Monitoring landbird populations in western Cyprus with particular reference to Paphos District

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Important changes are occurring in the populations of birds in Cyprus, owing to habitat loss and modification as a result of agricultural, and particularly tourist, developments, probably compounded by climate change and especially increasing aridity. In western Cyprus, mainly within Paphos District, we used Distance sampling to make population estimates for 32 species of landbirds for the period 2007–2010, in seven distinct land-use types. For an additional nine aerial and flocking species, it was only possible to estimate relative abundance, whilst notes were made of a further 17 less common species, whose numbers were insufficient for population estimates. Semi-natural habitats, such as forest and machis, were the most extensive and consequently of high conservation importance, as they harbour most of the bird populations and the most distinctive avifauna. However, arable land had the highest densities. Overall bird population densities for western Cyprus proved to be relatively low, particularly in semi-natural habitats, ranging from 3.3 to 5.6 birds per ha. Nevertheless, population estimates based on the data presented here provide the most cogent to date for species of semi-natural habitats. Altogether, Paphos District was estimated to have an average of *c*5 birds per ha, and a total of 700 000 breeding birds.

INTRODUCTION

Landbird populations on Cyprus are changing, and for many reasons. Currently, habitat loss, or change, is almost certainly having the biggest impact on landbirds, but climate change may already be having an effect too, and this will increasingly be the case, with drier years predicted. According to the Cyprus Department of Environment (2010),

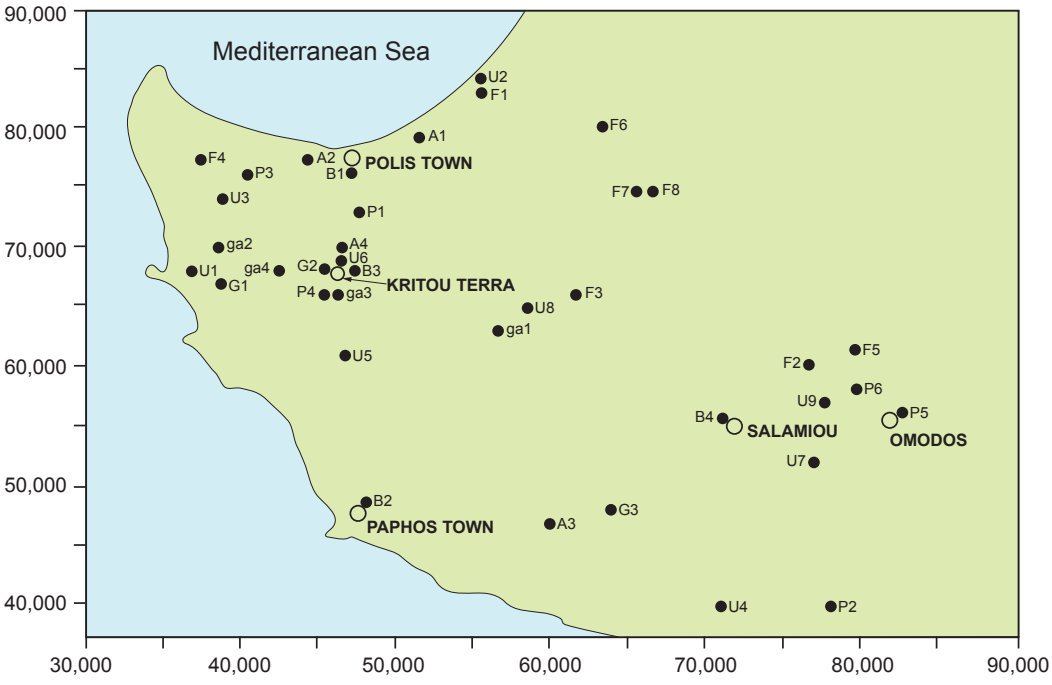

Figure 1. Map of western Cyprus showing location of sites listed in Table 1. Marginal co-ordinates refer to the Cyprus UTM system.

reporting on the climate of Cyprus as a whole, "annual precipitation has been decreasing at an average [rate] of one mm per year over the past century, while the temperatures have increased by 0.5°C over the same period". In other words, rainfall, which was already relatively low over most of the island, has already dropped by *c*100 mm. There is evidence too, that droughts (years with less than 80% of the long-term average rainfall) are becoming more frequent (Cyprus Meteorological Service 2012) and that the decline in rainfall has been faster in the upland areas of western Cyprus (Rossel 2001). A drier climate will mean less plant growth, and hence less food for insects. So birds that feed directly on plants, especially their fruits and seeds, as well as insectivorous birds, will be negatively affected, whilst that in turn will mean less for those at the top of the food chains, namely birds of prey and other predators such as Rollers *Coracias garrulus* and vultures.

A few species of birds may benefit from a drier climate; notably those, such as Calandra Lark *Melanocoryphra calandra* and Spectacled Warbler *Sylvia conspicillata,* which are characteristic of the drier parts of the island. These may spread westwards whilst the species already commoner in the wetter west of the island will be those most likely to decline. It is hard to know by how much the various changes in habitats and climate will affect birds and hence the need for monitoring their populations, with a view to proposing management actions wherever that may be practicable. If a species is declining, then it may be necessary to consider actions to halt or even reverse that process *eg* by protecting more of its required habitat, changing farming practices or revising hunting laws. Action is particularly called for if the species is already rare or if its breeding distribution is confined to Cyprus, as are the Cyprus Wheatear *Oenanthe cypriaca* and Cyprus Warbler *Sylvia melanothorax*. Four species have endemic races on the island, namely Eurasian Scops Owl *Otus scops cyprius*, Coal Tit *Periparus ater cypriotes*, Short-toed Tree-creeper *Certhia brachydactyla dorothea* and Eurasian Jay *Garrulus glandarius glaszneri*. For these endemic species and races, the Cyprus government, supported by NGOs, has the responsibility of ensuring their survival.

There are two stages for checking on species' welfare: knowing how many individuals there are (especially the sizes of their breeding populations) and then monitoring how their populations change in distribution and size with time. BirdLife Cyprus monitors both water and landbirds through a series of counting schemes, whilst the game and fauna service of Cyprus monitors numbers of raptors and other landbirds in a number of key sites, as well as several important game species including Chukar *Alectoris chukar* and Black Francolin *Francolinus francolinus*. The Cyprus government's forest department has a special concern for several raptors, including Griffon Vulture *Gyps fulvus*, Bonelli's Eagle *Hieraetus fasciatus* and Northern Goshawk *Accipiter gentilis*, for these species nearly always nest in forests. In this paper, we are only considering landbirds which regularly breed in western Cyprus, and which were recorded during our surveys. Inland passage migrants will be considered in a separate paper. Population estimates of some breeding species in western Cyprus have already been made, in each case using both transect counts and at least one other method *ie* Black Francolin (Pomeroy 2014), Common Kestrel *Falco tinnunculus*, Scops and Little Owls *Athene noctua* (Pomeroy & Walsh 2013) and Roller (Pomeroy *et al* 2013). Walsh & Pomeroy (2012) documented the spread of the Collared Dove *Streptopelia decaocto* and detailed studies of Northern House Martins *Delichon urbicum* have been made (Walsh *et al* 2013). Much attention has also been paid to the spread of breeding Sardinian Warblers *Sylvia melanocephala*, and the apparently negative effect of this on the endemic Cyprus Warbler *S. melanothorax* (Pomeroy & Walsh 2002, Jones 2006, Ieronymidou *et al* 2012, Flint & McArthur 2014, Pomeroy *et al* in review).

There are many methods available for monitoring bird populations (*eg* Bibby *et al* 2000, Buckland *et al* 2005). We document the recent state of breeding landbirds in western Cyprus and present estimates of their current populations in that part of western Cyprus which falls within Paphos administrative district, as described below. Paphos District itself is particularly important for bird conservation, as reflected in the declaration of 52% of PD as Important Bird Areas (Hellicar *et al* 2014). This provides a sound base from which to monitor changes as people and climate alter the environment. Following the example of bird population estimates for the UK (Newson *et al* 2005) we used land-use as a basis of sampling. We hope also to show which forms of land-use are most important for each of the 41 breeding species of landbirds for which we have adequate data, particularly for those of conservation concern.

