

Annual waterfowl counts in south-west Western Australia - 1991/92

S.A. HALSE¹, G.B. PEARSON¹, R.M. VERVEST² AND F.H. YUNG¹

¹Science and Information Division, Department of Conservation and Land Management, Wildlife Research Centre, PO Box 51 Wanneroo 6065, Western Australia.

²Royal Australasian Ornithologists Union, PO Box 199, Jolimont 6014, Western Australia.

ABSTRACT

Totals of 255 976 waterfowl, 99 nests and 766 broods were counted at 1102 wetlands in south-west Western Australia in November 1991 in a program conducted jointly by the Department of Conservation and Land Management and the Royal Australasian Ornithologists Union. In March 1992, 212 353 waterfowl, 3 nests and 21 broods were counted in 1084 wetlands. Black Swans, Eurasian Coots, 11 species of native ducks, and four species of exotic ducks, geese and swans were counted. Extrapolation of November and March counts suggests that there were c. 1 400 000 waterfowl in south-west Western Australia during the 1991/92 summer. Grey Teal were the most abundant species in both November ($356\,178 \pm 105\,648$) and March ($277\,424 \pm 136\,150$). Lakes supported 76 per cent of waterfowl in November and 65 per cent in March. Esperance and Wagin regions each contained approximately 20 per cent of the total estimated waterfowl population.

INTRODUCTION

In 1988 the Department of Conservation and Land Management (CALM) and the Royal Australasian Ornithologists Union (RAOU) began a four-year program of biannual waterfowl counts in south-west Western Australia (WA) to provide additional information about numbers and distribution of waterfowl in WA. Although counts of waterfowl numbers had previously been made for individual wetlands (e.g. Ford 1958; Sedgewick 1973), the only large-scale surveys in south-west WA were those of Jaensch *et al.* (1988) and Jaensch and Vervest (1988a,b). In addition to the biannual waterfowl counts, CALM and the RAOU conducted a more intensive three-year study of all waterbirds on c. 250 wetlands on the Swan Coastal Plain, near Perth, from 1989 to 1992 (Storey *et al.* 1993).

The program of biannual waterfowl counts was an extension of the March surveys conducted between 1986 and 1988 by Jaensch and Vervest (1988a,b) and used a fixed set of c. 1250 wetlands for survey by volunteers and CALM staff in November and March of each 'summer' period, starting in November 1988 (Halse *et al.* 1990, 1992). Larger or more inaccessible wetlands were surveyed from the air. The objectives of the biannual counts were: (1) to estimate numbers of ducks, swans and coots in south-west WA; (2) to examine regional distribution of the species each year in relation to wetland conditions; and (3) to compare regional distribution and types of wetlands used during the breeding season and in late summer.

This paper reports results for 1991/92, which was the final year of counting. Earlier counts were reported in Halse *et al.* (1990, 1992, 1994). Results for large-scale waterfowl counting programs elsewhere in Australia have been reported by Bayliss and Yeomans (1990a,b), Kingsford *et al.* (1992) and Peter (1992).

SURVEY DESIGN

The survey design was described by Halse *et al.* (1990, 1992, 1994) and only brief details are given here.

Survey methods

Thirteen native and four exotic species of waterfowl were counted: Black Swan (*Cygnus atratus*), Freckled Duck (*Stictonetta naevosa*), Australian Shelduck (*Tadorna tadornoides*), Pacific Black Duck (*Anas superciliosa*), Grey Teal (*A. gibberifrons*), Chestnut Teal (*A. castanea*), Australasian Shoveler (*A. rhynchotis*), Pink-eared Duck (*Malacorhynchus membranaceus*), Hardhead (*Aythya australis*), Maned Duck (*Chenonetta jubata*), Blue-billed Duck (*Oxyura australis*), Musk Duck (*Biziura lobata*), exotic swans, geese and ducks (Mute Swan, *Cygnus olor*; Greylag Goose, *Anser anser*; and domestic varieties of Mallard, *Anas platyrhynchos*, and Muscovy, *Cairina moschata*) and Eurasian Coot (*Fulica atra*).

Counts were made during nine-day periods (two weekends and the intervening week) towards the end of the breeding season in 1991 (16-24 November), and in early autumn 1992 when the birds were concentrated at 'summer' refuges (7-15 March).

The surveyed area in the South-West and the south-western part of the Eucla Land Divisions in south-west WA was divided into 20' blocks (Fig. 1). As far as possible, two permanent lakes with potential as summer refuges, two lakes (often seasonal) with potential as breeding sites, five farm dams and two sections of river were surveyed in each 20' block. All major estuaries¹ between Perth and Esperance were surveyed. Table 1 summarizes the number of wetlands surveyed in November 1991 and March 1992. For analysis of the distribution of waterfowl and its relation to rainfall, 20' blocks were grouped into 11 'regions' (Fig. 1) (Halse *et al.* 1990,1992).

Most wetlands were surveyed from the ground by 120 volunteer RAOU observers or by CALM staff. Some larger inland lakes, some lakes and river sections with difficult access, and all larger estuaries were surveyed from the air

over a four-day period using a Cessna Cutlass 172 flying at about 70 knots at a height of 25-30 m. Wetlands counted from the air are marked in Appendix 2². Observers recorded the number of birds, the number of nests containing eggs and the number of broods they saw at each wetland. They also recorded water depth (dry, <0.5 m, 0.5-<1.0 m, ≥1.0 m). Emergent vegetation in the inundated part of the each wetland was recorded during earlier surveys and the wetland assigned to a category reflecting the dominant type of vegetation (Halse *et al.* 1992). The categories were live trees, live trees and sedges, sedges, dead trees, samphire and open wetland (no vegetation).

¹ We use the term 'estuary' colloquially to include several wetlands, most notably Vasse-Wonnerup Estuary, that are not truly estuarine.

² Appendix 2 is lodged in the Wildlife Sciences Library, Department of Conservation and Land Management, PO Box 51, Wanneroo 6065.

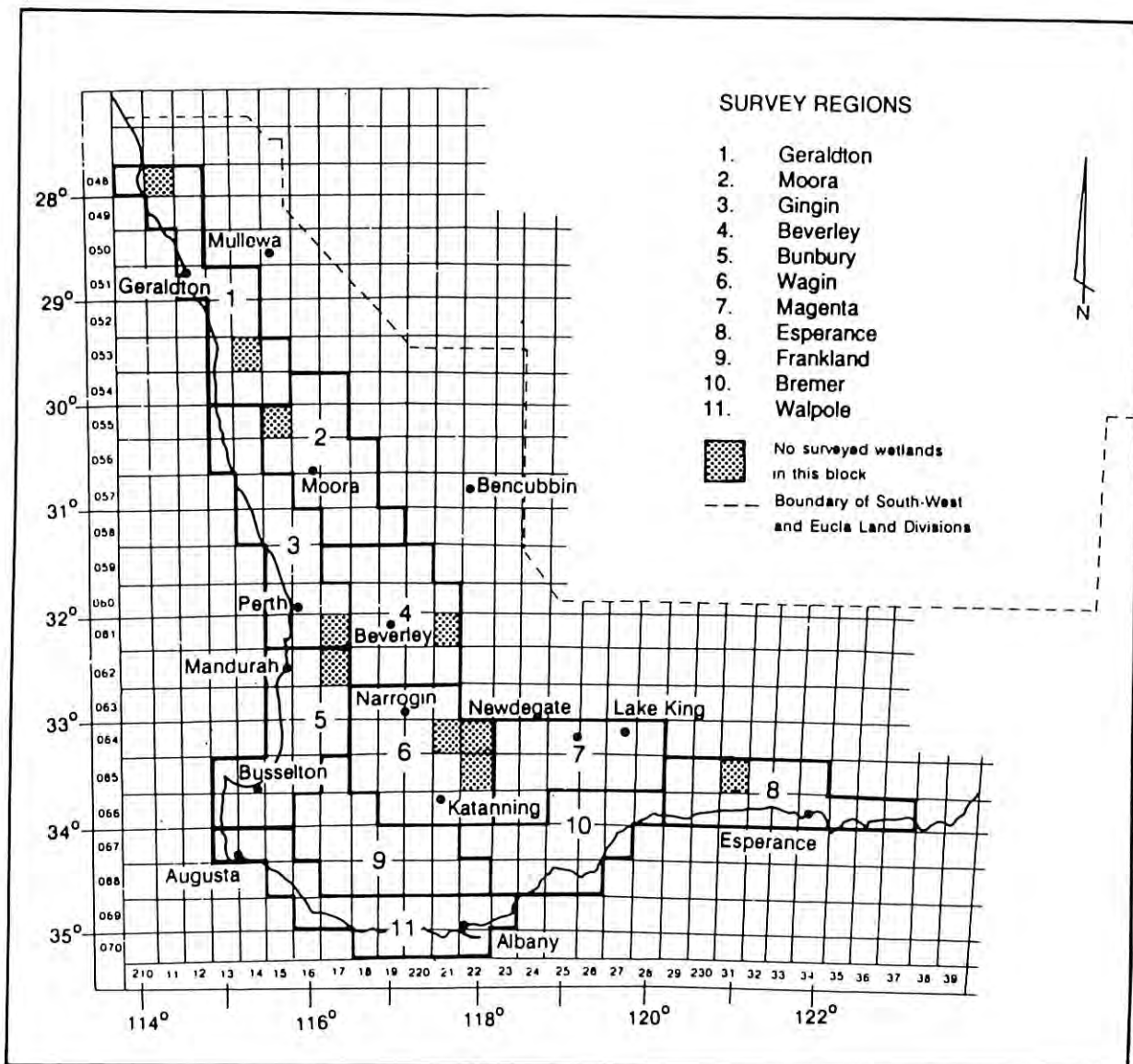


Figure 1. The area surveyed in the biannual waterfowl counts and regions recognized within the surveyed area. The 20' blocks, which form the basis of the survey design, are marked.

TABLE 1

Numbers of wetlands surveyed in each region in November 1991 and March 1992 compared with the number of wetland 'units' (see text) of each type identified from topographic maps. Figures in parentheses represent numbers of atypical waterbodies counted. Counts from atypical wetlands were added directly to the extrapolations.

