted on census in New Zealand. Considering just the data from the Firth of Thames, Kaipara Harbour and Manukau Harbour, the only occasions when there was a rise in counts of curlew sandpipers (1999 and 2001) and red-necked stints (1998–2000 and 2001) were when more than 20% of birds captured in Australia were first-year birds (Minton 2003). However, similar percentages of young curlew sandpipers in Australian catches in 1997/8 and red-necked stints in 1995/6 did not lead to increased counts in those years (Fig. 31). There was a more definite signal for the turnstones, with increases following high proportions of first-year birds in Australia in 1997/8 and 1999/2000 (Minton 2003), probably because these birds are more abundant; however, the increase was delayed until winter, suggesting that the migration of these young birds was later than that of adults and fell between the census periods (Fig. 32). The drop off in numbers was also rapid, suggesting that frequent productive breeding seasons are needed to maintain good population numbers for these three species at least.

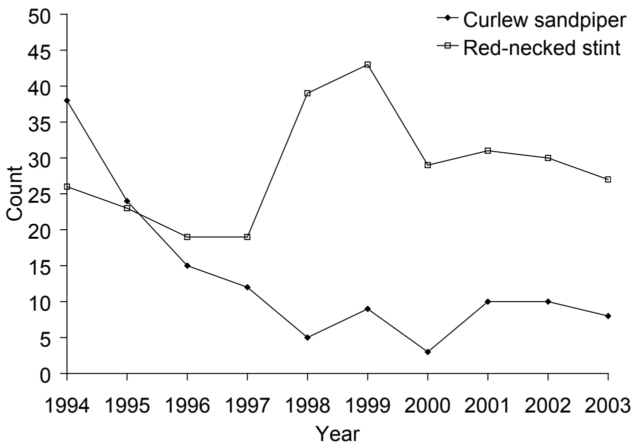


Figure 31. Counts of curlew sandpipers (*Calidris ferruginea*) and red-necked stints (*C. ruficollis*) from the Firth of Thames, and Kaipara and Manukau Harbours, New Zealand, during summer from 1994 to 2003.

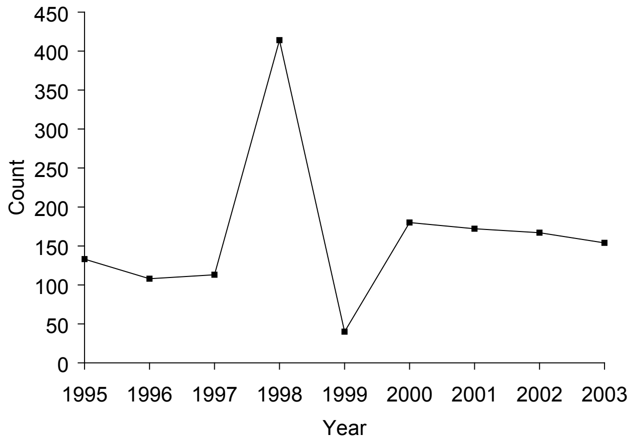


Figure 32. Counts of turnstones (*Arenaria interpres*) from Farewell Spit (1995 missing, replaced with mean), and Kaipara and Manukau Harbours, New Zealand, during winter from 1995 to 2003.

4. Discussion

4.1 POPULATION TRENDS

4.1.1 New Zealand breeding species

Many species of indigenous waders move to coastal sites after the breeding season and thus can be monitored well by these high-tide counts. This method is least effective for spur-winged plovers, which are largely terrestrial, and black-fronted dotterels, which prefer freshwater wetlands. While both these species appear to have increased, only a small proportion of their populations was available to be counted. Similarly, black stilt counts can be problematic, not only because more than 85% of individuals overwinter inland (Dowding & Moore 2004), but also due to the identification problems posed by immature plumages and hybrids.

Numbers of pied oystercatchers have increased steadily and spectacularly since 1940. Originally, they bred on braided riverbeds in the South Island; however, this habitat has become widely degraded by the spread of woody weeds (Dowding & Murphy 2001) and numbers have declined on Mackenzie Country riverbeds since the 1960s (Maloney 1999). They have, however, adapted to breeding on farmland (Baker 1973) and this is now an important breeding habitat. There was a lower rate of increase during 1994–2003 than during the previous decade (Sagar et al. 1999), suggesting that numbers may be stabilising. Pied oystercatchers have begun to colonise North Island sites in the Wairarapa and Hawke's Bay (Heather & Robertson 2000), however, and this foothold may be the prelude to further expansion of their breeding range.