METHODS

Each of 38 transect routes, widely dispersed in western Cyprus, were repeatedly walked in the six breeding seasons 2006–2011 (Table 1, Appendix 4). Most were in PD, although with fewer sites in the south, three in adjacent parts of Lefkosia and two were just within Lemesos District, the furthest east being near the village of Avdimou (Figure 1). Because it is a well-defined area, population estimates were made for PD, but data from similar habitats in adjacent districts were used to increase the sample size when making density estimates. And although there were fewer sites in the south of PD, the habitats found there were considered to be adequately covered elsewhere. Based upon a census of agriculture (Government of Cyprus 1994), Pomeroy & Walsh (2006) used six categories of land use, between them covering virtually every type found in PD and adjacent areas, and covering an altitudinal range of 30–1100 metres asl (Table 1). We used the same six categories in this paper.

Most analyses in the present paper are from data collected between 2007 and 2010, inclusive, during visits of several weeks, typically late April–late May, when most species were breeding. Data sets from years prior to 2007, and for 2011, are less complete (Appendix 4), but have been included in Distance analyses (see below). Each transect was selected to be representative of a particular form of land-use. Most were on minor roads or along farm tracks, none with much vehicular traffic. This allowed us to concentrate on the birds, since walking across country is usually rough and difficult. No site was selected for its known richness of birds, and the overall strategy was therefore one of stratified random sampling. The transects, which consisted of routes 0.8–2.4 km long, were slowly walked between one and three times (but usually twice) each breeding season and all birds detected were recorded. Most birds were seen, but many were detected by their songs or other sounds, particularly those in forests (Pomeroy & Gottschalk 2011).

For 32 of the species all records were marked on a map of the transect as it was walked, and the perpendicular distances from the transect to the birds were recorded in bands (0–5, 5–15, 15–25 and so on up to 85 m, then to 100, 120, 150 and 200 m). Distances were estimated by eye and periodically checked against a tape measure. This group of birds with distance data is referred to, collectively, as 'mapped birds'. Distances for occasional flying birds of the mapped species were taken as the distance at the point of first observation. In contrast, there were two categories of birds which were simply counted. For species which were almost always recorded flying, aerial species namely swifts and hirundines, recording distances was not practical. Secondly, regularly flocking species (Chukar, Feral Pigeon *Columba livia*, Eurasian Jackdaw *Corvus monedula* and House and Spanish Sparrows *Passer domesticus* and *P. hispaniolensis*) were also simply counted, since distances were often hard to give, particularly in urban areas. Together, these are the 'aerial and flocking species'.

Table 1. Site descriptions for 38 transects in western Cyprus.

Land use	Site name	Code[b]	n[a]	Length	Altitude (m)	Rainfall (mm)	Status[c]	Land cover (%)											
								Natural vegetation						Planted vegetation					
								Non woody		Woody				Non woody		Woody			
								<1	>1	0–1	1–3	3–8	>8	<1	>1	0–1	1–3	3–8	>8
FOREST	Yialia pines	F1	17	1680	180	500	F,G,S	64	0.3	32	33	34	1.4						
	Jephalas	F2	27	800	510	700	F,G,S	53	0	22	28	38	12						
	Psilophos	F3	25	1400	460	650	F,G,S	50	0	39	32	20	8						
	Akamas pines	F4	28	1070	370	500	F,S	40	0	22	26	24	0						
	West of Phini	F5	17	1150	630	750	F,G,S	58	0	17	24	26	10						
	Phirokli	F6	15	1280	800	700	F,G,S	35	0	22	23	13	2						
	Stavros lower	F7	17	2200	1050	800	F,G,S	16	0	20	35	28	6						
	Stavros upper	F8	27	2400	1150	800	F,G,S	28	0	27	36	31	8						
	FOREST MEAN							35	0	25	30	27	5.9	0	0	0	0	0	0
UNCULTIVATED	Lara juniper	U1	18	1680	50	450	F,G	27	0	69	35	0	0						
	Yialia broom	U2	17	1240	140	500	F,G,S	58	0	40	15	3.0	0						
	Akamas broom	U3	17	1500	350	500	F,S	25	0	61	14	1.6	0						
	Alektora	U4	20	1070	370	550	-	44	0.3	40	14	1.0	0	7.0	3.3	1.8	2.3	0.6	0
	Akoursos	U5	27	1100	350	650	G?	52	9	40	14	1.6	0						
	KT burnt	U6	20	900	420	600	G?	68	3.2	28	18	6.4	0						
	Ayios Yioryios	U7	27	940	530	650	-	62	0	34	24	6.5	0						
	Kritou Marottou	U8	10	1000	640	600	-	0	0	25	16	3.5	0	0	0	4.7	4.5	1.2	0
	Ag Nick upper	U9	17	950	950	650	-	46	0	37	15	2.6	0	0	0	1.9	0	0	0
	UNCULTIVATED MEAN							50	0.4	42	21	2.6	0	0.8	0.4	1.3	1.2	0.3	0

Table 1 cont. Site descriptions for 38 transects in western Cyprus.

Land use		Site name	Code[b]	n[a]	Length	Altitude (m)	Rainfall (mm)	Status[c]	Land cover (%)											
									Natural vegetation						Planted vegetation					
									Non woody		Woody				Non woody		Woody			
									<1	>1	0–1	1–3	3–8	>8	<1	>1	0–1	1–3	3–8	>8
GRASS/PHYGANA	LOWER ALTITUDE	Lara grass	G1	20	1380	170	550	-	78	0	17	4.7	0.3	0						
		KT grass	G2	17	930	490	600	-	89	0.5	4.5	2.5	0.4	0	0	0	2.0	3.8	1.4	0
		Stavros	G3	20	930	350	550	-	94	10	0	0	0	0						
	UPLAND	Drinia	ga1	14	1050	550	550	-	97	1.2	1.1	0.5	0	0						
		Inia	ga2	15	1000	530	600	-	93	1.5	2.9	0.2	0	0						
		Arodhes	ga3	13	490	620	600	-	98	3.2	0.1	0.3	0	0						
		Phasli	ga4	11	400	520	600	-	91	0	3.4	0.4	0	0						
		GRASS MEAN	ga1–4						91	2.3	4.1	1.3	0.1	0	0.2	0	0.3	0.5	0.2	0
ARABLE	UPLAND	Drinia	ga1	12	550	650	650	-	23	0	0	0	0	0	69	0.5	0.3	0.4	0	0
		Inia	ga2	14	600	530	600	-	23	0.3	3.1	1.5	0	0	53	0	0.9	1.5	0	0
		Arodhes	ga3	13	800	620	600	-	15	0.7	0	0	0	0	66	2.2	0.7	0	0	0
		Phasli	ga4	13	800	520	600	-	12	0	0.7	0.4	0	0	22	0	0	0	0	0
		UPLAND ARABLE MEAN							18	0.3	1.0	0.5	0	0	65	0.7	0.5	0.5	0	0
	LOWER ALTITUDE	Limni	A1	15	1180	80	500	-	37	0	2.7	2.3	0	3.0	17	0	3.9	3.5	0.8	0
		Latchi	A2	17	1200	30	450	-	21	1.2	4.7	3.8	0	0	43	0	1.3	0	0	0
		Nata	A3	17	2150	120	500	-	25	0.2	21	2.0	0	0	67	0	0.3	0.3	0	0
		Terra	A4	15	2100	350	600	-	22	0	0.3	8.8	3.3	0	34	0	4.6	16	8.0	0
		LOWER ALTITUDE ARABLE MEAN							28	0.4	3.9	4.2	0.9	0	40	0	2.5	5.0	2.2	0

Table 1 cont. Site descriptions for 38 transects in western Cyprus.

