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Status and distribution of European Nightjars *Caprimulgus europaeus* in the UK in 2004

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Capsule The population of Nightjars in the UK increased by over 36% between 1992 and 2004.

Aims To determine the population size and distribution of Nightjars in the UK and examine associations with forestry and heathland habitat features.

Methods A volunteer survey was supported by professional cover in remote parts of Wales, and areas of Dorset and lowland Scotland. Two visits to allocated 1-km squares were made between late May and mid-July. Each surveyor recorded the locations of calling males onto maps and the occurrence of habitat categories within 50 m of each Nightjar registration.

Results Observers surveyed 3264 1-km squares in 2004 and, on average, 78% of the target habitat (90% in southern England). The total number of males counted was 4131 (range 3850–4414), adjusted to 4606 (95% CL ± 913) to account for unsurveyed habitat. The adjusted total represented a 36% increase in 12 years. Nightjars were recorded in 275 10-km squares in 2004, a 2.6% increase since 1992. However, there was evidence of population decline and range contractions in northwest Britain, including north Wales, northwest England and in Scotland. In 2004, 57% of Nightjars were associated with forest plantations (similar to 1992) and 59% with heathland (slightly higher than in 1992).

Conclusion National objectives for Nightjar conservation (UK Biodiversity Action Plan: UKBAP) were reached in respect of population size and stability, but the target for a 5% range increase by 2003 was not met. The continued increase in the national population is probably attributable to habitat protection, management and restoration of heathlands, and the continued availability of clear-fell/young plantations in conifer forests. Management and/or protection/restoration/re-creation of these key habitats remains critical for the long-term objectives of UKBAP. The issue of providing foraging habitats, perhaps via agri-environment schemes, is also raised.

European Nightjars *Caprimulgus europaeus* (hereafter 'Nightjars') have declined in numbers and range since at least the 1950s. Europe constitutes over 50% of the species' global breeding range; it is most widespread and abundant in the Mediterranean countries, the Balkans, eastern Europe from Hungary eastwards into Russia, and north to southern Finland (Hagemeijer & Blair 1997). The European population is estimated at 470 000 to 1 000 000 breeding pairs (Burfield & Van Bommel 2004). In northwest and northern Europe it is currently regarded as having an 'unfavourable' declining population status (SPEC 2; Burfield & Van Bommel 2004). Breeding numbers have declined in many European countries, except in Britain, the Netherlands and Estonia, where numbers have increased (Burfield & Van Bommel 2004). Specifically, in Britain and Ireland, Nightjars are considered of high conservation concern, being classified as a red-listed species with a breeding range decline in excess of 50% between 1972 and 1992 (Gregory *et al.* 2002).

Nightjars were previously more widely distributed across Britain than at present, breeding as far north as the the Moray Firth, with strongholds in southern

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England, Wales and the Marches (Holloway 1996). Since the 1950s, large-scale losses of heathland to agriculture, construction and afforestation have led to both a contraction of range and a strong population decline. The population may have halved between 1972 (estimated at between 3000 and 6000 males; Sharrock 1976) and 1981 (estimated at 2100 males; Gribble 1983), and has certainly contracted in terms of range, with only scattered pockets now remaining in southwest Scotland and Wales. Declines also occurred throughout northern and central England. In Northern Ireland, where occupied habitats included 'cut-over' raised bogs, it is probably now extinct as a breeding species, having formerly had a widespread distribution (Gibbons *et al.* 1993). The last suspected breeding record for Northern Ireland was in 1987, when a pair was noted in Tyrone (Hutchinson 1989).

By 1992, the second national survey reported an increased total of 3400 'churring' (i.e. singing territorial 'song') males (Morris *et al.* 1994). This signified a change in circumstances, probably in response to beneficial changes in forest structure, through management or storm damage. Nightjars were showing an increasing dependency on clear-felled or young conifer plantations, and 54% of calling males were recorded there (Morris *et al.* 1994). Despite the partial population recovery, the breeding range of Nightjars, which declined from 562 10-km squares in 1968–72 to 241 in 1981, increased to only 268 10-km squares by 1992, still far short of its former range (Gibbons *et al.* 1993, Morris *et al.* 1994). The main centres of occupancy remained in the New Forest, on other heathland and afforested heaths in southern England, and in the Brecklands and Sandlings of East Anglia. Significant outlying populations occurred in the East Midlands and North Yorkshire.