REGION	LAKE			RIVER			DAM			ESTUARY		
	Nov 91	Mar 92	Units	Nov 91	Mar 92	Units	Nov 91	Mar 92	Units	Nov 91	Mar 92	Units
Geraldton	25	34	464	9	11	69	13	22	100	2	2	6
Moora	54(2)	40(2)	651	2	2	42	46	41	1000	-	-	-
Gingin	77(4)	76(4)	400	11	11	110	28	27	100	1	-	3
Beverley	31(2)	31(2)	102	15	15	105	59	57	1500	-	-	-
Bunbury	37(4)	41(4)	384	16(2)	17(2)	198	35	36	200	3	3	6
Wagin	46(8)	43(8)	209	19(1)	17(1)	112	61	67	1500	-	-	-
Magenta	45	46	350	1	1	5	57	57	1500	-	-	-
Esperance	49(5)	51(5)	650	7(3)	7(3)	57	40	42	1500	4	4	4
Frankland	34(1)	28(1)	343	23	22	288	55	48	3000	-	-	-
Bremer	36	32	232	19(3)	18(3)	219	35	35	1500	10	10	10
Walpole	39	37	206	14(1)	11(1)	135	37	35	2000	8	8	13
TOTAL	473(26)	459(26)	3991	136(10)	132(10)	1340	466	466	13900	27	27	42

Estimating numbers

Number of waterfowl in each region was estimated separately for lakes, rivers and dams by multiplying the mean number of birds counted per wetland by the total number of wetland 'units' of that type in the region. Topographic maps (1:100 000) were used to estimate the number of lakes and river sections in each region. Sometimes groups of small salt lakes were counted as one unit because this reflected the nature of the surveyed wetlands more closely than counting individual lakes. Similarly, long sections of flowing river were broken into several units or, in some cases, small pools were combined. Anon (1971) was used to provide information on the number of farm dams in each region and these data were converted to estimates of the numbers of dam units after correcting for bias in selection of surveyed dams (Halse *et al.* 1992). The estimated numbers of wetland units in each region are shown in Table 1.

The formula used to extrapolate from counts to estimated numbers of waterfowl is given below, estimating the number of Grey Teal on lakes in Beverley region as an example

$$\text{Estimated number} = \frac{\text{Count} \times N_T}{N_S} + C_A$$

where Count = number of Grey Teal counted in typical lakes in Beverley, N_T = total number of lake units in Beverley, N_S = number of typical lakes surveyed in Beverley, and C_A = number of Grey Teal counted in atypical lakes in Beverley.

Approximately 30 lakes and river sections supported much larger waterfowl populations than other wetlands in the same region. These 'atypical' wetlands were excluded from extrapolations, and counts at them were added directly to population estimates. Similarly, counts at estuaries were not extrapolated: all major estuaries were surveyed and our observations showed that most, if not all, of the remainder did not support significant numbers of waterfowl.

Ninety-five per cent confidence limits (C.L.) of estimates of waterfowl numbers were calculated using formulae derived from Snedecor and Cochran (1967, pp. 520-523) for standard errors associated with stratified sampling

$$S(\text{mean no. of birds/wetland}) = \frac{\sqrt{MS_{\text{error}}}}{\sqrt{N_S}} \times \sqrt{1 - \frac{N_S}{N_T}}$$

$$\text{C.L.} = 1.96N_T \times S(\text{mean no. of birds/wetland})$$

where MS_{error} = mean square of the within-regions term in a one-way ANOVA of number of birds per wetland according to region.

RESULTS

Rainfall and wetland conditions

Annual rainfall in 1991 in the area covered by the biannual waterfowl counts was 'average', except in the Gingin region where it was 'above average' and the Esperance region where it was 'very much below average' (Table 2, Fig. 2). In absolute terms, Walpole, Bunbury, Frankland and Gingin were the wettest regions; Magenta and Esperance were the driest (Fig. 3). Rainfall decreased along a north-easterly gradient.

TABLE 2

Annual rainfall for 1991 in the five meteorological districts of south-west WA within the surveyed area of the biannual waterfowl counts (Bureau of Meteorology 1991).

District	1991 rainfall (mm)	Average rainfall (mm)	Decile range ^a
North Coastal	412	396	6
Central Coastal	946	849	8
South Coastal	896	909	5
North Central	341	357	6
South Central	402	435	4

^adecile range 8-9 = above average rainfall
4-7 = average rainfall

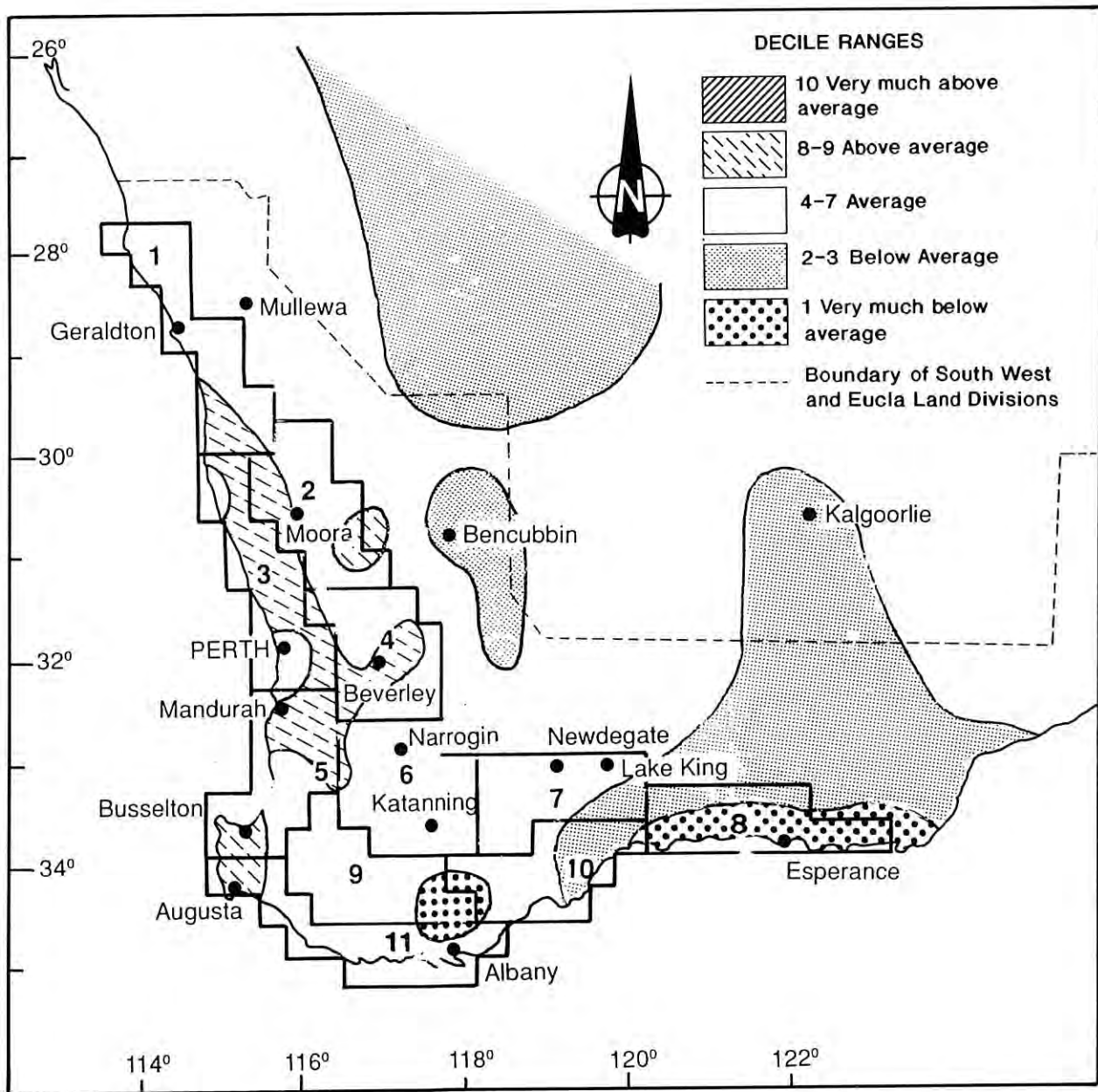


Figure 2. Decile ranges of the rainfall in south-west WA between January and December 1991 (Bureau of Meteorology 1991).

Ninety per cent of waterbodies (lakes, dams, etc.) contained water in November 1991. The regions where the largest numbers of waterbodies held water were Walpole (100 per cent), Frankland (100 per cent), Bunbury (99 per cent) and Gingin (98 per cent), while the driest regions were Geraldton (69 per cent) and Esperance (73 per cent) (Fig. 4).

Many wetlands in the survey area dried between November 1991 and March 1992 so that only 76 per cent of waterbodies contained water in March. Lakes were the wetland type showing greatest reduction in water levels (Fig. 5). Heavy rainfall (Fig. 6) and localized flooding in

the Gingin region in February were not reflected by depths of the wetlands surveyed in that region in March (Fig. 4) although many small waterbodies filled. There was also heavy rainfall in the northern Goldfields (north-east of the surveyed area) in February and extensive rainfall on the eastern margin of the surveyed area from 13 to 19 March (Bureau of Meteorology 1992).

The most common types of vegetation in lakes were live and dead trees, fringing trees or trees and sedges predominated in rivers, most estuaries were fringed by sedges and most dams lacked vegetation (Table 3).