Land use	Site name	Code[b]	n[a]	Length	Altitude (m)	Rainfall (mm)	Status[c]	Land cover (%)											
								Natural vegetation						Planted vegetation					
								Non woody		Woody				Non woody		Woody			
								<1	>1	0–1	1–3	3–8	>8	<1	>1	0–1	1–3	3–8	>8
PERMANENT CROPS	Ghoudhi orchards	P1	17	830	60	500	-	21	0.3	1.4	1.0	0.4	0	12	0	14	32	10	0
	Avdimou carobs	P2	20	1060	170	500	-	43	0.1	20	9.1	0.9	0	24	0	2.2	9.1	4.6	0
	Neo Chorio groves	P3	27	940	220	550	-	80	0.1	6.2	5.9	1.0	0	5.5	0	6.5	10	6.5	0
	Arodhes vines	P4	27	1700	610	600	-	35	1.2	3.6	4.1	0.9	0	0.5	0	16	4.2	1.0	0
	Omodos vines	P5	20	990	730	700	-	51	2.1	7.9	5.5	2.7	0	0	0	18	4.5	2.5	0
	Ag. Nick upper vines	P6	27	1210	980	650	-	11	0	5.7	2.6	0.1	0	0	0	20	0.7	0	0
	PERMANENT CROPS MEAN							40	0.6	7.3	4.7	1.0	0	7.0	0	13	10	4.1	0
BUILT-UP	Polis town	B1	20	2100	30	450	-	8.8	0	0	0	0	0	3.3	0	6.1	12	6.3	0.1
	Paphos town	B2	20	2400	50	450	-	19	0.5	1.1	1.8	2.3	0	5.8	0	9.8	16	8.5	0.8
	KT village	B3	27	1720	470	600	-	36	0.8	2.5	2.5	0.5	0.3	3.3	0	11	19	9.4	0
	Salamiou village	B4	17	1150	660	650	-	20	0	1.0	1.3	0	0	3.3	0	6.8	19	10	0
	BUILT-UP MEAN							21	0.3	1.2	1.4	0.7	0.1	4.0	0	8.4	17	8.8	0.2

[a] number of counts per site

[b] site code as shown in Figure 1

[c] F = Forest Reserve, G = Game Reserve, S = Special Protection Areas

Table 2. Estimation of the breeding population of Cyprus Wheatears *Oenanthe cypriaca* in Paphos District. A 'round' is a complete set of counts of all sites. ESW = Estimated Strip Width (on either side of the transect line); LCL, UCL = Lower, Upper Confidence Limits (95%). The models for Distance estimates were all half-normal; n = total number of birds for which Distance estimates were made, including those from years before 2007, and from 2011. Because there were few birds in Grass/phrygana and Arable areas, the statistics for 'Total' were used.

		Area (km^2)[a] of land-use type	Number of rounds 2007–10	Length (km)	ESW (n = 648)	LCL	UCL	Total birds counted
Forest		328	10	11.28	14.3	11.7	17.6	114
Uncultivated		345	10	9.90	13.7	10.5	18.0	69
Grass/phrygana		475	8	6.05	23.0	17.3	30.6	20
Arable	Lowland	80	10	6.49	38.8	26.1	57.7	3
	Upland	21	8	2.90				0
Permanent Crops		107	8	6.41	37.9	31.1	46.2	47
Built-up		40	9	7.14	16.8	11.4	24.8	41
Total		1396	63	50.13	15.7	13.7	18.1	294

		Area surveyed (km^2)[b]		Density (birds km^{-2})[c]		Total Population[d]	
		LCL	UCL	LCL	UCL	LCL	UCL
Forest		2.64	3.97	28.72	43.18	9420	14 163
Uncultivated		2.08	3.56	19.38	33.17	6686	11 444
Grass/phrygana		1.67	2.96	6.76	11.98	3211	5691
Arable	Lowland	3.39	7.49	0.40	0.88	32	70
	Upland	-	-	-	-	0	0
Permanent Crops		3.19	4.74	9.92	14.73	1061	1576
Built-up		1.47	3.19	12.85	27.59	514	1116
TOTAL		-	-	-	-	20 924	34 060

[a] = from Pomeroy & Walsh (2006), with their 101 km^2 of arable divided into 80 for lowland (to 400 m) and 21 km^2 for upland (formerly grass/phrygana), this division being based upon field observation

[b] = total transect length × number of rounds × LCL/UCL [in km] × 2 [because LCL/UCL applies to both sides of the route]

[c] = number of birds counted/area surveyed

[d] = density × area of land use type

Special methods would have been required to estimate the populations of these species, and although these exist (*eg* De Laet *et al* 2011 for House Sparrows), we had insufficient time to apply them. Common and scientific names are from BirdLife International (2015) whilst scientific names of subspecies endemic to Cyprus are from Flint & Stuart (1992).

The data for the mapped species allowed population densities (numbers of birds km^{-1}) to be estimated by means of the computer program Distance (Thomas *et al* 2010). Here we use density estimates to calculate populations for the whole of PD—but already the method has been used for a whole country, the UK (Newson *et al* 2008). Analysis by Distance was done separately for each land-use type with 30 or more observations for the species concerned, and for all land-use types combined. Where the number of birds recorded from a particular land-use was less than 30, we used the confidence limits for the totals for that species (as in the last line of Table 3). Table 2 provides an example for a species with many observations, the Cyprus Wheatear, showing results for each land-use category. Distance makes a number of assumptions, of which two are particularly pertinent. Firstly, that all birds along the transect line are detected, which is likely to have been the case, except for some skulking species (such as Cyprus Warbler) in places with many shrubs next to the path. Secondly, that the transect line crosses the countryside in

Table 3. Summary of main overall results for 32 species with density and population estimates (A) and nine flocking and aerial species (B). In part A, populations are shown as lower and upper 95% confidence limits (LCL, UCL).

A: SPECIES WITH DENSITY AND POPULATION ESTIMATES

	Estimated population in Paphos District		Land-use type[a] with highest estimated population			Land-use[a] with highest mean density	Birds km^{-2}	European Trends[b]	SPEC[c]	Cyprus Trend[d]
	LCL	UCL		LCL	UCL					
Common Kestrel *Falco tinnunculus*	2310	3816	Grass/phrygana	1443	2381	Grass/phrygana	4.0	↓	3	Uncertain –ve
Black Francolin *Francolinus francolinus*	344	500	Low-mid alt arable	296	431	Low-mid alt arable	4.5	ND	3	Uncertain –ve
Common Woodpigeon *Columba palumbus*	11 689	20 104	Grass/phrygana	3544	4859	Low-mid alt arable	27.6	↑	Non	Uncertain –ve
Collared Dove *Streptopelia decaocta*	6123	9489	Built-up	5136	7434	Built-up	157.1	↑	Non	Uncertain +ve
Turtle Dove *Sreptopelia turtur*	1391	2629	Low-mid alt arable	608	1311	Low-mid alt arable	24.7	↓	3	Uncertain +ve
Great Spotted Cuckoo *Clamator glandarius*	1866	3028	Uncultivated	836	1411	Uncultivated	3.2	ND	Non	Uncertain –ve
Scops Owl *Otus scops*	156	598	Uncultivated	83	317	Uncultivated	0.6	ND	3	Uncertain +ve
Little Owl *Athene noctua*	1484	2772	Grass/phrygana	1268	2342	Grass/phrygana	3.8	ND	3	Uncertain –ve
European Hoopoe *Upupa epops*	241	730	Forest	178	594	Forest	1.2	-	3	Uncertain –ve
European Roller *Coracias garrulus*	2896	4734	Grass/phrygana	1577	2641	Low-mid alt arable	6.3	ND	2	Moderate decline*
Crested Lark *Galerida cristata*	33 948	56 515	Grass/phrygana	29 148	47 500	Grass/phrygana	80.7	?	3	Uncertain +ve
Winter Wren *Troglodytes troglodytes*	2396	4048	Forest	1411	2290	Forest	5.5	↑	Non	Uncertain +ve
Cyprus Wheatear *Oenantha cypriaca*	20 924	34 060	Forest	9420	14 163	Forest	36.0	ND	Non	Uncertain –ve
Cetti's Warbler *Cettia cetti*	23 195	37 947	Uncultivated	12 176	19 092	Low-mid alt arable	72.2	↑	Non	Uncertain +ve
Zitting Cisticola *Cisticola juncidis*	31 304	45 540	Grass/phrygana	15 160	23 750	Upland arable	166.8	↓	Non	Uncertain +ve
Olivaceous Warbler *Hippolais pallida*	26 230	41 042	Uncultivated	15 171	22 285	Permanent crops	54.6	ND	3	Moderate increase**
Sardinian Warbler *Sylvia melanocephala*	109 403	152 814	Uncultivated	57 266	72 159	Low-mid alt arable	215.2	-	Non	Strong increase*
Cyprus Warbler *Sylvia melanothorax*	22 126	34 564	Uncultivated	12 202	16 281	Uncultivated	41.3	ND	Non	Moderate decline*
Coal Tit *Periparus ater*	27 540	31 969	Forest	27 270	31 667	Forest	89.8	-	Non	Strong increase**
Great Tit *Parus major*	25 017	41 701	Permanent crops	8392	13 102	Permanent crops	100.9	↑	Non	Uncertain +ve
Short-toed Tree-creeper *Certhis brachydactyla*	974	1781	Forest	971	1781	Forest	4.2	↑	Non	Uncertain +ve
Masked Shrike *Lanius nubicus*	2772	6214	Forest	2718	5531	Forest	12.6	ND	2	Uncertain –ve

Table 3 cont. Summary of main overall results for 32 species with density and population estimates (A) and nine flocking and aerial species (B). In part A, populations are shown as lower and upper 95% confidence limits (LCL, UCL).