The number of pied stilts appears to have increased by about 20% since the previous decade. Comparing 10-year means from Manukau Harbour and the Firth of Thames (Veitch & Habraken 1999) indicates that this change is within the range of previously recorded fluctuations but reflects a real increase in population size rather than the result of birds moving toward the coast in drier weather (Veitch 1999). A long-term banding study identified several sub-populations with different patterns of migration (Dowding & Moore 2004) and, based on changes at particular sites, these seem to have shown different trends. The stable populations at Ahuriri Estuary, Tauranga Harbour and Whangarei Harbour may reflect local birds breeding on the coast and inland. Parengarenga Harbour also has a locally resident population that may have increased. The numbers of pied stilts overwintering in the harbours of the Auckland isthmus have also increased, but they are a mixture of locally breeding birds and migrants from mid-Canterbury to Southland.

Wrybill numbers also appear to have increased by almost 30% over most of the sites tabulated by Sagar et al. (1999), with the population now averaging almost 4500 birds. Since the 1970s, numbers on the Firth of Thames and Manukau Harbour have averaged about 3770 birds (Veitch & Habraken 1999), suggesting a long-term average total population of about 4500 birds (Riegen & Dowding 2003). The lower numbers recorded in the mid-1980s by Sagar et al. (1999) may partly be the result of flooding on the breeding sites, as recorded by Hughey (1985) during the 1982 and 1983 breeding seasons. Whilst breeding, wrybills are also vulnerable to predation and probably loss of breeding habitat due to weed infestation (Riegen & Dowding 2003). Given these pressures, the constancy of the population size seems remarkable, and is perhaps due in part to the management of their breeding habitats in the Mackenzie Country by the Department of Conservation.

Numbers of northern New Zealand dotterels and, particularly, variable oystercatchers seem to have increased, continuing the trend reported by Sagar et al. (1999). Both species tend to favour the smaller harbours and estuaries along the northeastern North Island, and there are also large numbers of variable oystercatchers in the Nelson region. These increases appear to be the result not only of increasing numbers at some of the larger sites, but also of range expansion. Near the smaller estuaries that were identified by Sagar et al. (1999) as holding large numbers of variable oystercatchers, there now seem to be adjacent sites where large populations have developed in the last 10 years. This pattern is less obvious for New Zealand dotterels, as some sites had fewer birds; however, there are now significant numbers at sites that were not listed by Sagar et al. (1999). There has also been range expansion into Hawke's Bay and Taranaki (Heather & Robertson 2000). Predators have been controlled and human disturbance reduced at key sites on northern North Island beaches and harbours since the mid-1980s (Wills et al. 2003). This may explain the increase noted here, as about 20% of breeding pairs of northern New Zealand dotterels now occur at protected sites (Dowding & Murphy 2001; Wills et al. 2003). Since many pairs of variable oystercatchers are also encompassed by this protection, as they occupy similar habitats to northern New Zealand dotterels, it is tempting to also attribute the continuing increase in their numbers to this management. However, Crossland (2001) pointed out that numbers of this species seem to have increased a little earlier at some sites and in some places that are remote from the areas where protection was carried out.

By 1992, predation by cats (*Felis catus*) had reduced the population of southern New Zealand dotterels to about 60 birds (Dowding & Murphy 2001). However, since 1995, control of cats on Stewart Island/Rakiura has markedly improved adult survival and breeding success of the dotterels. Demographically, the southern form is quite different from the northern form, being more productive with a higher population turnover, which has resulted in a rapid increase in numbers since management began (Dowding & Murphy 2001). The total population was over 200 birds in 2004 (Dowding & Moore 2004). Since the two counts from Southland in this study were carried out very early in the recovery phase and no counts were made on Stewart Island/Rakiura, this population change is poorly documented here.