The partial recovery of Nightjars in southern and eastern England, in particular, was due, to a large extent, to the increase in large-scale harvesting of economically mature conifer plantations. Clear-felling and replanting has now slowed and it is unlikely that suitable habitat within forests will be available at the same scale in the future. Proposals for continuous cover forestry also have potential implications for the availability of nesting habitat. Meanwhile, the restoration and (re)creation of lowland heathland for conservation, particularly since 1992, is increasing the availability of suitable habitat for Nightjars. It was not known to what extent these changes in habitat availability had influenced the national and regional population status of Nightjars in the UK or the success of efforts to attain the targets of the UK Biodiversity Action Plan (UKBAP) for Nightjars (Anon. 1998).

Since 1992, there have been further regional and local surveys of Nightjars on a regular basis, which indicated further increases in numbers and range expansion, at least in southern England (Scott *et al.* 1998). It was not clear to what extent these changes have been replicated throughout the UK. The 2004 re-survey assessed changes in both the population size and distribution of Nightjars in the UK and examined the association of churring males with habitat features in both forestry and heathland sites.

METHODS

Strategy for site selection and coverage

Survey site locations were chosen on a hierarchical basis according to three levels of priority. The strategy was to cover all high probability sites and to sample buffer zones around these sites (to detect local range expansion). A random sample of areas of potentially suitable habitat, with no recent record of occupancy, was also made. Site allocation fell into the following categories.

High priority: sites found occupied in the 1992 survey and subsequently; a random sample of 500 1-km squares containing apparently suitable habitat in each 100-km buffer centred around clusters of 1992 sites.

Medium priority: a 30% sample of all the sites found occupied in the 1981 survey but not subsequently; a sample from areas likely to be considered for future Special Protection Area (SPA) designation or extension.

Low priority: a 10% sample of sites with apparently suitable habitat though not found occupied in either of the previous surveys; additional sites that observers considered to hold potentially suitable habitat.

Large expanses of relatively uniform heathland or forests (usually pine plantations in lowlands or mixed conifer plantations in uplands) were identified from heathland inventories (held by RSPB and English Nature) and forest stock maps (geographic information system (GIS) databases of the Forestry Commission) or the National Inventory of Woodland and Trees (Anon. 2002) respectively. The same habitat criteria were used in the present survey as in the previous Nightjar survey (Morris *et al.* 1994) to identify 1-km squares that contained potentially suitable habitat. These criteria included conifer plantation less than 21 years old, plus unplanted blocks, bare ground and clear-fell areas.

Bird survey methods

The survey was carried out mainly by volunteers but with professional ornithologists covering gaps in volunteer coverage, particularly in remote parts of Wales and areas in Dorset and lowland Scotland. A minimum of two visits to a site was required, either at dawn or dusk, between the last week of May and mid-July, with at least three weeks between visits and at least one visit in June. Surveyors made a preliminary visit to their site(s) to familiarize themselves with the terrain in daylight. During count visits each surveyor covered no more than 80 ha per visit, being sure to pass within 200 m of all potentially suitable habitat. The locations of 'churring' males were recorded onto 1:2500 scale maps (males marked A1, A2, etc., for visit A, and B1, B2, etc. for visit B). Special attention was given to simultaneously churring males. Other calling birds or birds seen flying were also marked on the visit maps. Sites were visited only in calm and usually dry evenings or mornings in wind conditions of less than Beaufort force 4. 'Playback' of recorded Nightjar calls was not used as it could have biased counts if not used ubiquitously, and could have caused disruption by drawing birds in from neighbouring areas.

Observer-based habitat recording

Nightjars' use of habitat has been studied in detail in previous studies (Alexander & Cresswell 1990, Bowden & Green 1991) and was not the principal focus of the present survey. Nevertheless, a change in the use of broad habitat categories by Nightjars is possible with expanding populations and/or within dynamic habitats, such as forests managed by clear-felling and replanting. Observers recorded the presence or absence of several habitat categories occurring within 50 m of each Nightjar registration or at the centre of sites where no Nightjars were recorded; this was the same as the method used in 1992, but the heathland category was divided into three subcategories. Habitats were categorized primarily as 'forest', 'heathland' or 'woodland'. The forest or woodland category was further subdivided according to the composition of the woodland (unplanted, conifer, broadleaved, mixed), four height categories (<1 m, 1–2 m, 2–4 m, >4 m), the presence of 'stands' of taller or mature trees within young plantations or 'brash/stump-rows' which may be used as song-posts, and the presence of 'rides' or woodland 'edge'. For 'heathland', ground cover was assessed as >50% cover of Bracken *Pteridium aquilinum*, grasses or heather species, and as 'wet 'or 'dry'. The presence of conifer/birch *Betula* species encroachment onto heathland was also recorded. These categories were not mutually exclusive as, for example, a Nightjar registration might be at the edge of both forest and dry heath.