Eurasian Jay *Garrulus glandarius*	2172	3770	Forest	2172	3770	Forest	26.4	↑	Non	Moderate increase*
Black-billed Magpie *Pica pica*	16 106	21 907	Grass/phrygana	12 018	5733	Grass/phrygana	29.2	↓	Non	Steep decline*
Hooded Crow *Corvus corone*	1702	2855	Grass/phrygana	542	802	Built-up	15.8	-	Non	Uncertain –ve
Eurasian Chaffinch *Fringilla coelebs*	4002	5109	Forest	4002	5109	Forest	13.9	-	Non	Uncertain +ve
European Greenfinch *Carduelis chloris*	32 548	51 273	Grass/phrygana	10 086	13 634	Low-mid alt arable	63.6	-	Non	Uncertain –ve
European Goldfinch *Carduelis carduelis*	42 682	72 646	Uncultivated	13 261	22 531	Permanent crops	75.1	-	Non	Steep decline*
European Linnet *Carduelis cannabina*	33 200	53 552	Uncultivated	10 313	18 113	Permanent crops	133.1	↓	2	Uncertain +ve
Cretzschmar's Bunting *Emberiza caesia*	30 607	47 639	Forest	27 282	41 115	Forest	104.3	ND	Non	Uncertain –ve
Black-headed Bunting *Emberiza melanocephala*	3865	6276	Uncultivated	1946	3336	Permanent crops	15.5	?	2	Steep decline**
Corn Bunting *Miliaria calandra*	11 242	18 977	Grass/phrygana	9697	16 106	Upland arable	58.1	↓	2	Moderate increase*

B. FLOCKING and AERIAL SPECIES

	Land-use with highest number per 100 counts	European trends	SPEC	Cyprus trend
Chukar *Alectoris chukar*	Uncultivated	ND	3	Uncertain –ve
Feral Pigeon *Columba livia*	Built-up	-	Non	Strong increase **
Common Swift *Apus apus*	Built-up	-	Non	Uncertain –ve
Barn Swallow *Hirundo rustica*	Built-up	↓	3	Moderate decline**
Red-rumped Swallow *Hirundo daurica*	Permanent crops	ND	Non	Uncertain –ve
Northern House Martin *Delichon urbica*	Built-up	-	3	Strong increase **
Eurasian Jackdaw *Corvus monedula*	Low-mid alt arable	-	Non	Uncertain –ve
House Sparrow *Passer domesticus*	Built-up	-	3	Strong increase **
Spanish Sparrow *Passer hispaniolensis*	Low-mid alt arable	ND	Non	Steep deline*

[a] Land-use type as in Appendix 2. [b] From PECBMS (2012); ND = no data ↑ = moderate increase, ↓ = moderate decrease, - = stable

[c] From BirdLife International (2004): SPEC
1—Global concern 2—Concentrated in Europe, unfavourable status 3—Not concentrated in Europe, unfavourable status
4—Concentrated in Europe, favourable status Non —Not concentrated in Europe, favourable status

[d] Data are regression slopes, positive or negative; * = $P < 0.05$, ** = $P < 0.01$

a random way. For practical reasons most transect routes were on minor roads and paths so this assumption is less likely to hold. In some places, particularly those with vines or fruit trees, fields were separated by walls and hedges, sometimes with trees, and these also bordered the tracks. These provided good habitat for species such as warblers and Great Tits *Parus major*, which may thus have been over-estimated, although not greatly so because the small size of fields (some were less than 20 m across) meant that the roadside habitat was in fact found across the countryside in general. These sources of bias are less important for monitoring purposes, since the same route is followed every time, than for population estimates, where they need to be considered. Estimating distances to birds that were only heard was more difficult in denser habitats, such as permanent crops and some forest areas with shrubs. Such species will often have been under-estimated if the sounds were mainly calls and songs, for that meant that males were only recorded if singing or calling, and that females were rarely included. These species are indicated in Appendix 1 by a hash symbol. Birds overflying a site, especially if higher up (*eg* Common Woodpigeons *Columba palumbus* going to drink) were not counted, but flying birds using the habitat, such as hunting Rollers, or just flying a short distance, were included. In addition to the 32 species with Distance estimates, and the nine flocking and aerial species, a further 16 species were recorded in such low numbers that analyses were impracticable, but they are included in Appendix 1, where they are indicated with an asterisk.

For analysis of trends, our transect data were also combined with those from other sites, across the island, co-ordinated by BirdLife Cyprus, and analysed by the Pan-European Common Bird Monitoring Scheme (PECBMS), for the period 2006–2011 (*Trends* in Results below).

Vegetation cover and some other site attributes (such as the presence of walls, buildings and power lines) were recorded at ten random points along each transect. Vegetation was divided into native and planted, and sub-divided into woody and non-woody. The % cover was then estimated in up to four layers above the ground, namely 0–1, 1–3, 3–8 and >8 m; only the first two applied to non-woody vegetation, and only in forests were there a few trees exceeding 8 m in height. Per cent cover was estimated by eye for a circle of 10 m radius from the observer, excluding the track he was on. Each circle was divided into four imaginary sectors, and the cover estimated as 0, 5, 10, 15, 20 or 25% in each sector, giving a possible total of 100%. The data for the ten points were averaged, and the exercise repeated in another year to produce an overall average based upon 20 points, as shown in Table 1.

Each transect was selected as being representative of one of six land-use types as defined by the 1994 Census of Agriculture (see above), namely forest, uncultivated land, grass/phrygana, arable, permanent crops and built-up (see next section and Appendix 1 for details). Changes in area since 1994 are not thought to have been great (but see comments below under the various land-use categories). There are other classifications and data on land-use (*eg* Ministry of Agriculture, Natural Resources and Environment 2005) but they do not give information at District level. We did, however, split the 101 km^2 of arable land, as defined by the Ministry of Agriculture, into an estimated 20 km^2 in uplands, the remainder being at low–mid altitudes (mainly below 400 m). To some extent, the land-use types described here correspond to habitats (*eg* forest, built-up) but not always, as Fuller (2012 p7) has emphasised. Thus *eg* 'permanent crops' includes both orchards of citrus or olive, and vineyards.

Major land-use types

The various land-use types are not, of course, always clear-cut, but each of our transects was predominantly within one type. We use 'forest' for areas within forest reserves which are dominated by *Pinus brutia* with a notable under-storey of the endemic Golden Oak

Quercus alnifolia, especially at higher altitudes. Other species of smaller trees and shrubs occur mainly in valley bottoms and gullies. In most places the forest was quite open with a canopy cover of *c*30% (Table 1). The Cyprus Cedar *Cedrus brevifolia* now occurs naturally only in the Paphos forest reserve, though it did not feature in any of our survey plots. Many shrubs, notably various species of *Cistus*, such as *C. creticus* and other related species are very common (scientific names of plants in the present paper follow Blamey & Grey-Wilson 2008). Until recently, the Akamas forest reserve was heavily browsed, mainly by goats (Ioannou 2006). There are Mouflon *Ovis musimon* in and around the Paphos forest reserve in relatively small numbers, mainly in more open areas where they prefer to graze, but are unlikely to have much effect on bird populations.