The one species of endemic wader that has clearly declined in numbers during the period of these counts is the banded dotterel. Several distinct sub-populations with different migratory behaviours have been identified from a large-scale banding study (Pierce 1999), but not all of these were well monitored by these counts. Most of the populations that breed between inland Canterbury and Southland migrate to southeastern Australia after breeding (Pierce 1999), and so are not covered by these counts. Some of these birds may overwinter at Lake Ellesmere (Te Waihora), where numbers went against the general trend, increasing by 38% in winter. Counts made at North Island sites in this study largely monitored banded dotterels breeding in the central North Island and Marlborough.

Two-thirds of the birds counted on Farewell Spit came from Marlborough and the West Coast (Pierce 1999). Most of these populations have declined since the previous decade. At present, a commonly used population estimate for banded dotterel is 50 000 birds, 20 000 of which overwinter in New Zealand and the remainder in Australia (e.g. Pierce 1999; Heather & Robertson 2000; Barter 2002). This total was based on counts from Australia, unpublished data from breeding sites and the proportions of colour-banded birds seen at non-breeding sites (Dowding & Moore 2004). Based on this study, however, substantially lower estimates of 5083–7335 were derived between 1995 and 2004. These estimates are not complete, as some moderately important overwintering sites (e.g. Whangapoua Harbour, Lake Grassmere/Kapara Te Hau and Lake Wairarapa; Dowding & Moore 2004) were not counted and some birds overwinter *in situ* in spite of harsh conditions (Pierce 1999; Sagar et al. 1999). However, even given this, it is difficult to justify a figure of 20 000 from the counts considered here.

For the banded dotterel, the overall picture is one of decline, as the population seems to have been very much higher in the 1940s, with counts of 1000+ and 2000 at Waitakaruru on the Firth of Thames, 3000 at Ohiwa Harbour, and 500–1000 at Mangere on the Manukau Harbour (Fleming & Stidolph 1951). Furthermore, they must have declined quickly, as average census counts at Manukau Harbour (337) and the Firth of Thames (44) were much lower during the 1960s (Veitch & Habraken 1999) than counts during the 1940s (Fleming & Stidolph 1951). More recent counts from these sites suggest that there was a slow, fluctuating recovery that peaked during the 1980s, followed by a decline (Veitch & Habraken 1999). The results from this study suggest that this decline is ongoing.

4.1.2 Arctic migrants

Situated at the extreme end of the East Asian Flyway, New Zealand receives an important proportion of the populations of only three species of long-distance migrants—eastern bar-tailed godwit, lesser knot and turnstone. The most common of these is the bar-tailed godwit. The Alaskan subspecies of bar-tailed godwit (*Limosa lapponica baueri*) that overwinters here has a population estimated at 170 000 birds (Barter 2002); at least 95 000 (56%) of these spent the non-breeding season in New Zealand during this study. Numbers have remained fairly constant at Manukau Harbour and the Firth of Thames since 1960 (Veitch & Habraken 1999), suggesting a stable population. Although there has been a steady decline in population size during the decade covered by these counts, the figures still fall within the range shown by Sagar et al. (1999) for the previous decade, and the overall population estimate is only a little less (Table 13).

There are thought to be c. 220 000 lesser knots (*Calidris canutus rogersi* and *C. c. piersmai*) visiting Australia and New Zealand each year (Barter 2002). Based on the estimate derived from these data, the almost 50 000 birds in New Zealand represent 23% of the total population. Generally, the lesser knots wintering in New Zealand and southern and eastern Australia have been regarded as belonging to the subspecies *rogersi*, while those in northwestern Australia are *piersmai*, but it has been suggested that both subspecies occur in New Zealand (Tomkovich & Riegen 2000). Overall, there seems to have been a fluctuating tendency for decline during the 10 years of this study. However, local trends in lesser knot populations are considerably different, with fairly large increases and decreases in numbers at different sites between the two 10-year periods (Table 15). This pattern has also persisted over the longer term, with a large and fairly steady decline in numbers counted at Farewell Spit, and a smaller decline at the Firth of Thames since 1960, both of which were balanced by an increase at Manukau Harbour over the same period (Veitch & Habraken 1999; Schukard 2002). This study suggests that between 1994 and 2003 the numbers of birds at the Firth of Thames and Kaipara Harbour have started to increase again, while there have been declines at Farewell Spit and Manukau Harbour. This shows that lesser knots are far more dynamic spatially than any other species of wader in New Zealand and are thus best monitored by a nationwide count.