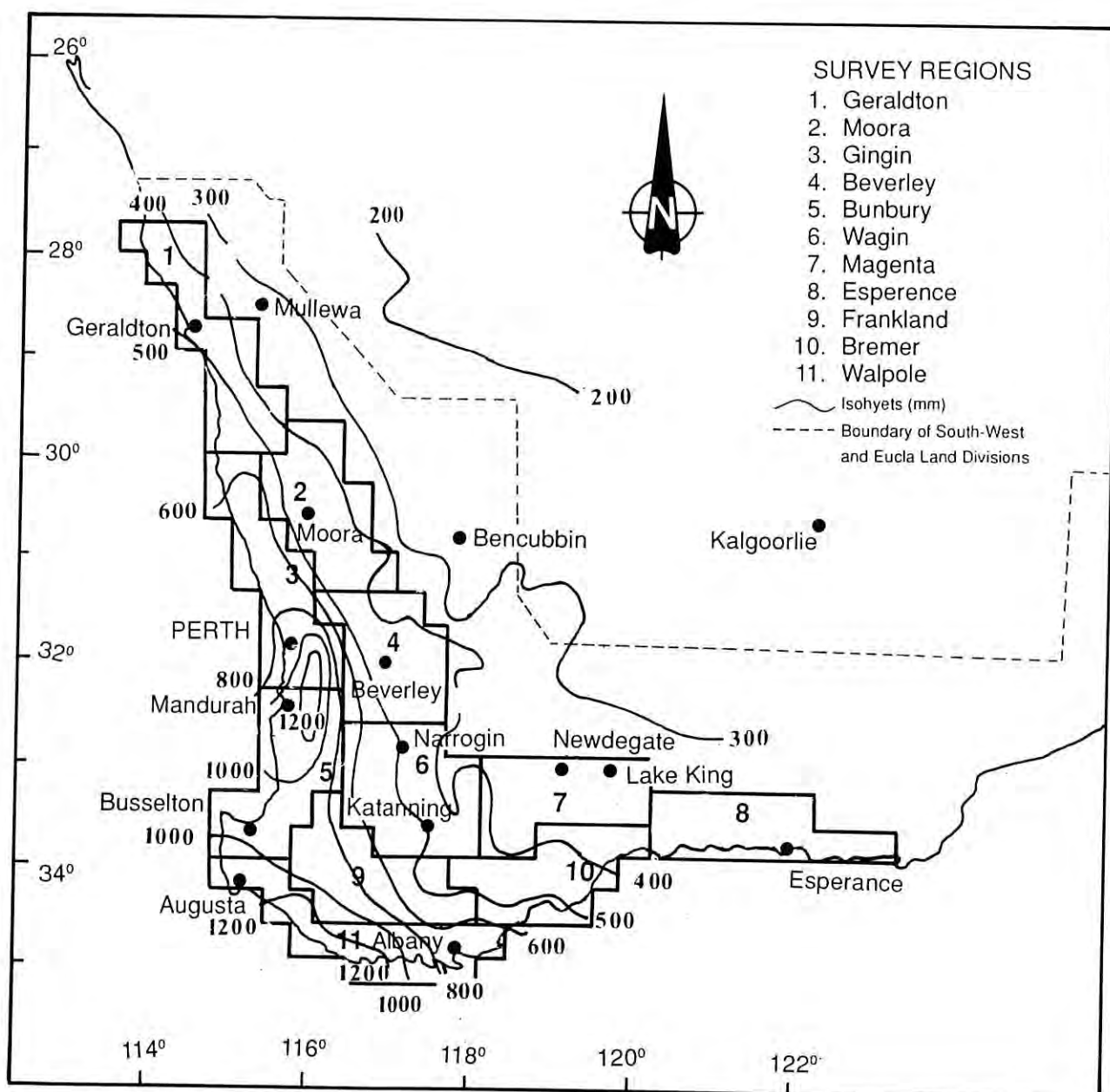


Figure 3. Rainfall (mm) in south-west WA between January and December 1991 (Bureau of Meteorology 1991).

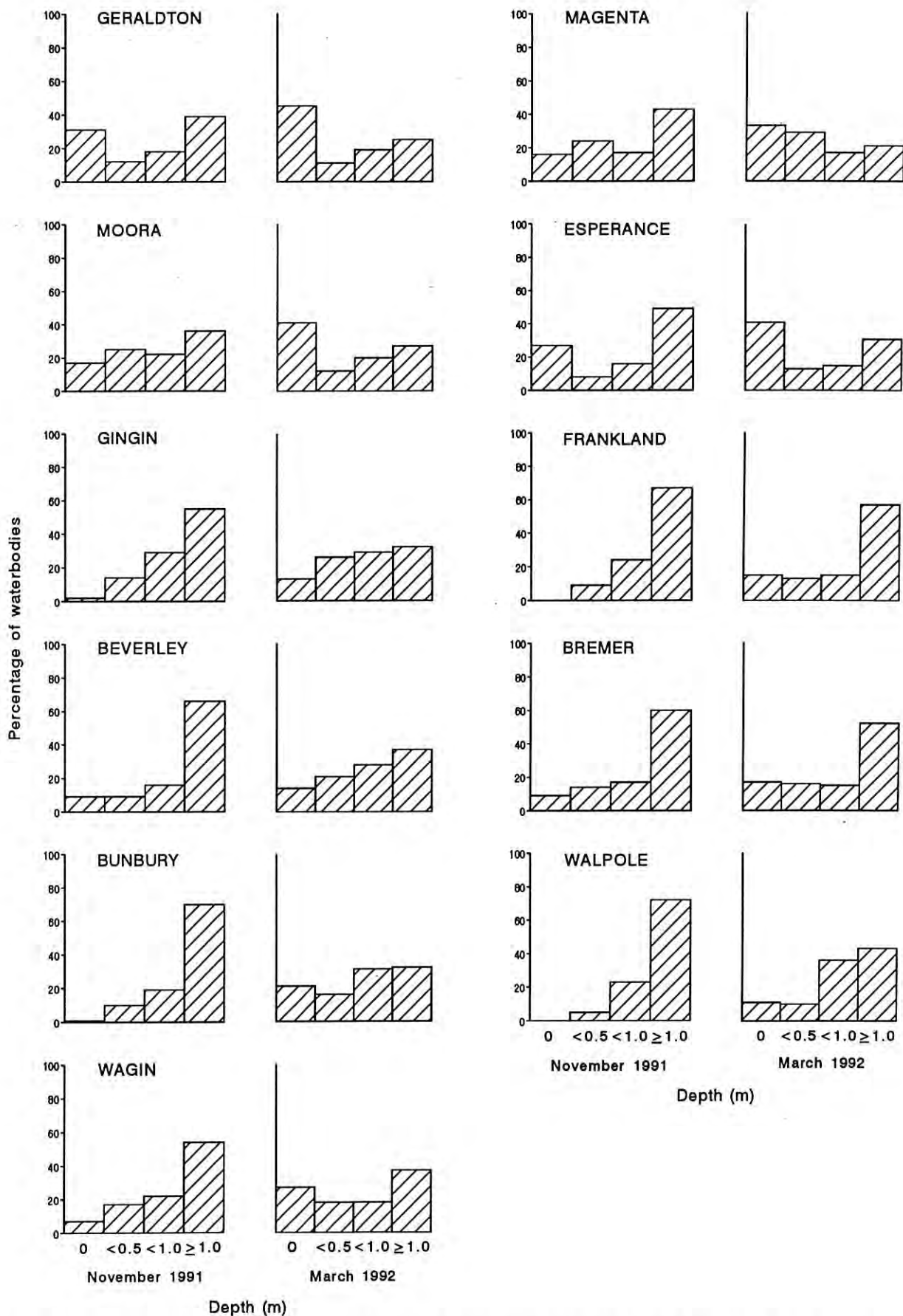


Figure 4. Percentage of waterbodies in each region containing various depths of water in November 1991 and March 1992.

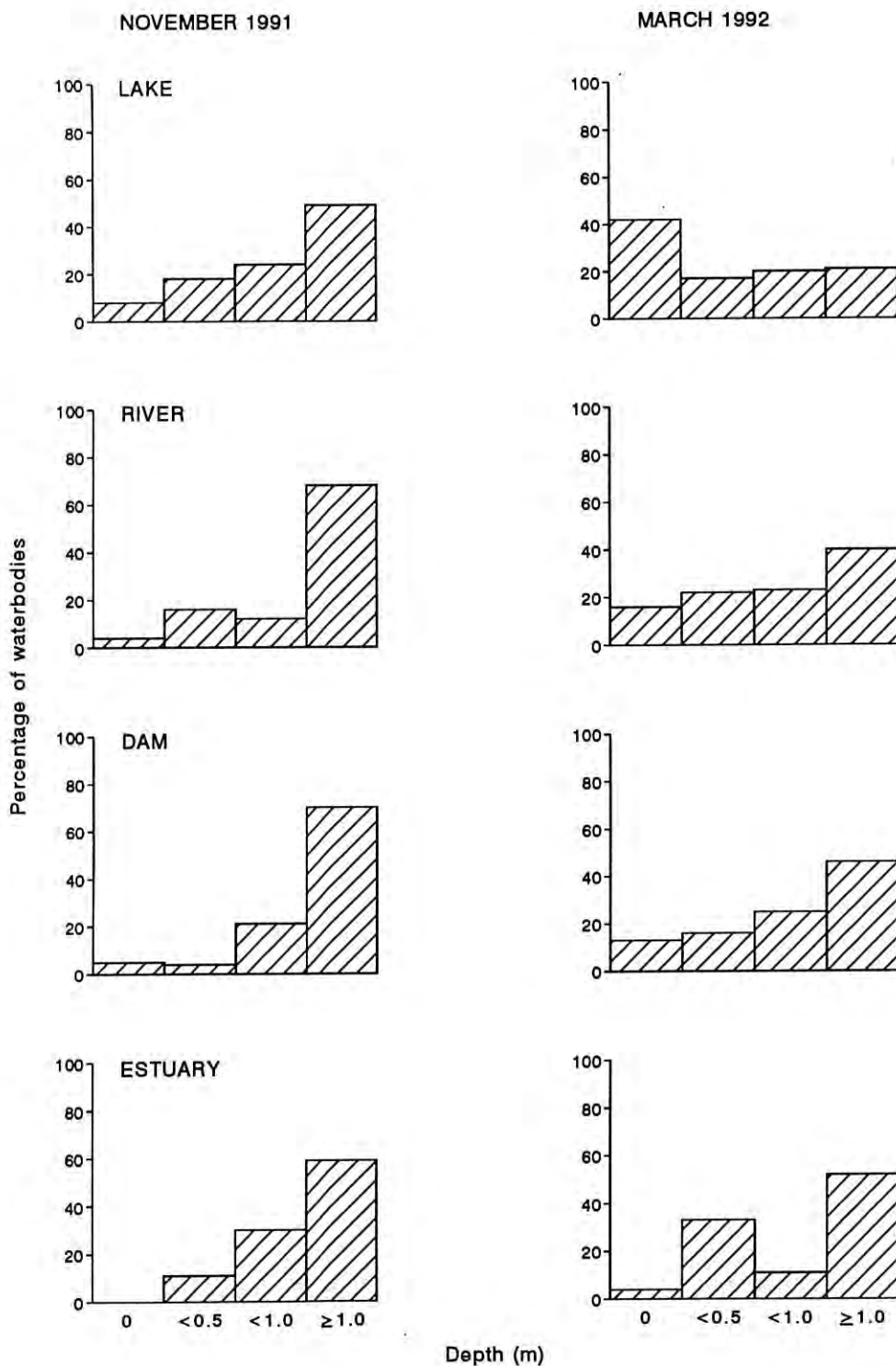


Figure 5. Percentage of waterbodies of each type containing various depths of water in November 1991 and March 1992.

Number of birds

Totals of 255 976 waterfowl were counted at 1102 wetlands in November 1991, and 212 353 at 1084 wetlands in March 1992 (Table 4). Extrapolations suggested that there were $1\ 154\ 645 \pm 46\ 404$ waterfowl in the surveyed area in November and $1\ 075\ 154 \pm 65\ 496$ in March (Table 5). The six more abundant species during both surveys were Grey Teal, Australian Shelduck, Eurasian Coot, Pacific Black Duck, Maned Duck and Black Swan. They accounted for 93 per cent of the estimated waterfowl population in November and 92 per cent of the estimated March population (Table 5).