Analysis

Calibrating bird counts

All data for males and females, or unidentified individuals, and their activity (e.g. 'churring' or flying) was recorded onto site-maps and transferred to summary sheets. The summary sheets were used to collate the estimated number of males recorded on each visit, according to each observer. The mapped registrations were plotted on a GIS (Arcview; ESRI). For consistency, across all sites, individual territories were determined from the GIS location data for each bird registration, according to the following criteria: (1) where observers identified different individuals on maps, such as simultaneously churring males; (2) where churring male registrations were over 350 m apart (cf. 400 m in plantations; Bowden & Green 1994), except where known topographical or structural features ('barriers' such as a hill ridge or forest block) were present; (3) where clusters of registrations, from sequential visits, indicated the presence of distinct groupings that were indicative of discrete territories.

Lone males that were heard churring in May only, particularly along the English Channel coastal counties, and were not subsequently observed during the breeding season were excluded from the population calculation. These individuals were considered to be mainly passage birds *en route* to breeding grounds further north.

Assessing population estimates

A boot-strapping, resampling method (Efron 1982) was used, with 999 reiterations to calculate 95% confidence intervals around mean population estimates, based on the actual counts of territorial males seen or heard per square kilometre. From the real counts, regional (and hence national) extrapolated population estimates were calculated to account for unsurveyed areas of habitat. These calculations accounted for differences in habitat composition (i.e. the relative proportion of forestry or heathland present per km^2) and the mean area of habitat availability (i.e. the area of all potentially suitable habitat per km^2) between surveyed and unsurveyed squares. In practice habitat composi-

tion was relatively similar between surveyed and unsurveyed squares and no adjustments were made (some potential biases are analysed and discussed below) but the mean area of available habitat per km^2 sometimes differed. In such circumstances, male densities were recalculated for a subset of the regional data that contained a similar area of available habitat, per km^2 (±1 sd). These new density estimates were used to adjust the number of males on a regional basis, to account for the 1-km squares not surveyed. This was important as male densities varied disproportionately with the area of available habitat per km^2.

We analyse the validity of the standardized approach above, in estimating the number of territories present in a square, and the effectiveness of two-visit surveys for recording Nightjar abundance are discussed. These issues are important for calibrating extrapolated population estimates from the absolute number of males counted during a survey.

Changes in Nightjar density and range were indicated on a map of the UK from calculations at the 10-km square scale.

RESULTS

Survey coverage

Observers surveyed approximately 3264 1-km squares, in 2004 (at least 3214 1-km squares plus an assumed 50 1-km squares in Cannock Chase) within 603 10-km squares. Each visited 1-km square comprised, on average, 22.1 ha (95% CL = 4.95) of potentially suitable habitat (Table 1). In 1992, 2256 sites were surveyed but the area of sites was not recorded and some sites comprised subsections that would have been classified as individual sites in 2004. Although the figures are not directly comparable, the distribution of survey coverage at the 10-km-square scale is broadly similar between 1992 and 2004 (Fig. 1, Table 2). Table 2 shows that regional coverage at the 10-km-square scale was 16% higher, on average, in 2004. In Scotland, coverage was lower at the 10-km scale than in 1992 (Table 2) but higher than 1992 at the 1-km scale (29 'sites' in 1992 and 202 1-km squares in 2004) particularly in Dumfries and Galloway (Fig. 1).

The proportion of potentially suitable habitat that was surveyed in 2004 is presented in Table 1 by region, according to the initial survey site-selection criteria. An average of 78% of the target habitat was surveyed, supporting a mean density of 1.27 males/km^2 of suitable habitat, albeit with strong regional variation. The highest level of habitat coverage (and bird densities) was in southern and eastern England and the lowest was in Scotland. The density estimates were used with comparisons of mean habitat composition and availability between surveyed and unsurveyed 1-km squares (Fig. 2), to make the final population adjustments.

National population estimate and change

The total number of churring males in Britain during 2004, based on totals uncorrected for visit frequency or percentage habitat coverage, was 4131. Boot-strapping

Table 1. Regional account of Nightjar survey coverage, male Nightjar density estimates and population adjustments based on the area of available habitat.