Turnstones are one of the less common long-distance migrants, with a flyway population of 35 000 birds (Bamford et al. 2008). The New Zealand population of 2500 birds comprises about 8% of this total. In the previous decade, Sagar et al. (1999) suggested that 18% of the population migrated to New Zealand; in the decade of this study, the Australian estimate rose as the New Zealand one decreased (Table 24). Considering data from both sets of counts, the New Zealand turnstone population has been in almost continual decline since 1983. Since the 1960s, the numbers of turnstones at the Firth of Thames and Manukau Harbour increased to reach a peak in the 1980s and then they began to decline again (Veitch & Habraken 1999). At these sites, the numbers counted during this study were close to those from 40 years earlier.

The other species of Arctic migrants in New Zealand are much less common and make up only a very small proportion of the flyway populations. Of these species, only red-necked stints and pectoral sandpipers appear to have occurred in similar numbers to the previous decade. The apparent decline in whimbrel and eastern curlew numbers is small, but Pacific golden plover and curlew sandpiper counts have more or less halved, while counts of sharp-tailed sandpipers are down by more than two-thirds.

4.2 SITE USE DURING THE NON-BREEDING SEASON

4.2.1 New Zealand breeders

While winter counts of New Zealand breeders generally exceeded summer counts, the reverse was true for banded dotterels and pied oystercatchers from the Southland region, and for pied stilts from Lake Ellesmere (Te Waihora) south to Southland. Extensive banding projects with banded dotterels (Pierce 1999) and pied stilts (Dowding & Moore 2004) in New Zealand showed that both species were divided into sub-populations that had different migratory behaviours and that utilised different wintering sites. The pied oystercatchers monitored by these counts showed similar differences between sites in the way their counts changed seasonally, suggesting that they may also have a structured population; for example, most of the birds from Southland seem to migrate away from the region in winter.

For these species, the higher numbers of birds counted in summer at southern sites will have consisted partly of relatively sedentary coastal and lowland breeders, and perhaps failed breeders from inland sites. In addition, pre-breeding age banded dotterels, pied stilts and presumably pied oystercatchers migrate toward the breeding areas (Sagar et al. 1999; Dowding & Moore 2004), which may explain the higher numbers at nearby sites. There was also an increase in wrybills during summer at Lake Ellesmere (Te Waihora) (Table 7). Since about half of the young birds return south in spring (Davies 1997), some of these are likely to have been young birds that had not yet established a breeding territory. Similarly, banded dotterel numbers were relatively high during summer in the Hawke's Bay and Canterbury regions, suggesting that young birds may also be congregating on the coast near these important inland breeding sites.

4.2.2 Arctic migrants

Provided they are able to build up sufficient energy reserves, adult Arctic migrants are expected to return to their breeding sites in the austral autumn. The majority of the populations that remain during the austral winter are usually composed of young birds that have not reached breeding age. Even the apparently higher proportion of adult lesser knots in winter may simply reflect difficulties in aging some birds (Battley 1999). If the relative quality of the sites is the same in winter as it is in summer, a similar proportion of the summer flocks of Arctic migrants might be expected to remain over winter at each site. This was true for bar-tailed godwits, with the proportion of the summer flock counted during winter varying little between most sites. In contrast, lesser knots showed a quite different pattern, with only a very small proportion of the summer flock (2%–6%) remaining at most sites except Manukau Harbour (17%), which equated to an average of 78% of the national population in winter. Turnstones appeared to be intermediate, with about 10% of the summer totals remaining at most sites, but fewer in the Southland region and, perhaps, more at Farewell Spit.

Regional differences in the seasonal use of some sites by lesser knots and probably also turnstones suggested local movements within New Zealand. Presumably this reflects changes in food supply, perhaps exacerbated by the winter climate. Given the predominance of pre-breeding birds in the flocks remaining over the southern winter, the favoured sites are disproportionately important for the recruitment of breeding adults. An example of this is the premier importance of Manukau Harbour for lesser knots.