Population estimates of half the species differed significantly between November and March (Table 5). Estimates for Australasian Shoveler (5.6 times more, $t=2.82$, $P<0.01$), Musk Duck (2.2, $t=2.29$, $P<0.05$) and Pacific Black Duck (2.0, $t=2.02$, $P<0.05$) were higher in March; estimates for Pink-eared Duck (2.7 times more, $t=2.28$, $P<0.05$), Australian Shelduck (1.8, $t=2.83$, $P<0.01$) and Maned Duck (1.6, $t=2.72$, $P<0.01$) were higher in November.

Summing the higher of the November and March estimates for each species suggested the total waterfowl population in south-west WA during summer of 1991/92 was approximately 1 400 000.

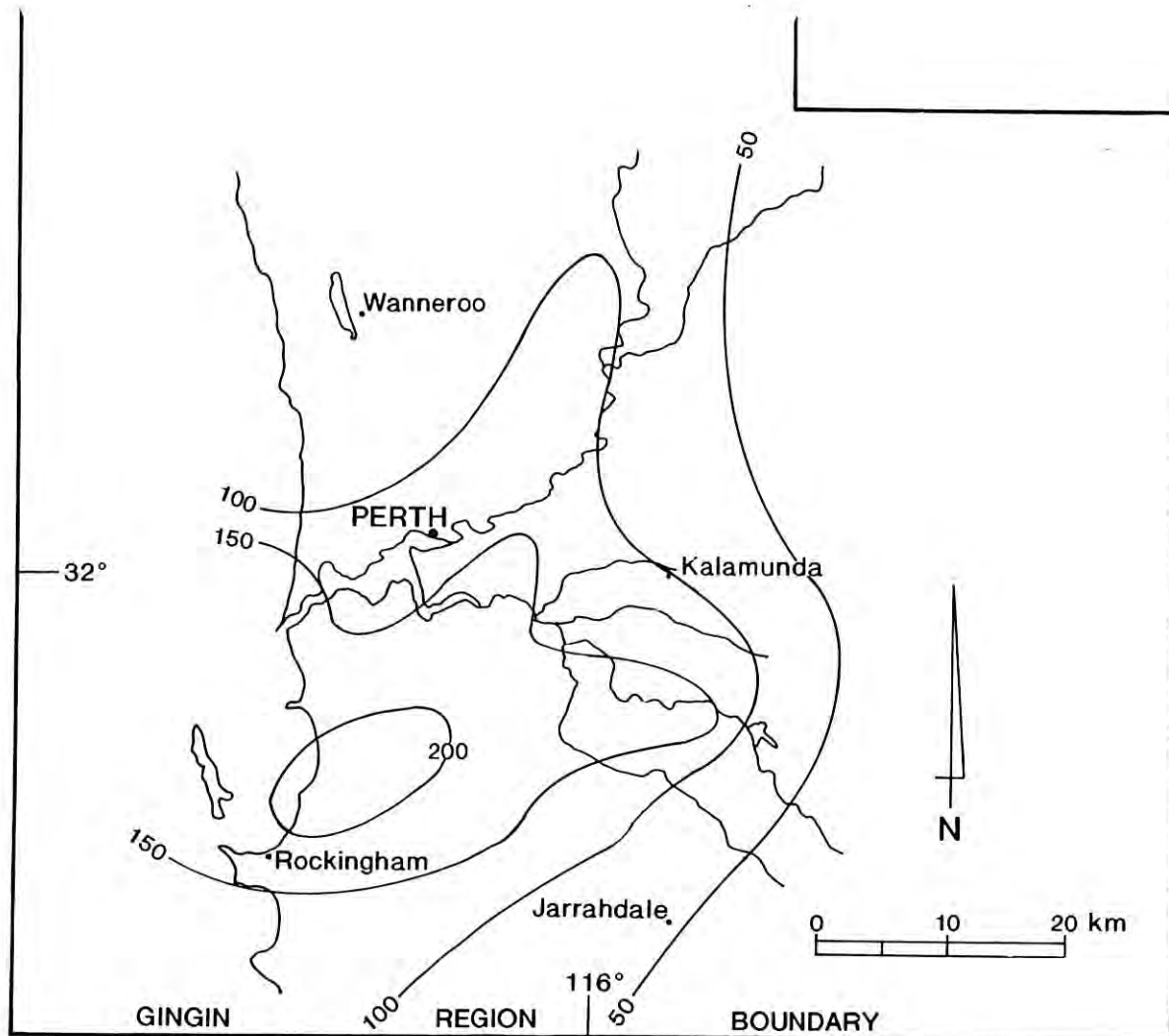


Figure 6. Rainfall (mm) around Perth in the Gingin region in February 1992 (Bureau of Meteorology 1992).

TABLE 3

Percentage of the different types of waterbody surveyed in biannual waterfowl counts in 1991/92 supporting various categories of vegetation.

Vegetation	NOVEMBER 1991				MARCH 1992			
	Lake	River	Dam	Estuary	Lake	River	Dam	Estuary
Live trees	33	37	4	4	33	36	4	4
Trees/sedges	14	26	3	26	14	26	3	26
Sedges	17	7	8	44	15	7	8	44
Dead trees	20	7	3	-	21	8	2	-
Samphire	5	-	-	11	5	-	-	11
Open	11	23	82	15	12	23	83	15
N	473	136	466	27	459	132	466	27

TABLE 4

Number of birds, nests and broods counted for each waterfowl species in November 1991 and March 1992 in south-west WA.

Species	NOVEMBER 1991			MARCH 1992		
	Birds counted	Nests counted	Broods counted	Birds counted	Nests counted	Broods counted
Black Swan	15279	6	236	14953	-	4
Freckled Duck	12	-	-	88	-	-
Australian Shelduck	99147	-	24	42924	-	-
Pacific Black Duck	19322	13	107	26811	-	-
Grey Teal	69986	31	100	78512	-	3
Chestnut Teal	2714	3	-	6960	-	-
Australasian Shoveler	732	-	5	3576	-	-
Pink-eared Duck	13613	7	27	3356	1	1
Hardhead	1228	-	9	433	-	1
Maned Duck	4901	4	64	2556	-	-
Blue-billed Duck	228	1	8	691	-	1
Musk Duck	1111	-	13	2810	-	-
Exotic ducks	390	3	4	323	-	3
Unidentified ducks	6	-	-	-	-	-
Eurasian Coot	27327	31	169	28360	2	8
TOTAL	255976	99	766	212353	3	21

TABLE 5

Estimated number of birds (\pm 95 per cent confidence limits) of each waterfowl species in November 1991 and March 1992 in south-west WA.

SPECIES	NOVEMBER 1991	MARCH 1992
Black Swan	44461 \pm 14954	54877 \pm 20438
Freckled Duck ^a	118	670
Australian Shelduck	333501 \pm 74826	181911 \pm 73500
Pacific Black Duck	104938 \pm 32579	215555 \pm 102233
Grey Teal	356178 \pm 105640	277424 \pm 136150
Chestnut Teal	17360 \pm 10214	26746 \pm 16198
Australasian Shoveler	3587 \pm 1738	20190 \pm 11411
Pink-eared Duck	36886 \pm 18089	13887 \pm 8051
Hardhead	7249 \pm 8607	2721 \pm 3667
Maned Duck	103288 \pm 22363	62869 \pm 18668
Blue-billed Duck	1338 \pm 1199	2368 \pm 2693
Musk Duck	6715 \pm 1726	14452 \pm 6399
Exotic ducks	2896 \pm 5113	1990 \pm 2058
Unidentified ducks ^a	33	-
Eurasian Coot	139491 \pm 54730	199495 \pm 74318
TOTAL	1154645 \pm 46404	1075154 \pm 65496

^aConfidence limits could not be calculated because of too few occurrences.

Distribution

In November 1991 and March 1992, 76 and 65 per cent, respectively, of the estimated waterfowl population in south-west WA occurred on lakes, 15 and 21 per cent on dams, 4 and 10 per cent on river pools and approximately 5 per cent on estuaries (Table 6).

Maned Ducks were the only species that occurred mostly away from lakes - approximately 80 per cent were on dams during both counts. Pacific Black Ducks were most flexible in their use of wetland types: in March 49 per cent of them occurred on lakes, 30 per cent on rivers, 18 per cent on dams and 2 per cent on estuaries. Other species, especially Australasian Shovelers, Pink-eared Ducks, Blue-billed Ducks and Musk Ducks, were found mainly at lakes (Table 6).

The important regions for waterfowl during surveys in 1991/92 were Esperance, Wagin, Bunbury and Gingin (Tables 7 and 8). In November, the Wagin region contained 22 per cent of the estimated population in south-west WA, Esperance 21 per cent and Bunbury 11 per cent. In March, Wagin held 19 per cent, Esperance 16 per cent and Bunbury 15 per cent, while six of the 14 taxa were most abundant in Gingin.

Chestnut Teal exhibited the most pronounced geographical bias in distribution, with 63 and 86 per cent of the species occurring in the Esperance region in November and March, respectively, and 28 and 13 per cent in the Bremer region (Tables 7 and 8). More than half the Maned Duck population occurred in the Wagin and Frankland regions during both surveys. Gingin supported 87 per cent of Blue-billed Ducks in March but only 47 per cent during the wetter November survey period. Hardheads (60 per cent) were also concentrated in Gingin in March. Exotic waterfowl were virtually restricted to the Gingin, Beverley and Bunbury regions.

The number of birds counted at wetlands with different categories of vegetation is shown in Table 9. As a group, waterfowl appeared to prefer wetlands of the 'dead trees' and 'sedges' categories in both November and March (each category represented approximately 12 per cent of wetlands and supported 27 and 30 per cent, respectively, of birds in November and 26 and 35 per cent of birds in March³). There was also a disproportionately high number of birds on wetlands of the 'trees/sedges' category in March (11 per cent of wetlands and 18 per cent of birds). 'Open' wetlands, which represented 44 per cent of all waterbodies, were strongly avoided by most species and supported only 7 per cent of birds in November and 3 per cent in March.

The distribution of species at lakes, which supported the greatest range of vegetation categories of all the wetland types surveyed, showed that most species had strong associations with some vegetation categories (Fig. 7). Australian Shelducks and Grey Teal appeared to prefer lakes of the 'dead trees' category during both surveys, Pacific Black Ducks and Blue-billed Ducks were associated with 'sedges' or 'trees/sedges', Chestnut Teal preferred 'live trees' and Musk Ducks showed positive association with lakes of the 'sedges' category. There was a tendency for all species except Black Swans to avoid open lakes; similarly all species, except Pacific Black Ducks in November, were negatively associated with wetlands of the 'samphire' category.

³ Results of statistical tests of habitat preferences are not presented because valid hypotheses could not be constructed. If occurrence of each bird was treated as an independent event, then deviations from expected frequencies were significant even when they constituted a very small percentage deviation. Analysis based on presence/absence also seemed flawed because if only one bird of a species was seen in a wetland that supported vast numbers of other waterfowl, the habitat was probably less suitable for the rare species than the abundant ones.