	Scotland	N England	Midlands	Wales	E England	SE England	SW England	Britain
Males	**27**	**308**	**159**	**244**	**649**	**1468**	**1276**	**4131**
No. surveyed sites (1-km squares)	203	327	(204)[a]	369	364	1063	734	(3264)[a]
Density (males/km^2) (95% CL)	0.13 (0.10)	0.94 (0.19)	0.78 (0.31)	0.66 (0.12)	1.79 (0.20)	1.38 (0.10)	1.74 (0.11)	1.27 (0.16)
Mean % habitat/km^2	33.7	22.3	12.8	19.8	26.2	21.6	18.9	
Average area of 'suitable' habitat per male (ha)	253	24	16	11	15	16	11	49.4
No. unsurveyed 1-km squares	154	124	115	206	114	221	165	
% unsurveyed habitat (ha)	46	17	23	31	18	7	9	21.6
Projected number of extra males[b]	17	42	64	36	125	112	78	475
Potential grand totals	**44**	**350**	**223**	**280**	**774**	**1581**	**1354**	**4606**
±95% CL (number of males)	32	72	89	52	87	120	87	913

[a]Includes an estimate of 50 1-km squares for Cannock Chase. [b]Unsurveyed areas of habitat within 1-km squares were, on average, smaller than areas of habitat within squares covered by the survey. Smaller areas of habitat supported disproportionately lower densities of birds. Thus for each region, estimates are based on the proportional difference in densities of males in surveyed squares that contained an area of habitat (±1 sd) similar to that available in unsurveyed 1-km squares, compared to males in all surveyed squares, multiplied by the area of habitat that was not surveyed.

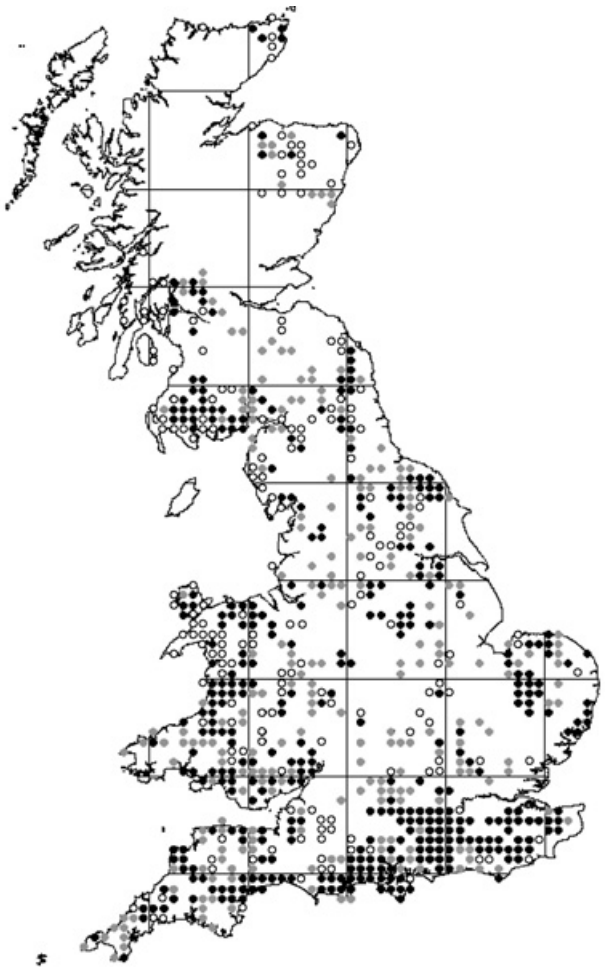

Figure 1. Survey coverage by 10-km square: ●, 1992 and 1994; ○, 1992 only; ●, 2004 only.

calculations, using 999 iterations, gave rather narrow 95% CL of ±1.95, but figures ranged from 3850 to 4414 males. This population of males represents a 34% increase in 12 years. Regional and county totals are given in the Appendix. Extrapolation to the remaining 22% of unsurveyed habitat results in an amended total of 4606 males for Britain (95% CL ± 913, calculated from regional density estimates, as in Table 1). This represents a 36% increase on the 1992 adjusted total of 3400 males. The mean distance between a randomly selected sample of simultaneously calling males was 360 m (n = 331, sd = 184.9 m) and the median distance was 314 m (interquartile values, 221 m and 460 m). The 350-m threshold used in this paper to distinguish between different males seems justified, if slightly conservative.