4.3 CHANGING SITE USE

Among the trends and fluctuations in this dataset there seems to have been a consistent shift in importance between the Firth of Thames and Manukau Harbour for several species. For example, traditionally, the Firth of Thames has been the main wintering site for wrybills, but Veitch & Habraken (1999) noted a difference in trends between counts at the two sites, with numbers apparently beginning to converge since the 1980s. This trend has continued, resulting in more birds being counted at Manukau Harbour than at the Firth of Thames since June 2000. Similarly, there were consistently more lesser knots on the Firth of Thames until the late 1970s (Veitch & Habraken 1999), following which the number of birds declined on the Firth of Thames and increased at Manukau Harbour. This trend may be reversing now, with an increase in numbers on the Firth of Thames and a decrease at Manukau Harbour between the 1983–1994 and 1994–2003 periods. Manukau Harbour has also become increasingly important as an overwintering site for lesser knots and birds may congregate there from throughout New Zealand.

Numbers of less common species at these two sites have also been affected. Counts of Pacific golden plovers have declined during the two count periods to c. 25% and 13% of their previous totals at Manukau Harbour and the Firth of Thames, respectively. When the same data were used by Veitch & Habraken (1999) to compare the 1980s with the 1990s, there was an even larger contrast. Observations throughout the year over the time period covered by these studies showed that the large number of zero counts at Manukau Harbour were a result of birds not being found, whereas the once important roosts on the southern shores of the Firth of Thames have been abandoned (Tony Habraken, OSNZ, pers. comm.). The only well-known and well-counted site where numbers of red-necked stints have declined was the Firth of Thames; numbers at Manukau Harbour remained stable. While the number of curlew sandpipers has halved nationally since 1983–1993, the number at the Firth of Thames has declined by 75%; Manukau Harbour was the only site where numbers increased, making it the second most important site in the country, even though this species was rarely seen there before 1992 (Veitch & Habraken 1999). The number of eastern curlews visiting New Zealand, including the Firth of Thames, has decreased recently; however, the population at Manukau Harbour has risen and perhaps now stabilised (Veitch & Habraken 1999).

While the Firth of Thames and Manakau Harbour are the best monitored sites, there may also have been long-term changes elsewhere. Between 1983 and 2001, numbers of pied oystercatchers declined at Golden Bay and Tasman Bay, but increased at Farewell Spit (Schukard 2002). Between the 1983–1994 and 1994–2003 periods, all three sites had statistically significant declines, unlike the Firth of Thames, Kaipara Harbour and Manukau Harbour, where the number of pied oystercatchers increased. Numbers of lesser knots declined even more substantially at Farewell Spit than anywhere else during this study, following on from a long period of decline there (Schukard 2002).

These changes in counts of particular species at specific sites that do not reflect the wider trend might reflect impacts from local habitat change. It has been shown that black-tailed godwits in England maintain a fairly constant population size at good non-breeding sites, where birds have a higher prey intake, better survival and earlier arrival on the breeding grounds, whereas the population varies greatly at poorer sites (Gill et al. 2001). Where populations have generally declined, it could be argued that proportional changes in counts may reflect differences in habitat quality. This may be the case for the increased proportion of lesser knots using Manukau Harbour in winter, which may simply highlight the premium importance of that site for this declining species. Wrybills, on the other hand, have clearly maintained a constant population, and if their numbers reflect site quality, then there must have been habitat changes underlying the shift of the main population from the Firth of Thames to Manukau Harbour. Also convincing are the counts of curlew sandpipers and eastern curlews, which show quite different trends at Manukau Harbour and the Firth of Thames than seen across the country as a whole. There has been speculation that the increasing area of mangroves (*Avecinnia marina*) on the Firth of Thames may have been responsible for this shift (e.g. Riegen & Dowding 2003), but there have been many changes to the habitats at both sites (Veitch & Habraken 1999) that could have impacted on the habitat quality for wading birds.

In at least some of these cases, birds do actually seem to have shifted sites, suggesting changes in habitat quality have occurred rather than preferential declines of these species at poorer sites. Species such as the wrybill and lesser knot, which depend on a very small number of sites nationally, are clearly vulnerable to changes at their wintering sites.

4.4 ARCTIC MIGRANTS, NEW ZEALAND AND THE EAST ASIAN FLYWAY

Unfortunately, the decline in so many wader populations in New Zealand is not unexpected. There appears to be a widespread trend for declining wader populations, particularly for long-distance migrants. Of 207 populations worldwide for which trends are known, 92 (44%) have decreased and only 27 (13%) have increased (Zöckler et al. 2003). Although these declines are almost universal, the causes of them are hard to pin down, with many different reasons being suggested in different studies (Zöckler et al. 2003). It may be fair to characterise these causes as being related to either climate change or varied human pressures on specific habitats along the flyway. It has been suggested that climate change may be having a long-term impact on ruff (*Philomachus pugnax*), but it is a difficult phenomenon to prove (Zöckler 2002).