Even within the forest reserves, some areas were much more open as with two of our transects that fall into the diverse category 'uncultivated', which also includes locally extensive areas of taller scrub types such as maquis (see below). Some smaller areas of abandoned cultivations, which were often terraced and retained some trees, especially almonds *Prunus dulcis*, are included in this category, and formed parts of three transects. Much of the uplands of PD are hilly and either covered with low grass and other plants, which we refer to as grass/phrygana and discuss below, or rather bushier machis vegetation, with mostly thorny sub-shrubs, and often rocky too. Larger shrubs, such as Juniper *Juniperus excelsa*, Thorny Broom *Calycotome villosa* and Thorny Gorse *Genista sphacelata*, together with occasional trees, mainly pines but often with oaks and other species in valleys, also occur, whilst smaller shrubs such as *Cistus* spp are widespread. Where the scattered trees are more common, the term mattoral could apply.

The third category is 'grass/phrygana'. This and the previous category are similar in being typical of higher land, especially the more hilly areas, and both having been grazed and browsed, mainly by sheep and goats, until the recent changes in favour of zero grazing (penning and stall feeding) for most livestock. *Phrygana* is the term used in the Balkans and eastern Mediterranean for garigue, a term more widely used in the western Mediterranean. Polunin & Walters (1985 p131) defined it as "more or less open shrub community, usually about 50 cm high, and rarely growing above 1 m. Consists of dwarf shrubs…often thorny…and often in clumps with a considerable amount of bare, stony ground." They distinguish it from maquis which is taller, and usually in wetter places, and which may include taller shrubs and trees such as broom, juniper and pines. They give details of a sub-type termed 'Eastern thorny garigue (phrygana)'. Although at first glance, this habitat appears to consist mainly of grass, closer inspection shows a wide range of other herbaceous plants, often spiny, and sometimes woody (Table 1).

These first three categories can all be considered as semi-natural; the plant species are almost all native, but the vegetation has been affected by several thousand years of burning, grazing and the removal of trees. In PD only about 7% of the land is devoted to annual crops. In the broader valleys, such as at Chrysochou and Nata, arable farming consists of relatively large fields, typically up to 5 ha, devoted to cereals and vegetables, often with fallow, and with relatively few walls and hedges. The adjacent field margins support strips of native plants, often including shrubs and small trees. In upland areas, fields have been created, or revived, in a number of relatively flat areas, usually within grass/phrygana habitats. Some fields are cut for hay. Transects in these areas necessarily included both forms of land-use, but each bird was noted as being in (or over) one or the other, and they were analysed separately. 'Permanent crops' were of two main categories: trees and vineyards. Trees were mainly olive *Olea europea*, carob *Ceratonia siliqua* and various citrus. The total area of permanent crops in PD has been declining for many years and is now only *c*8%. Almost all villages have a belt of tree crops, principally almonds, surrounding them. Carobs are becoming much less common than formerly, but more

land is being devoted to olives, for which there is a good market. Vineyards, mainly at higher altitudes, are also declining (Bruggerman *et al* 2011), but replanting with improved varieties has increased in recent years. Finally, 'built-up' areas were towns and villages, within which were often some almonds, olives or other trees (usually exotic, particularly species of *Eucalyptus*) and sometimes, as in Paphos, cultivated fields within the town.

RESULTS

Each of the six main land-use types has its characteristic bird communities, so these are considered first, before concluding with an overview of bird populations in PD as a whole. As can be seen from Table 1, the amounts of bare ground, non-woody and woody vegetation (both natural and planted) varied considerably between sites. The mean values for each main category of land-use show *eg* that canopy cover of forests was less than 30% for trees between 3 and 8 m tall, and that very few trees exceeded 8 m in height. There were no clear correlations with other variables recorded, such as the presence of walls.

Forests

Forests are special for several reasons, not least their environmental and economic aspects. The estimated forest cover of PD is 328 km^2, most of it being in Paphos forest reserve (which also extends into Lefkosia and Lemesos Districts), and the next most important, the Akamas forest reserve.

We recorded nearly a thousand birds of 29 species on the eight forest transects during the four survey years (Appendix 2). One transect was in the Akamas forest reserve, the others in Paphos FR, where they ranged from below 200 to over 1100 m asl, and totalled 11.28 km in length. A few bird species that might have been expected were not encountered, notably Bonelli's Eagle and Common Nightingale *Luscinia megarhynchos* which were observed outside of our counts. For 20 species there were sufficient data to undertake Distance analyses, and these gave a total density of *c*4.4 birds per ha, to which must be added a few aerial species (hirundines and Swift), and two flocking species of sparrows, so the total density probably approaches 5 birds ha^{-1}, a fairly low figure, perhaps related to the highly sclerophyllous nature of most of the vegetation.

The forest avifauna is unusual and special because five species (three in Appendix 2, plus Common Cuckoo *Cuculus canorus* and Eurasian Blackbird *Turdus merula*) were confined to forest sites, whilst a further five species were more common in forest than anywhere else. No other land-use type has 'unique' species, but on the other hand, there were also five species which occurred in every land-use category except forest. And amongst those species that do occur in forest, Coal Tit, Eurasian Jay and Eurasian Chaffinch *Fringilla coelebs* are notably absent from the Akamas FR. It seems likely that this is due to the forests on the Akamas peninsula having been long separated from Paphos FR, rather than being related to altitude, since all three occur down to at least 200 m (Chaffinch) or 100 m asl (the other two) in Paphos FR forest; most of the Akamas forest is above these altitudes.

Uncultivated land

There were nine transects in these important habitats, ranging in altitude from 50 m near Lara on the west coast, to nearly 1000 m asl above Ag Nicklaus in the east, and totalling 9.90 km in length. Although this habitat had less woody vegetation than the forests (Table 1), more bird species were recorded and the overall density of birds was the highest of the semi-natural habitats (Appendix 2). Of the species whose densities were estimated, eight had their highest populations in uncultivated areas, although only three had their highest densities there (Appendix 2).

Grass/phrygana

Three transects, at altitudes between 150 and 350 m asl, consisted only of this grass/phrygana habitat, but in four sites at higher altitudes, 520–610 m asl, parts had been cultivated for cereals or cut for hay in recent years particularly since 2010 when most livestock were kept penned rather than grazing the hillsides. Together, these transects had a total length of 6.05 km. All bird records were allocated to one or other of these two habitats as they were recorded. The agricultural parts (including hayfields) are considered in the next section.

Thirty species of birds were recorded as using this habitat, but at relatively low densities, perhaps because of the virtual absence of trees and the fact that much of the vegetation is spiny and tough. Nevertheless, ten species were estimated to have their highest populations in this, the most extensive habitat, which is important for that reason.

Arable

There are two broadly different types of arable land, at low–mid altitudes (up to *c*400 m), and at the higher altitudes described above. In the low–mid altitude areas, the principal crops were cereals and vegetables (mainly potatoes and cabbages) and some arable land was fallow in all years. We had four transects in each of the two categories, parts of the upland ones being grass/phrygana, which were counted separately, as described in the previous section. They totalled 6.49 and 2.90 km in length respectively. Upland arable sites had the fewest species (22) of any habitat, and their relatively small area was one reason for their not being very important for any particular species, although the Zitting Cisticola *Cisticola juncidis* reached its highest density there. If cultivation continues to expand in these upland areas, it will mainly be at the expense of the grass/phrygana habitat. Low–mid altitude arable areas were of considerable interest and importance, partly because agriculture was rarely intensive, often leaving quite wide field margins which supported significant amounts of native vegetation (Table 1). The presence of this cover, and the softer nature of crop plants, in comparison to those which are native, may be the main reasons for the high density of birds in these habitats—nearly double the average of that in the semi-natural habitats.

Permanent crops

We had three sites below 250 m in olive and carob groves, and a citrus orchard, and three above 600 m asl, all in vineyards; in total, these covered 6.41 km. There was only a small amount of native woody vegetation around permanent crops (Table 1), but the crops themselves supported a wide variety of species and at relatively high densities (Table 3, Appendix 2). For the Great Tit, the orchards were the habitat supporting the largest part of its population, and Greenfinches *Chloris chloris* and European Linnets *Carduelis cannabina* also had their highest densities in these habitats (Table 1).