Regional estimates

In Scotland, Nightjars have probably not increased in population size or range since 1992 (Figs 3–6), and may have declined. Wide error margins around imprecise estimates (Table 1) are due to the existence of widely scattered areas of potentially suitable habitat in Scotland, of which 54% was surveyed in 2004 (lower, but fairly comparable to 1992). Nevertheless, 85% of the key sites in Dumfries and Galloway (i.e. those occupied in 1992 and those identified locally as being high priority) were surveyed in 2004, thus covering the expected majority of the Scottish Nightjar population. High concordance (r = 0.90) in habitat composition and availability, between surveyed and unsurveyed squares (Fig. 2), allowed a direct extrapolation to six additional males estimated for Dumfries and Galloway. A further ten males may occupy habitats beyond Dumfries and Galloway, but only two were found, near Stirling.

In northern England, a population of 350 males is estimated (Table 1), and 84% of suitable habitat was

Table 2. The regional account of Nightjar occupancy, change in Nightjar occupancy and survey coverage, at the 10-km scale, comparing surveys in 1992[a] and 2004.

	Occupied squares		Surveyed squares		Rounded percentage change	
Region	1992[a]	2004	1992[a]	2004	Occupied squares	Surveyed squares
Scotland	18	*7*	86	*77*	–61	–10
N England	36	41	81	102	14	26
Midlands	20	22	54	65	10	20
Wales	51	41	99	97	–20	–2
E England	28	36	41	66	29	61
SE England	68	76	93	119	12	28
SW England	54	64	89	109	19	22
Britain total	268[b]	275[b]	519[b]	619[b]	3	19

[a]Data from Morris *et al.* (1994). [b]Some 10-km squares straddled regions, so total coverage appears less than the column total.