Breeding success may affect the numbers of at least some wader species. When species sharing the same breeding areas show similar trends in the proportions of yearling birds in their flocks but different trends from those nesting elsewhere, it may be fair to suspect that factors such as predation pressure and weather conditions operating on the breeding sites are important (Minton 2003). However, there are wider concerns too.

Recent research indicates that the links on a flyway are tight and interdependent, with the birds operating near the limits of their capabilities. To make the prodigious flights necessary to link the sites they use through the year, migratory waders reorganise their whole body. For instance, in lesser knots the wing and heart muscle masses increase along with fat and protein reserves, while non-essential organs such as the gut, kidneys and leg muscles reduce in size (Battley et al. 2000). In spite of this, wind assistance may still be required for lesser knots to carry out their migration within their energy budgets (Piersma et al. 1991), which must place these birds under extreme selective pressure to meet the demands of preparation for and recovery from migration on top of breeding and moulting.

Better non-breeding sites, where there is enhanced prey uptake and survival, allow the earlier departure of migrating black-tailed godwits, which, in turn, has been shown to influence breeding site quality and productivity (Gunnarsson et al. 2005). Early arrival at staging sites before the food is depleted is expected to be advantageous (Drent et al. 2003; Schekkerman et al. 2003), and food failure at staging sites can be critical. This has been shown for lesser knots (*Calidris canutus rufa*) staging at Delaware Bay, where catastrophic food failure due to overharvesting of horseshoe crabs (*Limulus polyphemus*) had critical impacts, leading to loss of body condition followed by dramatically reduced productivity, recruitment and adult survival, and a loss of 50% of the wintering population between 2000 and 2002 (Baker et al. 2004; Morrison 2006). However, more subtle effects will also cause population declines. Commercial dredging of shellfish in the Dutch Wadden Sea led to annual declines of 2.6% in the settlement of young cockles and an 11.3% annual decline in food quality (flesh to shell ratio) for lesser knots (*Calidris canutus islandica*), reducing their survival. A third to a half of the entire population of this subspecies winters or stages in the Dutch Wadden Sea and the decline observed there was sufficient to account for the 25% decline recorded throughout northwestern Europe between 1997–8 and 2002–3 (van Gils et al. 2006). European oystercatchers (*Haematopus ostalegus*) are also sensitive to the amount of food available in winter, so that shellfishing leads to reduced body condition and survival (Stillman et al. 2003; Atkinson et al. 2005; Verhulst et al. 2004); a concurrent decline in breeding success was also observed, but the link between this and shellfishing was not tested (Verhulst et al. 2004). Many birds were dying when only a fraction of the available food was consumed, as dominance relationships led to the exclusion of some birds from preferred feeding sites (Stillman et al. 2003).

For bar-tailed godwits (*Limosa lapponica taymyrensis*), many key parameters that are probably related to breeding success, and short- and long-term survival seem to be already determined when they arrive at their spring staging site on the Dutch Wadden Sea. These characteristics appear to be signalled by the intensity of their breeding plumage; however, the fact that plumage colour for individual birds does not seem to vary much between seasons (Drent et al. 2003) suggests that the quality of individuals is determined early in life. Right from their first capture, the body condition index of lesser knots (*Calidris canutus islandica*) captured at a staging site in Iceland was higher in birds that were recaptured in subsequent years than in birds that were not, and this was particularly marked during seasons that had harsh weather with low temperatures or late snow cover (Morrison 2006). This also suggests that bird quality is a lifetime, rather than a seasonal, attribute.

There may be a genetic component to the survival and lifetime productivity of individual birds, but the quality of the habitats they occupy as they mature must also be an important factor in population dynamics. A population of semipalmated sandpipers that was monitored during the last stages of a decline from abundance to extinction actually showed increased breeding success—enough for the population to increase, all things being equal. Unfortunately, the return rates of the adults to the breeding grounds fell, fewer young returned to breed and those that did return bred only once before disappearing. These factors indicate a decline in bird quality and the high breeding success indicates that it happened away from the breeding grounds. Semipalmated sandpipers stage at Delaware Bay and may have been affected by the same food failure that impacted on the lesser knots there; however, the decline in this species has been occurring for at least 50 years and few birds remained by the time this event took place (Jehl 2007). Similarly, a long-term decline in the number of curlew sandpipers overwintering in Victoria, Australia, seems to be a consequence of reduced adult survival rather than breeding failure or the mortality of young birds prior to completing their first migration (Rogers & Gosbell 2006).