TABLE 6

Estimated number of waterfowl of each species at each wetland type in November 1991 and March 1992.

Species	NOVEMBER 1991				MARCH 1992			
	Lake	River	Dam	Estuary	Lake	River	Dam	Estuary
Black Swan	37028 ± 14102	468 ± 401	586 ± 451	6380	45447 ± 18795	1186 ± 891	1213 ± 752	7032
Freckled Duck	68	-	50	-	670	-	-	-
Australian Shelduck	305100 ± 71374	1378 ± 741	7356 ± 2711	19765	128045 ± 53193	2337 ± 1528	46807 ± 18779	4682
Pacific Black Duck	61118 ± 15947	17873 ± 10242	18259 ± 6390	7688	105742 ± 29435	65591 ± 55200	39705 ± 17598	4517
Grey Teal	274103 ± 80011	14526 ± 6789	52585 ± 18848	14963	191596 ± 106636	13956 ± 9236	53521 ± 20278	18351
Chestnut Teal	11110 ± 8741	664 ± 585	1112 ± 1388	1080	23070 ± 15119	1418 ± 845	96 ± 234	2162
Australasian Shoveler	3034 ± 1386	95 ± 91	284 ± 261	175	19989 ± 11374	73 ± 37	-	128
Pink-eared Duck	33487 ± 17557	43 ± 51	737 ± 481	2620	13430 ± 7427	-	457 ± 624	-
Hardhead	5830 ± 7124	279 ± 437	1049 ± 1048	91	2217 ± 3109	62 ± 146	441 ± 412	-
Maned Duck	16357 ± 6180	9275 ± 3314	77618 ± 12869	39	5299 ± 2715	5166 ± 2829	52392 ± 13124	12
Blue-billed Duck	1126 ± 702	170 ± 153	43 ± 344	-	2362 ± 2673	6 ± 20	-	-
Musk Duck	6356 ± 1483	99 ± 81	249 ± 162	11	13308 ± 5309	192 ± 174	894 ± 916	59
Exotic ducks	1545 ± 1102	754 ± 1037	596 ± 2974	-	1553 ± 1154	437 ± 904	-	-
Unidentified ducks	33	-	-	-	-	-	-	-
Eurasian Coot	115532 ± 42243	4069 ± 4225	17723 ± 8262	2167	147434 ± 47746	17866 ± 10151	33240 ± 16421	954
TOTAL	871827 ± 35280	49691 ± 3844	178147 ± 7280	54979	700160 ± 38344	108332 ± 16258	228765 ± 10894	37897

TABLE 7

Estimated number of waterfowl of each species in each region in November 1991.

Species	REGION										
	Geraldton	Moora	Gingin	Beverley	Bunbury	Wagin	Magenta	Esperance	Frankland	Bremer	Walpole
Black Swan	60	1254	7723	772	5054	2810	1159	16719	4057	2003	2851
Freckled Duck	50	-	5	-	-	-	62	-	-	-	-
Australian Shelduck	3486	24455	23330	10924	26338	35049	10522	137534	14908	28495	18460
Pacific Black Duck	4332	4015	20551	5091	22332	2569	357	14013	15785	3047	12846
Grey Teal	15407	62669	11951	35305	51294	109912	17217	17859	21047	4050	9469
Chestnut Teal	-	-	115	-	5	12	23	8862	1091	3847	11
Australasian Shoveler	1415	238	506	7	369	233	-	258	46	305	210
Pink-eared Duck	217	7095	1789	1816	2817	15011	93	7064	718	239	26
Hardhead	217	426	2078	1147	320	2570	-	118	-	103	269
Maned Duck	2616	1672	8796	12010	6922	38035	3928	2977	20832	2034	3467
Blue-billed Duck	56	-	644	53	281	-	-	57	64	26	158
Musk Duck	445	175	1011	49	711	187	86	2379	976	185	510
Exotic ducks	-	250	2196	294	145	-	-	-	-	-	10
Eurasian Coot	1890	17726	19546	3723	5528	43717	3516	30787	7610	4606	842
TOTAL ^a	30191	119975	100274	71191	122116	250105	36963	238627	87134	48940	49129

^aincludes unidentified waterfowl

TABLE 8

Estimated number of waterfowl of each species in each region in March 1992.

Species	REGION										
	Geraldton	Moora	Gingin	Beverley	Bunbury	Wagin	Magenta	Esperance	Frankland	Bremer	Walpole
Black Swan	246	2139	7728	587	5260	1617	23	20524	5431	921	10400
Freckled Duck	-	-	-	-	-	-	670	-	-	-	-
Australian Shelduck	4089	14054	8267	21351	10103	54926	972	10996	44811	7479	4863
Pacific Black Duck	7153	1595	29987	12904	73909	12392	221	31014	24770	8010	13601
Grey Teal	10537	6472	15808	49526	44469	87087	906	36395	10742	9405	6077
Chestnut Teal	-	34	6	-	35	52	-	22868	185	3567	-
Australasian Shoveler	3182	522	4466	18	1934	540	-	3158	1187	3262	1921
Pink-eared Duck	1633	1637	4828	334	1373	744	1636	539	-	740	423
Hardhead	48	17	1640	60	88	71	-	152	26	312	308
Maned Duck	268	2604	2859	4721	4833	20676	1825	3581	11992	6742	2770
Blue-billed Duck	6	-	2062	120	42	-	-	28	-	-	111
Musk Duck	671	171	2464	98	1686	250	99	1942	5908	392	771
Exotic ducks	-	-	1529	301	159	-	-	-	-	-	-
Eurasian Coot	1322	20558	39216	5628	19953	23249	784	35968	18578	8938	25301
TOTAL	29155	49803	120859	95648	163843	201603	7136	167164	123629	49768	66546

TABLE 9

Number of waterfowl counted on wetlands of each vegetation category in 1991/92.

CATEGORY	NOVEMBER	MARCH
Live trees	56718	36239
Trees/sedges	26363	37679
Sedges	68154	54941
Dead trees	76435	73693
Samphire	9108	2379
Open	19198	7422
TOTAL	255976	212353

Numbers of birds

The number of surveyed wetlands without birds increased between November 1991 and March 1992, usually because the wetlands were dry (Fig. 8a). Just over 30 per cent of the waterfowl occurred on wetlands containing 10 000 or more birds in both November and March (Fig. 8b).

The 15 wetlands supporting highest numbers of waterfowl in November 1991 and March 1992 are listed in Table 10. Peel-Harvey Estuary supported most birds in both November (23 060) and March (21 826). Jerdacuttup West Lake, Coyrecup Lake, Lake Dumbleyung, Culham Inlet and Lake Gundaring were also in the top 15 wetlands in both surveys. Eleven of the major wetlands during November counts were lakes, three were estuaries and one was a river; there were two estuaries, one river and twelve lakes in March. Wetlands with high numbers of birds were concentrated in the Wagin region in both November and March (six and five, respectively).

Wetlands with the three highest counts for each species in November and March, respectively, are listed in Appendix 1. Thirty-one wetlands were lakes, seven were estuaries, six were river sections and two were dams. All regions except Moora were represented although listed wetlands were concentrated in Gingin and Bunbury.

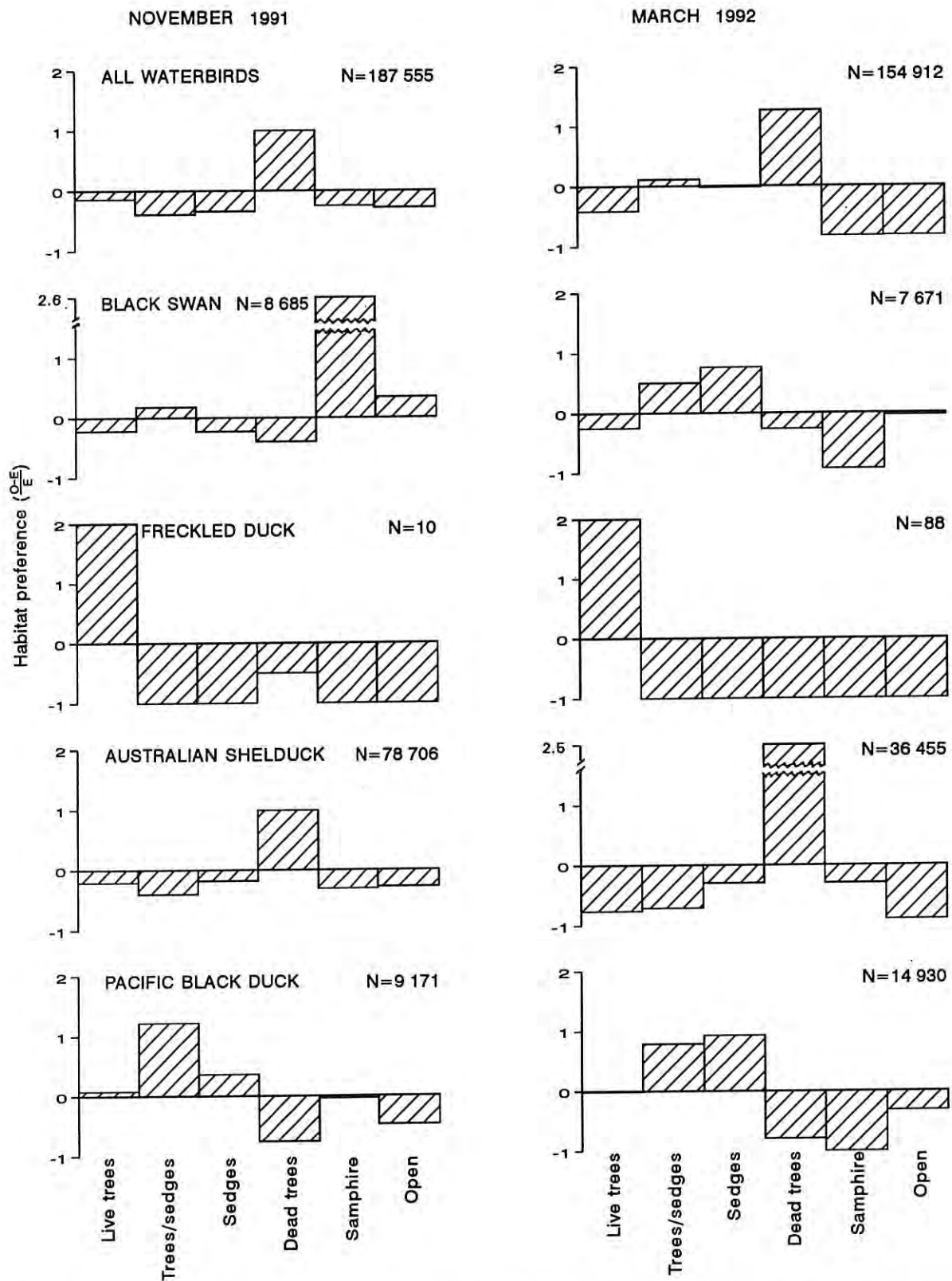


Figure 7. Preferences of waterfowl species for wetlands of different vegetation categories during biannual waterfowl counts in 1991/92. Preference for each wetland vegetation category calculated as $(O-E)/E$ where O was number of birds counted at wetlands of each category and E was number expected if occurrences were proportional to the number of waterbodies of each category. Values of $(O-E)/E$ are not symmetrical about zero.