Built-up areas

Transects were established in the two towns of PD, Paphos and Polis, and both were below 50 m, whilst the two villages selected from many, Kritou Terra and Salamiou, were at *c*470 and 660 m asl respectively. These four transects had a total length of 7.14 km. Villages are particularly important for Common Swifts *Apus apus*, Barn Swallows *Hirundo rustica*, House Martins and House Sparrows, as well as Feral Pigeons *Columba livia* and Collared Doves. Each uses a different element *eg* under the eaves of upper storeys on older stone and concrete buildings for House Martins (Walsh *et al* 2013). The swallow, martin and sparrow are all SPEC 3 species and, whilst all are numerous at present, may well decline as village houses and other buildings are renovated and modernised.

Flocking and aerial species

Although it was not considered practicable to estimate distances from the track to these species, they were nevertheless counted, and the results of this are summarised in Appendix 3. The range of numbers in these counts was considerable, and averages were therefore expressed as birds per one hundred counts to avoid too many decimal numbers at the lower end. It is not surprising that five of the nine species have their highest numbers in the villages and towns, because these are their main breeding sites, although they occupy a relatively small area of PD, so that their total populations would not be proportionately high.

Trends

Overall PECMBS (2012) found 19 species in Cyprus showing positive trends, and 22 declining (Table 3). However, only four of the positive trends and eight of the negative ones are statistically significant *eg* the Sardinian Warbler shows a 'moderate increase', whilst its congener the Cyprus Warbler has a 'moderate decrease', both $P<0.01$.

DISCUSSION

Birds are not only an important part of the natural environment, they are also widely considered to represent biodiversity as a whole (*eg* Bibby *et al* 2000, Furness & Greenwood 1993). A number of the species in this study are still abundant, contributing to ecosystem services and potentially to be 'green-listed', which IUCN is proposing as a category for species which are 'fully conserved' (Redford *et al* 2013). This is in line with other recent attempts to give more consideration to keeping common species common, rather than always worrying about those that are rare. Nevertheless, whilst some species are doing well, maintaining their numbers or even increasing, others are declining, three at least of them declining steeply (Table 3). This last group— Black-billed Magpie, Spanish Sparrow and Black-headed Bunting—are therefore of greatest conservation concern, and for these it is of particular importance to determine their requirements and to attempt to discover the causes of their decline. The magpie is currently numerous; however it is also the main host of the Great Spotted Cuckoo, which is already showing signs of a decline, although not yet statistically significant. Interestingly, in Cyprus and Israel (Yom-Tov *et al* 2012) the proportions of birds that are increasing (roughly half) are closely similar though the data for Israel are over a much longer period and involve more species. The situation in Turkey is causing much concern (Şekercioğlu *et al* 2011), primarily due to habitat loss particularly of the Mediterranean ecosystems.

BirdLife International (2004) published estimates for the breeding populations of birds in Europe, including Cyprus; but for the latter, with very few actual census data available, numbers given were very approximate. For that reason, and because here we are only concerned with PD, comparison with the earlier figures does not seem very helpful, as the following examples show. BLI gave the population of Coal Tits as 5 000–15 000 *pairs*, whereas we estimate 28 000–32 000 *birds* (to the nearest thousand) for PD alone. For Cyprus Wheatear BLI gives 90 000–180 000 *pairs* whilst we estimate for PD only 21 000–34 000 *birds*. It seems likely, therefore, that some earlier estimates were too high (*eg* Cyprus Wheatear) and others too low (*eg* Coal Tit).

Arable land in western Cyprus holds large populations of a wide range of species but when combined with other man-modified habitats, comprises less than 20% of the land area of PD. Agricultural land is an important Mediterranean landscape and needs to be included in conservation planning (Montana *et al* 2011). However, in Cyprus the more than 80% of semi-natural habitats are where most of the birds are, and consequently are

of greatest importance for conservation. Forests are the most important habitat of all, and they are currently well-managed from a conservation point-of-view. The more open lands (here referred to as uncultivated, grass and phrygana) together cover nearly 60% of PD, and they are undergoing several man-made changes in addition to the underlying trends in climate (higher temperatures, lower rainfall). These areas have been subject to grazing, browsing and fire for so long that, for most areas, it is hard to know what would happen if those actions stopped. And the recent trend of penning livestock for much of the year, allows grasses and other plants to grow, become rank, and potentially more combustible. The monitoring programme of BirdLife Cyprus should allow the impact of these changes on birds to be followed.

Pine forests in Cyprus support a wide variety of species, several of which are commoner at higher altitudes, and these are likely to be adversely affected by a warmer, drier climate. Under such conditions, they are likely to move to even higher altitudes, which of course are smaller in area and can thus only support smaller populations (Huntley 2007). Forests with a variety of other tree species would be expected to contain more bird species than pure pine forests, as has been found in Spain (Diaz 2006); and is probably the case in Cyprus. Natural pine forests also contain more bird species and at higher densities than the pine plantations which are common in the western Mediterranean (Diaz *et al* 1998). In the tropics, bird population densities in natural pine forests have been recorded as *c*10 birds ha^{-1} in the Bahamas (Emlen 1977), but only 2.6 in pine plantations in Uganda (Pomeroy & Dranzoa 1998). The creation of plantations of exotic pines on Cyprus would almost certainly have a negative effect on birds.

We have mentioned that one of the most important assumptions in Distance sampling was not followed closely. The presence of trackside walls and hedges in some sites will have inflated population estimates of some species, although not too seriously since many fields in Cyprus are small, less than 0.1 ha in size, and relatively few are more than 1.0 ha (and these have fewer hedges). The fact that our routes were not random lines is partly mitigated by *eg* their following contours and not being directed at places where most birds were expected. This gave them a measure of independence. Whilst these weaknesses make the estimation of actual numbers less accurate, they are not so serious for monitoring, where consistency between years is more important. That said, the overall bird population densities in Cyprus appear to be relatively low, particularly in the semi-natural habitats where many of the woody plants, from sub-shrubs to trees, are sclerophyllous, which as well as making them hard to eat also increases their resistance to fire. Our density estimates, ranging from 3.3–5.6 birds ha^{-1} for these habitats, do not include the aerial and flocking species, only a few of which were at all common (notably Jackdaws and House Sparrows in uncultivated, grass/phrygana and, for sparrows, built-up areas).

For the man-modified habitats, bird densities were higher, and we can make some comparisons with data from the UK (Newson *et al* 2005). Those authors give density estimates for 20 species which 'commonly use farmland'. In their table 5, farm 4 was described as 'tilled farmland' and the 20 species combined had a density of 2.4 birds ha^{-1}, compared to our low–mid altitude arable land estimate of 8.3; this surely reflects the generally much lower intensity of arable farming in western Cyprus compared to the UK. Two other comparisons can be made: Newson *et al*'s farm 5 included orchards, and had 3.6 birds ha$^{-1,}$ whilst we had 6.7 for permanent crops, which also included orchards; and their estimates of 4.4 and 3.1 birds ha^{-1} for urban and suburban compare to our 3.4 for built-up areas, in all cases excluding House Sparrows which, in Cyprus, were numerous but for which, as explained above, we had no density estimate. The comparisons of density estimates are at best approximate, since the UK data were confined to the 20 common

farmland species and ours excluded aerial and flocking species. The pine forest data (both natural and plantations) are from the tropics, in warmer, wetter climates. Overall, it seems that landbird population densities in man-modified habitats in Cyprus are at least comparable to those elsewhere. If we use an overall density estimate of 5 birds ha^{-1} in PD, rather higher than the densities in the various habitats surveyed by Newson *et al* (2005) in the UK, there would be nearly 700 000 birds in PD (plus the waterbirds), considerably more birds than people. If one were to predict that the whole of Cyprus probably supports several million birds in the breeding season, this would be broadly similar to the numbers caught and eaten in Cyprus each year, although those are mostly passage migrants.

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Appendix 1. Notes on particular species.