It is likely that different species will have evolved different strategies for negotiating the flyway, but that impacts in one place will be quickly felt along the flyway, making it difficult to unravel local effects without making direct measurements. Although speculative, it seems that the quality of non-breeding sites in New Zealand, for example, could have a large influence on the lifetime productivity of birds maturing here as well as affecting the year-to-year survival and productivity of adults. The habitat quality of wintering sites used by sub-adult New Zealand breeding waders may have similar effects, so changes to these habitats (e.g. Veitch & Habraken 1999) must be of concern.

Declines in the numbers of Arctic migrants reaching New Zealand are not, however, necessarily matched by declines elsewhere. For example, although numbers of Pacific golden plovers have fallen severely in New Zealand, in Hawaii this species appears to have benefited from urbanisation and numbers seem to have increased. Thus it is possible that the decline of this species in Australia and New Zealand may be due to 'short stopping' in places like Hawaii (Johnson 2003), where improving conditions allow birds to overwinter closer to their breeding sites. Similarly, one could also speculate that more turnstones and eastern curlews stop over in Australia than formerly, as the populations there appear to have increased while they have declined in New Zealand. Given the indications that young turnstones move from Australia to New Zealand after the main period of migration, there may be less incentive to leave Australia when conditions are more favourable there. This highlights the need to consider the wider context when interpreting these counts.

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Appendix 1

COMMON AND SCIENTIFIC NAMES OF THE WADERS COUNTED IN NEW ZEALAND BETWEEN 1994 AND 2003

COMMON NAME	SCIENTIFIC NAME
Pied oystercatcher	*Haematopus ostralegus finschi*
Variable oystercatcher	*Haematopus unicolor*
Hybrid oystercatcher	*Haematopus ostralegus* x *unicolor*
Pied stilt	*Himantopus himantopus leucocephalus*
Black stilt	*Himantopus novaezelandiae*
Hybrid stilt	*Himantopus novaezelandiae x leucocephalus*
Northern New Zealand dotterel	*Charadrius obscurus aquilonius*
Southern New Zealand dotterel	*Charadrius obscurus obscurus*
Banded dotterel	*Charadrius bicinctus bicinctus*
Black-fronted dotterel	*Charadrius melanops*
Large sand dotterel	*Charadrius leschenaultii*
Mongolian dotterel	*Charadrius mongolus*
Shore plover	*Thinornis novaeseelandiae*
Wrybill	*Anarhynchus frontalis*
Pacific golden plover	*Pluvialis fulva*
American golden plover	*Pluvialis dominicana*
Grey plover	*Pluvialis squatarola*
Spur-winged plover	*Vanellus miles novaehollandiae*
Turnstone	*Arenaria interpres*
Lesser knot	*Calidris canutus*
Great knot	*Calidris tenuirostris*
Sanderling	*Calidris alba*
Dunlin	*Calidris alpina*
Curlew sandpiper	*Calidris ferruginea*
Sharp-tailed sandpiper	*Calidris acuminata*
Pectoral sandpiper	*Calidris melanotos*
Red-necked stint	*Calidris ruficollis*
Least sandpiper	*Calidris minutilla*
Broad-billed sandpiper	*Limicola falcinellus*
Ruff	*Philomachus pugnax*
Eastern curlew	*Numenius madagascariensis*
Whimbrel	*Numenius phaeopus*
Little whimbrel	*Numenius minutus*
Eastern bar-tailed godwit	*Limosa lapponica baueri*
Black-tailed godwit	*Limosa limosa melanuroides*
Hudsonian godwit	*Limosa haemastica*
Wandering tattler	*Tringa incana*
Grey-tailed tattler	*Tringa brevipes*
Marsh sandpiper	*Tringa stagnatilis*
Terek sandpiper	*Tringa terek*
Red-necked phalarope	*Phalaropus lobatus*

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