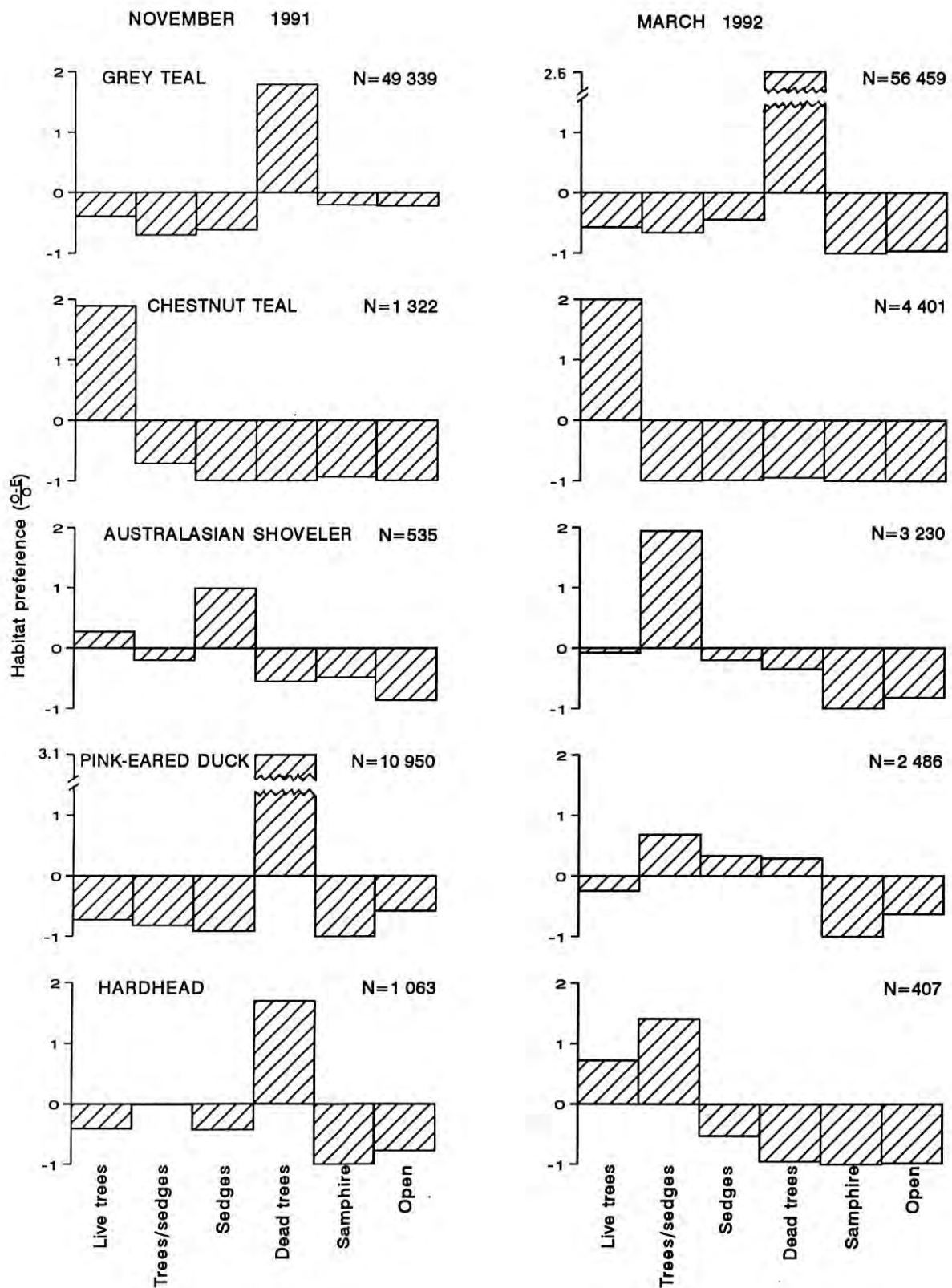


Figure 7 (continued).

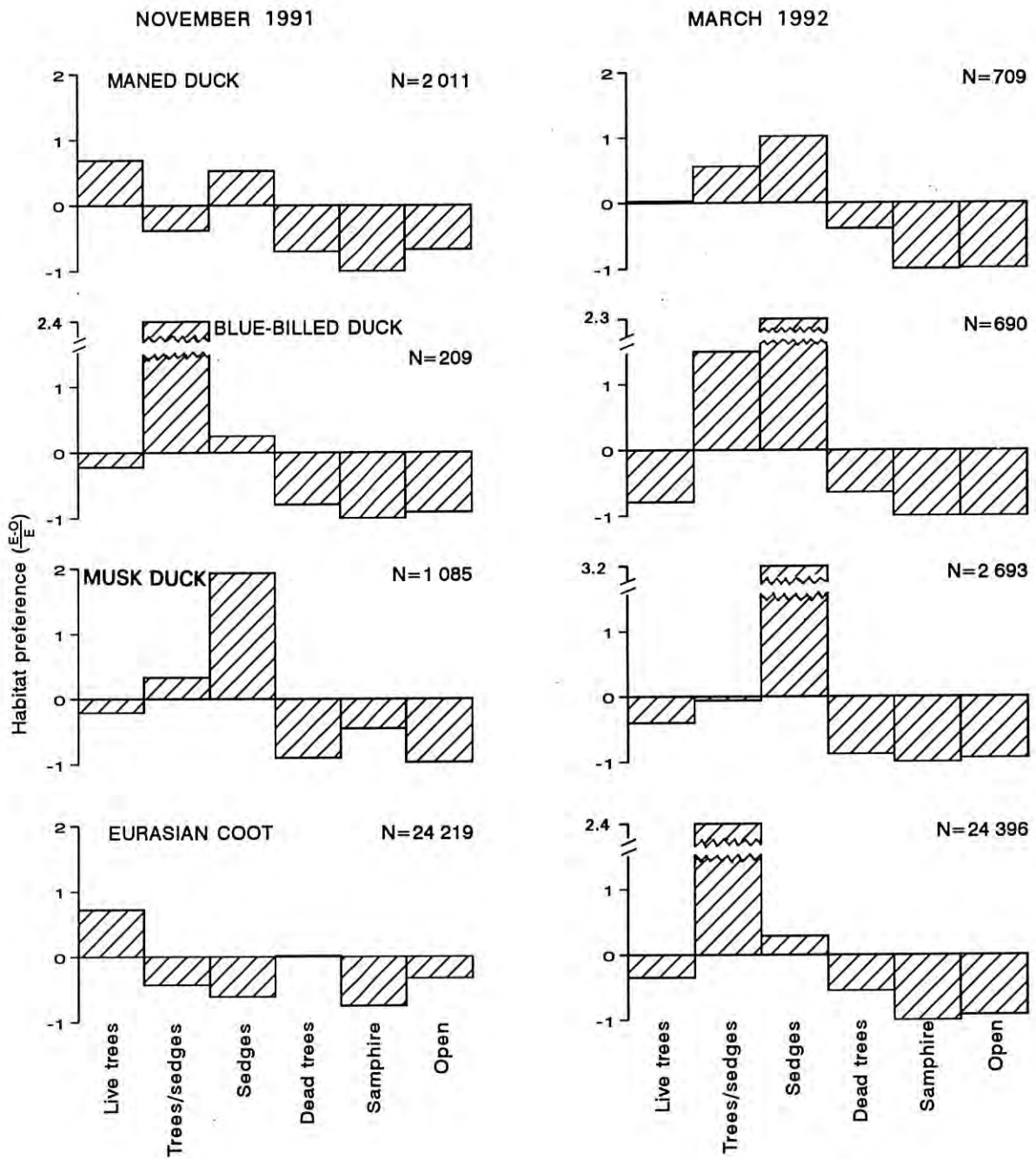


Figure 7 (continued).