Notes here include species whose numbers were too small for population estimates to be made; these are indicated by an asterisk. In addition, we have included species which were probably under-estimated, due to issues of detectabilty; these are marked # or ## in cases where the under-estimation is particularly likely to be large (see Methods section of text).

Eurasian Griffon* *Gyps fulvus.* Recorded several times near Salamiou, but not within counts.

Long-legged Buzzard* *Buteo rufinus*. Recorded twice, near Lemona and Salamiou.

Northern Harrier* *Circus cyaneus*. Occasional in upland grasslands, but not in counts.

Northern Goshawk** *Accipiter gentilis.* Occasionally heard calling in Paphos FR, mostly above Stavros-tis-Psokis.

Bonelli's Eagle* *Aquila fasciatus.* Although widespread, this eagle is sparse and was not seen during our counts. Its population on the nearby Pentadaktylos range was recently estimated as between 10 and 18 pairs, and its ecology was also reviewed (Beton *et al* 2013).

Peregrine Falcon* *Falco peregrinus.* Occasionally seen on the Akamas peninsula, usually near the coast.

Common Kestrel *F. tinnunculus.* A more detailed account of this species is given by Pomeroy & Walsh (2013) who show a steep decline in numbers, possibly due to hunters destroying their nests (Hadjisterkotis 2003).

Black Francolin# *Francolinus francolinus.* See Pomeroy (2014) for a detailed account of this species, which shows that known males were only recorded on one visit out of three; the birds were rarely seen. There is evidence of a recent decline in numbers, but see Hadjigerou *et al* (2004) for an estimate of far higher numbers.

Chukar *Alectoris chukar.* Later counts often included parties of recently-hatched young, and some larger groups were also found around Game and Fauna Service cages, where they were attracted by food put out for hatchlings. Management of the species is discussed by Panayides *et al* (2011).

Common Woodpigeon *Columba palumbus.* Most forest records were of distant birds heard, so populations there are likely to have been under-estimated.

Eurasian Collared-dove *Streptopelia decaocto.* This, like the Feral Pigeon, is largely a species of built-up areas, but is gradually becoming more common in the wider countryside (Walsh & Pomeroy 2012), particularly in arable areas.

European Turtle-dove# *S. turtur.* Records near the coast, especially in arable areas, may have referred to late migrants, but in most habitats, birds were regularly singing and therefore assumed to be preparing to breed.

Common Cuckoo## *Cuculus canorus.* Recorded at a Paphos FR site, several km west of Phini, in every year 2006–2011. In May 2008 a bird that flew out of a bush, closely followed by a Masked Shrike *Lanius nubicus*, was considered to be a probable young Cuckoo. Birds were also heard calling on several occasions at Phinokli.

Great Spotted Cuckoo *Clamator glandarius.* A parasite of various other birds, notably Magpies (Snow & Perrins 1998); as would be expected its population density is much lower (about a fifth) than its main host's.

Eurasian Scops#, **Little Owl#** *Otus scops*, *Athene noctua.* Because these small owls call mainly in the early part of the night and only occasionally during the day, estimates here are likely to be much too low (see also Pomeroy & Walsh 2013), but both species appear to be declining. Little Owls are often found as road kills (P Flint pers comm). The Scops Owl is an endemic subspecies *O. s. cyprius.*

Eurasian Nightjar## *Caprimulgus europaeus.* Heard on several occasions in Paphos FR at Yialia.

Alpine Swift* *Tachymarptis melba.* A few records, widely distributed.

European Roller *Coracias garrulus.* Has been studied in detail (Pomeroy *et al* 2013).

Eurasian Crag-martin* *Hirundo rupestris.* Recorded only at Stavros-tis-Psokis.

Northern House Martin *Delichon urbicum.* Population estimates in Walsh *et al* (2013).

Winter Wren# *Troglodytes troglodytes.* Vocal but rarely seen.

Cyprus Wheatear *Oenanthe cypriaca.* Recent papers include Randler *et al* (2010) and Flint (2011).

Eurasian Blackbird* *Turdus merula.* Recorded singing at a Paphos FR site, several km west of Phini, in each of three years.

Common Nightingale*# *Luscinia megarhynchos.* Occurred by a river amongst vines near Omodos and occasionally at several sites at higher altitudes in Paphos FR.

Zitting Cisticola *Cisticola juncidis*. Particularly numerous in arable land, at all altitudes (Appendix 2) but does occur occasionally in other habitats, such as old olive groves and waste land in urban areas.

Caspian Reed-warbler*# *Acrocephalus scirpaceus fuscus.* Singing birds noted in reed beds near Omodos, Nata and Polis.

Sardinian Warbler, **Cyprus Warbler** *Sylvia melanocephala, S. melanothorax.* These two species have received much recent attention, since the Sardinian is thought to be displacing its endemic congener (Pomeroy & Walsh 2002, Jones 2006, Flint & MacArthur 2014, Pomeroy *et al* in review). That view has been contested (Ieronymidou *et al* 2012). But whilst the Sardinian has been spreading, and increasing within its settled areas, the Cyprus Warbler in these same areas has been declining, although not elsewhere on the island.

Spotted Flycatcher* *Muscicapa striata.* Occasional in higher areas of forest, often near streams.

Coal Tit *Periparus ater.* This endemic subspecies, *P. a. cypriotes,* is almost confined to forest, down at least to 100 m; at higher altitudes it is very common and allows very close approach.

Great Tit *Parus major.* Widespread and especially numerous in orchards and olive groves.

Short-toed Treecreeper# *Certhia brachydactyla.* An endemic subspecies *C. b. dorotheae,* confined to forest.

Eurasian Golden Oriole* *Oriolus oriolus.* Present for several weeks in at least four years on the eastern side of Kritou Terra and suspected of breeding but not proved.

Woodchat Shrike* *Lanius senator.* Present in small numbers for several years to the west of Neo Chorio and may have bred there.

Masked Shrike# *Lanius nubicus.* Recorded in small numbers but perhaps under-recorded because it rarely sings and sits very still.

Eurasian Jay# *Garrulus glandarius.* An endemic subspecies *G p glaszneri*, occurs commonly in forest and not only in areas where oaks are common.

Black-billed Magpie *Pica pica.* A remarkable decline in recent years, perhaps due to shooting, of both birds and nests (Hadjisterkotis 2003) although still common particularly in open grasslands.

Spanish Sparrow *Passer hispaniolensis.* Declined steeply in western Cyprus.

Eurasian Chaffinch# *Fringilla coelebs.* In Cyprus this species is virtually confined to pine forests, where it is common, particularly at higher altitudes.

European Serin*# *Serinus serinus.* Occasional, usually in pairs, at several sites in Pafos FR mainly above 1000 m.

Appendix 2. Density data for all commoner species of birds, and for six land-use categories (with arable being divided into low–mid altitudes, and upland).

	FOREST			UNCULTIVATED			GRASS/PHRYGANA			LOW-MID-ALTITUDE ARABLE			UPLAND ARABLE			PERMANENT CROPS			BUILT-UP AREAS		
	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL
Common Kestrel *Falco tinnunculus*				2.29	1.73	2.85	4.03	3.04	5.01	1.50	1.13	1.80	2.34	1.76	2.91	1.06	0.80	1.31	1.14	0.80	1.47
Black Francolin *Francolinus francolinus*										4.54	3.70	5.38	0.90	0.73	1.06	0.21	0.17	0.24			
Common Woodpigeon *Columba palumbus*	8.03	5.63	10.43	8.69	5.06	12.24	8.85	7.46	10.23	49.23	38.93	59.53	17.96	1.18	21.74	15.75	10.18	21.31	1.52	1.28	1.75
Collared Dove *Streptopelia decaocta*							0.66	0.54	0.77	10.17	5.67	14.66				3.70	2.58	4.82	157.12	128.39	188.85
Turtle Dove *Streptopelia turtur*	1.21	1.13	1.28	1.34	0.91	1.76				12.44	8.50	16.38				1.47	0.93	2.00			
Scops Owl *Otus scops*				0.58	0.21	0.92	0.34	0.14	0.54	0.13	0.05	0.20							0.12	0.0053	0.203
Little Owl *Athene noctua*							378	2.62	4.93	0.50	0.35	0.65				2.65	1.76	3.53			
Great Spotted Cuckoo *Clamator glandarius*				3.26	2.42	4.09	1.80	1.40	2.20	2.12	1.65	2.58	0.54	0.42	0.66	2.68	2.08	3.27			
European Hoopoe *Upupa epops*	1.18	0.54	1.81	0.22	0.14	0.29										0.21	0.13	0.28	0.08	0.053	0.113
European Roller *Coracias garrulus*				2.57	1.85	3.28	4.39	3.22	5.56	6.25	5.14	7.36	0.68	0.46	0.90	2.07	1.74	2.39	2.39	2.08	2.86
Crested Lark *Galerida cristata*				7.45	4.57	10.32	40.13	2941	50.85	40.13	29.41	50.85	55.13	41.37	68.88						
Cyprus Wheatear *Oenantha cypriaca*	35.95	28.72	43.18	26.28	19.38	33.17	9.37	6.76	11.98	0.64	0.40	0.88				12.33	9.92	14.73	20.22	12.85	27.59

Appendix 2 cont. Density data for all commoner species of birds, and for six land-use categories (with arable being divided into low–mid altitudes, and upland).