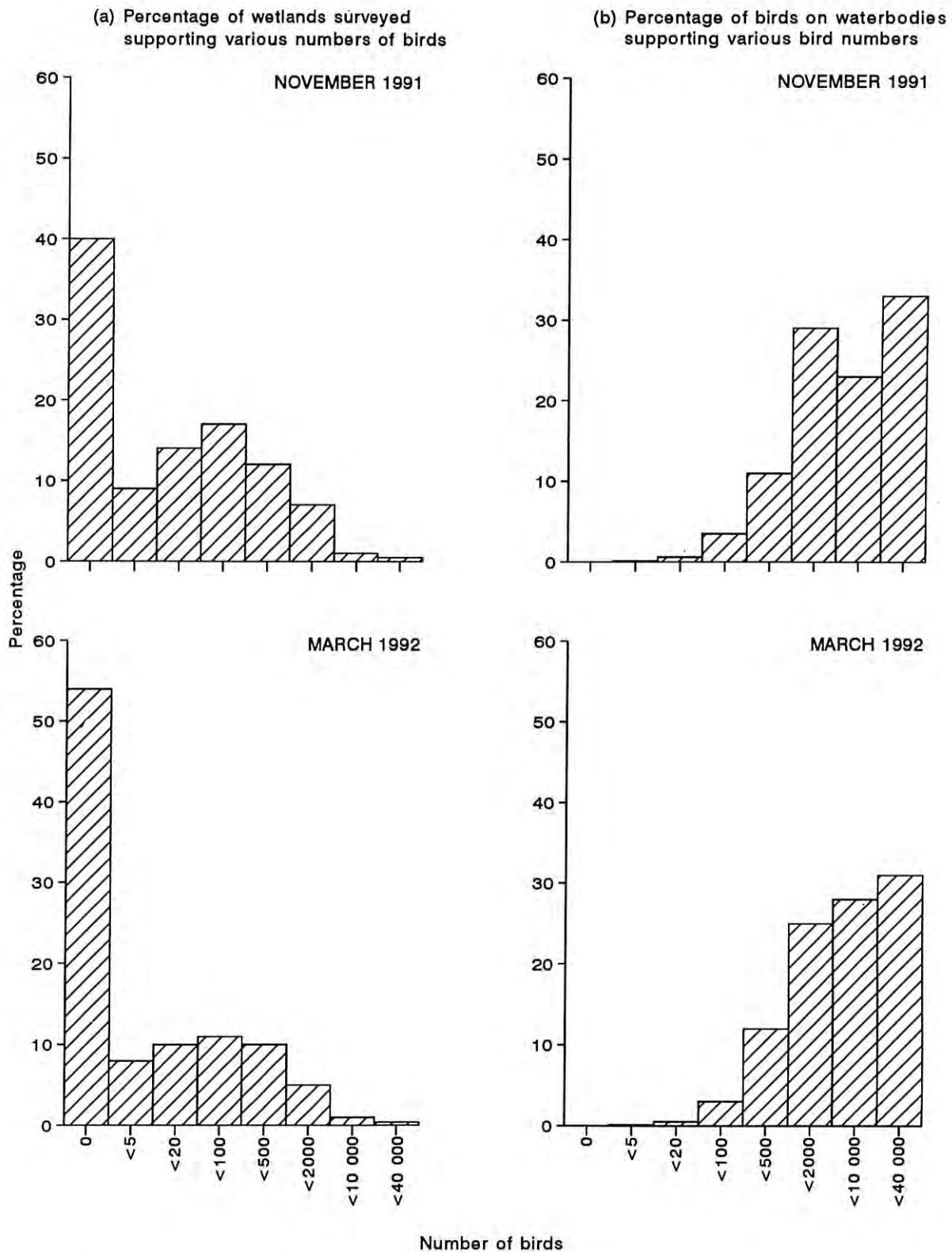


Figure 8. Number of birds at surveyed wetlands during the 1991/92 biannual waterfowl counts. (a) The percentage of waterbodies supporting various numbers of birds. (b) The percentage of birds at waterbodies supporting various bird numbers.

TABLE 10

The 15 wetlands supporting highest numbers of waterfowl in November 1991 and March 1992.

NOVEMBER 1991				MARCH 1992			
Wetland	Number	Region	Type	Wetland	Number	Region	Type
1 Peel Harvey Estuary	23060	Bunbury	E ^a	Peel-Harvey Estuary	21826	Bunbury	E
2 Vasse-Wonnerup Estuary	14150	Bunbury	E	Lake Dumbleyung	15636	Wagin	L
3 Jerdacuttup West Lake	13017	Esperance	L	Coyrecup Lake	15594	Wagin	L
4 Coyrecup Lake	11855	Wagin	L	Lake Yealering	13493	Beverley	L
5 Lake Guraga	10764	Gingin	L	Lake Forrestdale	7335	Gingin	L
6 Lake Dumbleyung	10421	Wagin	L	Lake Brown	6030	Beverley	L
7 Lake Preston	7436	Bunbury	L	Jerdacuttup West Lake	4530	Esperance	L
8 Casuarina Lake	6327	Wagin	L	Mullet Lake	4074	Esperance	L
9 Lake Gore	6147	Esperance	L	Wilson Inlet	3809	Walpole	E
10 Culham Inlet	5060	Esperance	E	Lake Gundaring	3794	Wagin	L
11 Lake Muir	4955	Frankland	L	Lake Clifton	3731	Bunbury	L
12 Beverley Lakes	4298	Beverley	L	Lake Towerinning	3635	Wagin	L
13 Lake Parkeyerring	3713	Wagin	L	Clarkes Lakes A & B	3602	Beverley	L
14 Lake Gundaring	3594	Wagin	L	Ewlyamartup Lake	3055	Wagin	L
15 Cobline River Flats	3125	Wagin	R	Goegrup Pool (Serpentine R)	2894	Bunbury	R

^aWetland types: E = estuary, L = lake, R = river

Breeding

Ninety-nine nests and 766 broods were found in November 1991. Three nests and 21 broods were recorded in March 1992 (Table 4). No nest of Freckled Duck, Australian Shelduck, Australasian Shoveler, Hardhead or Musk Duck was found in either survey. The most commonly found nests belonged to Eurasian Coots and Grey Teal, and the most commonly seen broods belonged to Black Swans, Eurasian Coots, Pacific Black Ducks and Grey Teal. In relation to number of birds counted, Blue-billed Duck broods were found most frequently (ratio of 1 brood : 28 adults). Broods of Black Swans (1:65), Maned Ducks (1:76) and Musk Ducks (1:85) were common. Broods of exotic ducks (1:98), Hardheads (1:136), Australasian Shovelers (1:146) and Pacific Black Ducks (1:181) were less common, as were broods of Pink-eared Ducks (1:504) and Grey Teal (1:700). Australian Shelduck broods (1:4131) were scarce. No brood of Freckled Duck or Chestnut Teal was seen.

Distribution of breeding

Lakes were the most important breeding areas surveyed in 1991/92: 59 per cent of nests and 66 per cent of broods found in November occurred there. River sections contained 19 per cent of nests and 8 per cent of broods, dams contained 20 per cent of nests and 11 per cent of broods. Estuaries contained 2 per cent of nests and 15 per cent of broods (mostly Black Swans) (Table 11). Most nests and broods seen in November 1991 occurred in the Gingin (38 per cent of records), Bunbury (24 per cent) and Wagin (12 per cent) regions. The importance of Bunbury was exaggerated by the large number of breeding records of Black Swans (Table 12).

The distribution of breeding among vegetation categories was examined only for lakes, which had the most diverse vegetation of the wetland types surveyed. Wetlands of the 'trees/sedges' category appeared to be preferred breeding sites (14 per cent of wetlands vs 33 per cent of breeding activity), while those that were open or supported only samphire tended to be avoided (16 per cent vs 4 per cent) (Table 13). The breeding that did occur on open wetlands was at fresh, rather than saline, water.

DISCUSSION

Approximately 1 150 000 and 1 080 000 waterfowl, respectively, were estimated to occur in the surveyed area of south-west WA in November 1991 and March 1992, although summing the higher of the November and March estimates for each species suggests there were 1 400 000 birds during the 1991/92 summer. These figures are similar to results from previous surveys that suggest approximately 1 500 000 waterfowl occur in south-west WA (Fig. 9; Halse *et al.* 1992, 1994). The lower estimate obtained in March rather than in November is puzzling. Previous work suggests that when conditions become drier between November and March, as they did overall in 1991/92, the number of birds counted and the estimated number of birds should be higher (Fig. 9). A possible explanation for the low March estimate is that heavy rainfall in February around Perth (Fig. 6) and north-east of the surveyed area (Bureau of Meteorology 1992) caused some birds to move onto types of wetland in the Gingin region, such as roadside pools, that were not surveyed. Other birds may have moved north-eastwards out of the surveyed area. Heavy rainfall along the eastern edge of the

TABLE 11

Distribution of breeding by waterfowl species among wetland types in south-west WA in November 1991.

Species	LAKE		RIVER		DAM		ESTUARY	
	Nests	Broods	Nests	Broods	Nests	Broods	Nests	Broods
Black Swan	2	123	1	2	1	2	2	109
Freckled Duck	-	-	-	-	-	-	-	-
Australian Shelduck	-	17	-	-	-	4	-	1
Pacific Black Duck	7	71	2	18	4	14	-	7
Grey Teal	21	55	5	21	5	23	-	1
Chestnut Teal	-	-	-	-	3	-	-	-
Australasian Shoveler	-	1	-	3	-	1	-	-
Pink-eared Duck	7	27	-	-	-	-	-	-
Hardhead	-	7	-	1	-	1	-	-
Maned Duck	-	26	-	10	4	28	-	-
Blue-billed Duck	1	8	-	-	-	-	-	-
Musk Duck	-	13	-	-	-	-	-	-
Exotic ducks	-	3	3	-	-	1	-	-
Eurasian Coot	20	148	8	9	3	12	-	-
TOTAL	58	501	19	61	20	86	2	118

TABLE 12

Distribution of breeding (nests and broods combined) by waterfowl species among regions in south-west WA in November 1991.

Species	REGION										
	Geraldton	Moora	Gingin	Beverley	Bunbury	Wagin	Magenta	Esperance	Frankland	Bremer	Walpole
Black Swan	0	6	55	2	120	25	-	1	11	1	21
Australian Shelduck	-	3	8	5	4	3	-	-	-	1	-
Pacific Black Duck	2	-	57	8	33	2	-	-	6	-	12
Grey Teal	-	7	31	12	15	33	1	2	10	-	9
Chestnut Teal	-	-	-	-	-	-	-	-	3	-	-
Australasian Shoveler	-	-	2	-	1	2	-	-	-	-	-
Pink-eared Duck	-	5	11	11	-	7	-	-	-	-	-
Hardhead	-	-	7	1	1	-	-	-	-	-	-
Maned Duck	-	1	19	2	13	11	2	-	17	-	3
Blue-billed Duck	-	-	6	-	2	-	-	-	-	-	1
Musk Duck	2	-	9	-	-	-	-	-	1	-	1
Exotic ducks	-	-	4	2	1	-	-	-	-	-	-
Eurasian Coot	2	7	123	18	17	24	4	3	1	1	1
TOTAL	6	29	332	72	207	107	7	6	49	3	48

TABLE 13

Distribution of breeding records within lakes according to vegetation category in south-west WA in November 1991. N = nests, B = broods

Species	LIVE TREES		TREES/SEDGES		SEDGES		DEAD TREES		SAMPHIRE		OPEN	
	N	B	N	B	N	B	N	B	N	B	N	B
Black Swan		28	1	46	1	20	-	18	-	4	-	7
Australian Shelduck	-	7	-	5	-	-	-	4	-	3	-	-
Pacific Black Duck	4	15	-	27	3	20	-	6	-	-	-	3
Grey Teal	11	28	-	6	2	8	8	13	-	-	-	-
Chestnut Teal	-	-	-	-	-	-	-	-	-	-	-	-
Australasian Shoveler	-	-	-	-	-	-	-	1	-	-	-	-
Pink-eared Duck	-	6	1	-	-	4	6	17	-	-	-	-
Hardhead	-	1	-	3	-	2	-	-	-	-	-	1
Maned Duck	-	9	-	7	-	8	-	1	-	-	-	1
Blue-billed Duck	-	4	-	1	-	2	1	1	-	-	-	-
Musk Duck	-	3	-	9	-	1	-	-	-	-	-	1
Exotic ducks	-	-	-	2	-	-	-	-	-	-	-	-
Eurasian Coot	5	36	10	67	-	24	5	16	-	-	-	5
TOTAL	20	137	12	173	6	89	20	77	-	7	-	18

surveyed area late in March (Bureau of Meteorology 1992) may also have caused birds to move. Halse *et al.* (1992) discussed the difficulty of estimating waterfowl numbers after summer rainfall.

Species with lower than expected population sizes in March 1992, compared with patterns observed in 1988/89 and 1990/91 (Halse *et al.* 1992,1994), were the Australian Shelduck, Grey Teal, Pink-eared Duck, Hardhead and Maned Duck. These species were also less abundant during March 1989/90, the other count after summer rainfall (Halse *et al.* 1992). The original observation that these species respond to rainfall in south-west WA was made by Bekle (1983), who found that Australian Shelduck, Grey Teal and Hardhead dispersed from wetlands in Perth after rain in January 1982. Maned Duck and Pink-eared Duck were rare in the wetlands Bekle (1983) studied.

Although winter of 1991 was the second wettest of the four winters during the waterfowl counting program (Fig. 9), it appeared to result in least breeding. There were 1801 breeding records in November 1988, 955 in 1989, 920 in 1990 and 865 in 1991 (Halse *et al.* 1990,1992,1994). This pattern may be caused by declining effort spent searching for nests. Alternatively, waterfowl may have perceived 1991 as a drier year than rainfall records (Table 2) or the percentage of waterbodies containing water (Fig. 9) indicated. A higher proportion (86 per cent)

of waterfowl were counted on wetlands supporting at least 500 birds in 1991 than in other Novembers (70 per cent in 1988, 80 per cent in 1989 and 1990), suggesting that birds were already congregating at summer refuges.

Most waterfowl were found in Wagin and Esperance regions during November 1991 and March 1992 surveys. Wagin was comparatively wet in 1991/92 (see Halse *et al.* 1990,1992,1994) but conditions in Esperance were comparatively dry. Large numbers of birds occurred in Wagin during all surveys between 1988 and 1992. The region is a stronghold for waterfowl in south-west WA, in spite of severe salination (Mulcahy 1978; Halse *et al.* 1993a) that makes it less favoured by salt-sensitive species such as Blue-billed Duck, Pacific Black Duck and Hardhead most years (Halse *et al.* 1993b). Numbers of waterfowl in Esperance were not high until March 1990. The region flooded extensively in the winter of 1989 (Halse *et al.* 1992) and, as water levels receded, it supported large numbers of birds (Halse *et al.* 1992,1994).

As in previous surveys (Halse *et al.* 1990,1992,1994), Bunbury and Gingin were the most important regions for breeding in November 1991. Unlike previous years, in 1991 Bunbury was less important than Gingin, perhaps because conditions were slightly drier in Bunbury.

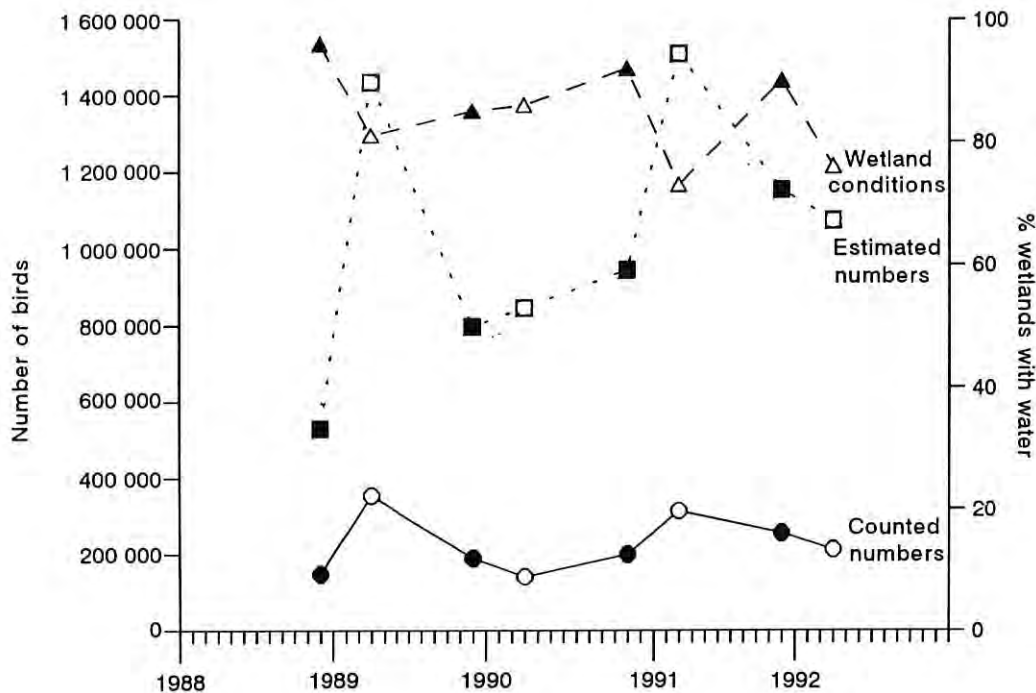


Figure 9. Numbers of birds counted, estimated numbers of birds in the surveyed area and percentage of wetlands surveyed that contained water during November and March waterfowl surveys between 1988/89 and 1991/92 in south-west WA.

ACKNOWLEDGEMENTS

Rob Turner was a skilful pilot during the aerial surveys; Chris Wilder entered the waterfowl data on computer and Alan Clarke prepared the figures. Most of the funding for this project was provided by the Nature Conservation and National Parks Trust Fund and through observers meeting their own costs. We thank the following observers who participated in the counts.

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APPENDIX 1

The number of wetlands in which each native waterfowl species occurred (N) and the three wetlands supporting highest numbers (in parentheses) of each species in November 1991 and March 1992. Regions and wetland types are given below the main body of the table.

SPECIES	N	1	2	3
NOVEMBER 1991				
Black Swan	211	Vasse-Wonnerup Estuary (1873)	Lake Muir (1493)	Wilson Inlet (909)
Freckled Duck	4	East Bryde Nature Res. Lake (8)	Dam 2 054-215 (2)	Gibbs Road Swamp (1)
Australian Shelduck	286	Lake Dumbleyung (9138)	Peel-Harvey Estuary (7691)	Lake Preston (7201)
Pacific Black Duck	407	Vasse-Wonnerup Estuary (3784)	Peel-Harvey Estuary (1793)	Jerdacuttup West Lake (911)
Grey Teal	387	Peel-Harvey Estuary (10745)	Vasse-Wonnerup Estuary (3093)	Coblinine River Flats (2817)
Chestnut Teal	41	Gordon Inlet (646)	Two Mille Lake (379)	Mullet Lake (275)
Australasian Shoveler	64	Peel-Harvey Estuary (150)	Jerdacuttup West Lake (130)	White Lake (Eneabba) (75)
Pink-eared Duck	96	Coyrecup Lake (6393)	Peel-Harvey Estuary (2000)	Casuarina Lake (1012)
Hardhead	68	Casuarina Lake (415)	Lake Chittering (100)	Culham Inlet (90)
Maned Duck	299	Taylor's Lakes (220)	Lake Chittering (142)	Waneragup Lake (120)
Blue-billed Duck	39	Lake Monger (23)	Yangebup Lake (20)	Bibra Lake (20)
Musk Duck	125	Lake Clifton (357)	Thomson's Lake (37)	Lake Mariginiup (34)
Eurasian Coot	248	Jerdacuttup West Lake (6932)	Casuarina Lake (2010)	Lake Guraga (1472)
MARCH 1992				
Black Swan	144	Wilson Inlet (2590)	Irwin Inlet (1340)	Mullet Lake (933)
Freckled Duck	1	East Bryde Nature Res. Lake (88)		
Australian Shelduck	235	Lake Dumbleyung (14022)	Peel-Harvey Estuary (3509)	Lake Brown (2000)
Pacific Black Duck	322	Murray River (Delta to Pinjarra) (2284)	Harvey River (Lower reach) (1554)	Lake Clifton (1199)
Grey Teal	284	Peel-Harvey Estuary (16462)	Lake Yealering (11720)	Coyrecup Lake (11040)
Chestnut Teal	47	Jerdacuttup West lake (2730)	Stokes Inlet (983)	Wheatfield Lake (848)
Australasian Shoveler	59	Coyrecup Lake (385)	Lake Forrestdale (370)	Lake Torrup (345)
Pink-eared Duck	56	Amarillo Pool (Serpentine River) (850)	Coyrecup Lake (711)	Thomson's Lake (303)
Hardhead	41	North Lake (173)	Lake Forrestdale (60)	Yellilup Swamp (40)
Maned Duck	154	Dam 1 063-217 (130)	Penwortham Pool (100)	Big SEC Swamp (82)
Blue-billed Duck	30	Thomson's Lake (318)	Lake Monger (130)	Lake Bambun (82)
Musk Duck	101	Lake Clifton (1240)	Katherine Lake (202)	Lake Preston (195)
Eurasian Coot	205	Lake Forrestdale (5750)	Goegrup Pool (Serpentine River) (1205)	Coyrecup Lake (1152)

Appendix 1 (continued)

NOTE

WETLAND	REGION	TYPE	WETLAND	REGION	TYPE
Amarillo Pool (Serpentine River)	Bunbury	R	Katherine Lake	Frankland	L
Lake Bambun	Gingin	L	Lake Mariginiup	Gingin	L
Bibra Lake	Gingin	L	Lake Monger	Gingin	L
Big SEC Swamp	Bunbury	L	Lake Muir	Frankland	L
Lake Brown	Beverley	L	Murray River (Delta to Pinjarra)	Bunbury	R
Casuarina Lake	Wagin	L	Mullet Lake	Esperance	L
Lake Chittering	Gingin	L	North Lake	Gingin	L
Lake Clifton	Bunbury	L	Peel-Harvey Estuary	Bunbury	E
Coblinine River Flats	Wagin	R	Penwortham Pool	Frankland	R
Coyrecup Lake	Wagin	L	Lake Preston	Bunbury	L
Culham Inlet	Bremer	E	Stokes Inlet	Esperance	E
Dam 1 063-217	Bunbury	D	Taylor's Lakes	Gingin	L
Dam 2 054-215	Geraldton	D	Thomson's Lake	Gingin	L
East Bryde Nature Reserve Lake	Magenta	L	Lake Torrup	Bremer	L
Lake Dumbleyung	Wagin	L	Two Mile Lake	Bremer	L
Lake Forrestdale	Gingin	L	Vasse -Wonnerup Estuary	Bunbury	E
Gibbs Road Swamp	Gingin	L	Waneragup Lake	Bunbury	L
Goegrup Pool (Serpentine River)	Bunbury	R	Wheatfield Lake	Esperance	L
Gordon Inlet	Bremer	E	White Lake (Eneabba)	Geraldton	L
Lake Guraga	Gingin	L	Wilson Inlet	Walpole	E
Harvey River (Lower reach)	Bunbury	R	Yangebup Lake	Gingin	I
Irwin Inlet	Walpole	E	Lake Yearloring	Beverley	L
Jerdacuttup West Lake	Esperance	L	Yellilup Swamp	Bremer	L