	FOREST			UNCULTIVATED			GRASS/PHRYGANA			LOW-MID-ALTITUDE ARABLE			UPLAND ARABLE			PERMANENT CROPS			BUILT-UP AREAS		
	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL
Winter Wren *Troglodytes troglodytes*	5.04	4.30	6.78	2.82	2.02	3.61										3.75	2.70	4.79			
Cetti's Warbler *Cettia cetti*	8.09	6.22	9.95	44.32	35.29	53.34	7.26	4.52	10.00	72.70	53.95	90.44				24.34	20.47	28.21	11.39	8.13	14.64
Zitting Cisticola *Cisticola juncidis*				7.09	6.02	8.16	40.95	31.90	50.00	145.36	121.30	169.42	166.84	150.00	183.67	11.94	10.14	13.73	2.05	1.73	2.36
Olivaceous Warbler *Hippolais pallida*	14.71	11.79	17.62	54.28	43.97	64.59	3.93	2.60	51.26	27.04	22.39	31.69	2.61	2.16	3.05	54.63	37.61	71.65	4.50	3.70	5.29
Sardinian Warbler *Sylvia melanocephala*	35.48	27.60	43.36	187.58	165.99	209.16	55.56	40.21	70.90	215.15	189.90	240.40	4.60	4.07	5.13	92.66	73.55	111.76	28.67	20.72	36.61
Cyprus Warbler *Sylvia melanothorax*	9.51	7.67	11.34	41.28	35.37	47.19	7.83	4.98	10.68	7.66	4.46	10.85				62.52	44.64	80.39	0.46	0.40	0.53
Coal Tit *Periparus ater*	89.85	83.14	96.55	0.83	0.78	0.88	8.76	6.25	11.26												
Great Tit *Parus major*	7.09	6.01	8.16	28.35	19.72	36.98				59.01	44.81	73.21				100.44	78.43	122.45	40.68	32.41	48.95
Short-toed Tree-creeper *Certhia brachydactyla*	3.75	2.07	5.43																		
Masked Shrike *Lanius nubicus*	12.58	8.29	16.86	1.51	1.03	1.98															
Black-billed Magpie *Pica pica*				4.28	3.31	5.24	29.21	25.30	33.12	16.35	14.17	18.52	14.43	12.50	16.35	13.40	10.37	16.43	15.2	10.98	19.56

Appendix 2 cont. Density data for all commoner species of birds, and for six land-use categories (with arable being divided into low–mid altitudes, and upland).

	FOREST			UNCULTIVATED			GRASS/PHRYGANA			LOW-MID-ALTITUDE ARABLE			UPLAND ARABLE			PERMANENT CROPS			BUILT-UP AREAS		
	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL	Est. mean density (birds km^{-2})	LCL	UCL
Eurasian Jay *Garrulus glandarius*	9.06	6.62	11.49																		
Eurasian Chaffinch *Fringilla coelebs*	13.89	12.20	15.58																		
Hooded Crow *Corvus corone*				0.70	0.56	0.83	1.42	1.14	1.69	4.58	2.68	6.48				3.47	2.80	4.14	15.79	11.33	20.25
European Greenfinch *Carduelis chloris*	31.32	23.45	39.19	29.46	20.85	38.06	24.97	21.23	28.70	63.56	54.60	72.52	3.45	2.63	4.26	28.15	20.20	36.09	3.46	24.83	48.08
European Goldfinch *Carduelis carduelis*	49.54	37.80	61.28	51.88	38.44	65.31	20.86	15.51	26.21	65.94	47.27	84.60	4.74	3.40	6.08	75.10	52.60	97.60	5.08	4.40	5.76
European Linnet *Carduelis cannabina*	0.94	0.79	1.08	41.20	29.89	52.50	0.4	0.28	0.68	17.78	12.42	22.93	32.31	19.16	45.45	133.13	100.00	166.25	1.65	1.39	1.90
Cretzschmar's Bunting *Emberiza caesia*	104.27	83.18	125.35	7.75	6.02	9.47										0.66	0.54	0.78			
Black-headed Bunting *Emberiza melanocephala*										5.93	4.94	6.92	3.34	2.26	0.42	1547	12.53	18.41			
Corn Bunting *Miliaria calandra*				1.37	0.87	1.86	27.17	20.42	33.91	3.32	2.36	4.28	58.09	41.32	74.85	2.35	1.75	2.94			
Total density	441.99			564.03			333.05			831.53			367.96			669.14			344.59		
Total mapped + aerial/flocking spp	19 + 7 spp			26 + 9 spp			22 + 8 spp			24 + 9 spp			15 + 7 spp			25 + 9 spp			18 + 8 spp		

Appendix 3. Counts of flocking and aerial species (see Methods for selection of species). Data are birds per 100 counts. The land-use with the highest count-rate is underlined.

Land use	Forest	Uncultivated	Grass/ phrygana	Arable Low-med	Arable Up	Permanent crops	Built-up
No of counts	80	90	56	40	32	48	36
Chukar *Alectoris chukar*	5.0	45.5	35.7	5.0	0	20.8	0
Feral Pigeon *Columba livia*	0	8.9	200.0	210.0	43.6	154.2	1750.0[a]
Swift *Apus apus*	2.5	8.9	8.9	102.5	0	29.2	419.4
Swallow *Hirundo rustica*	5.0	108.8	91.1	462.5	106.3	214.6	2571.9
Red-rumped Swallow *Hirundo daurica*	1.3	8.9	3.6	5.0	25.0	25.0	19.4
Northern House Martin *Delichon urbicum*	46.3	15.5	0	150.0	6.3	43.8	513.9
Eurasian Jackdaw *Corvus monedula*	0	25.5	253.6	352.5	156.3	89.6	4.2
House Sparrow *Passer domesticus*	3.8	85.5	155.4	742.5	93.8	473.8	6000.0[a]
Spanish Sparrow *Passer hispaniolensis*	31.3	36.6	33.9	52.5	21.9	39.6	4.2

[a] only one complete round of counts included these species, and numbers of House Sparrows were estimates rather than actual counts.

Appendix 4. Numbers of transect counts for each land-use type per year from 2006–2011[a]. The overall average was 2.00 counts per land-use type per year.

	2006	2007	2008	2009	2010	2011
Forest	2[b]	3	3	2	2	1[c]
Uncultivated	2	3	3	2	2	1
Grass/phrygana	2	3	2	1	3	1[d]
Arable – upland	2	3	2	2	2	2[f]
mid/low	2[e]	3	3	1	2	2
Permanent Crops	2	3	2	1	2	1
Built-up	2[g]	3	2	2	2	2[h]

[a] small number of Distance data from a few sites counted in 2003–2005 also included in the data-set.
[b] excluding Akamas Pines (see Table 1 for key to footnotes [b–h])
[c] excluding Yialia pines
[d] only Lara, Iria and Arodhes
[e] excluding Nata
[f] excluding Drinia and Phasli
[g] only Polis and Kritou Terra
[h] excluding Salamiou