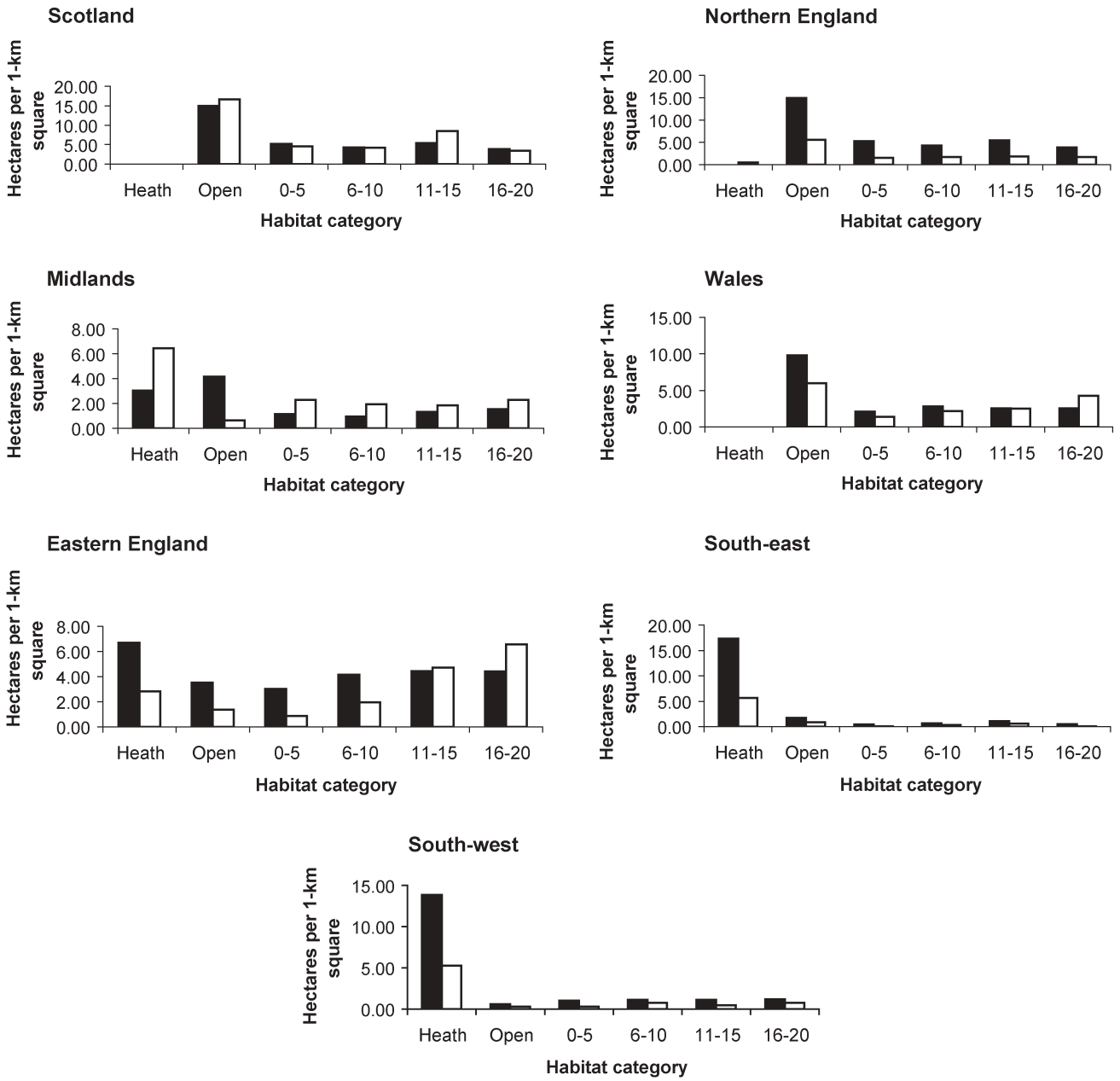

Figure 2. Habitat composition within sampled (■) and unsampled (□) 1-km squares in 2004 by region, based on known suitable habitat. Habitat categories include plantation ages: 0–5, 6–10, 11–15 and 16–20 years.

surveyed in 2004. Habitat composition and habitat availability were closely correlated between surveyed and unsurveyed squares ($r > 0.90$; Fig. 2). Overall there was a slight increase in population size (Appendix) and an increase in range at the 10-km-square level of 14% (Table 2). More locally, the population doubled in North Yorkshire but declined by 78% in Northumberland (Table 1, Figs 3–6).

In the Midlands, at least 77% of habitat was covered by the survey in 2004 (not including Cannock Chase). The population has increased by 24%, to 223 males since 1992 (Table 1) with a 10-km range expansion of 20%. In Wales, too, the population has increased by 24% since the 1992 survey (Table 1), and approximately 69% of potential habitat was covered by the 2004 survey. The adjusted population estimate of 280 males in Wales accounts for a lower availability of potentially suitable habitat per 1-km square in unsur-

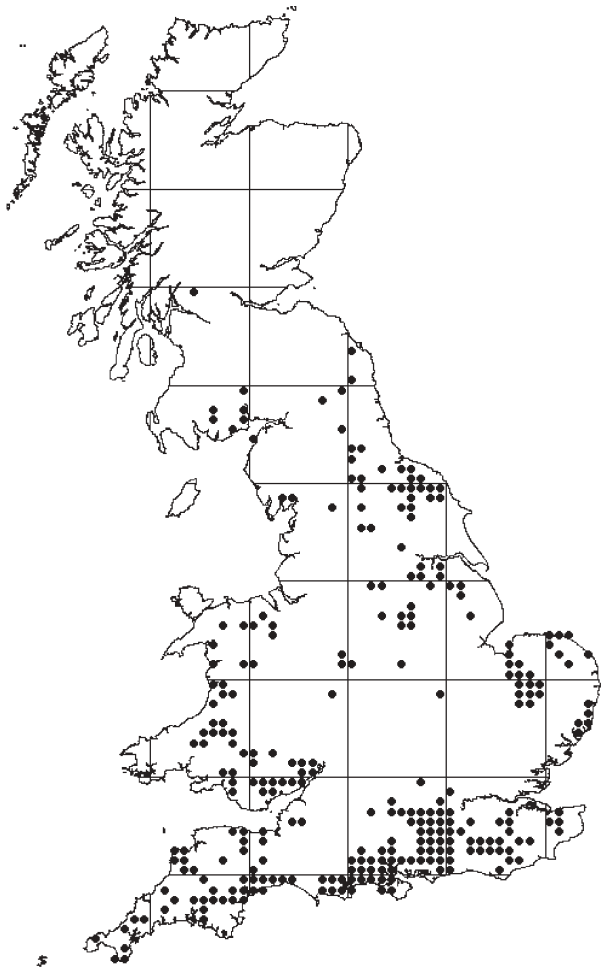

Figure 3. Distribution of males by 10-km square in 2004.

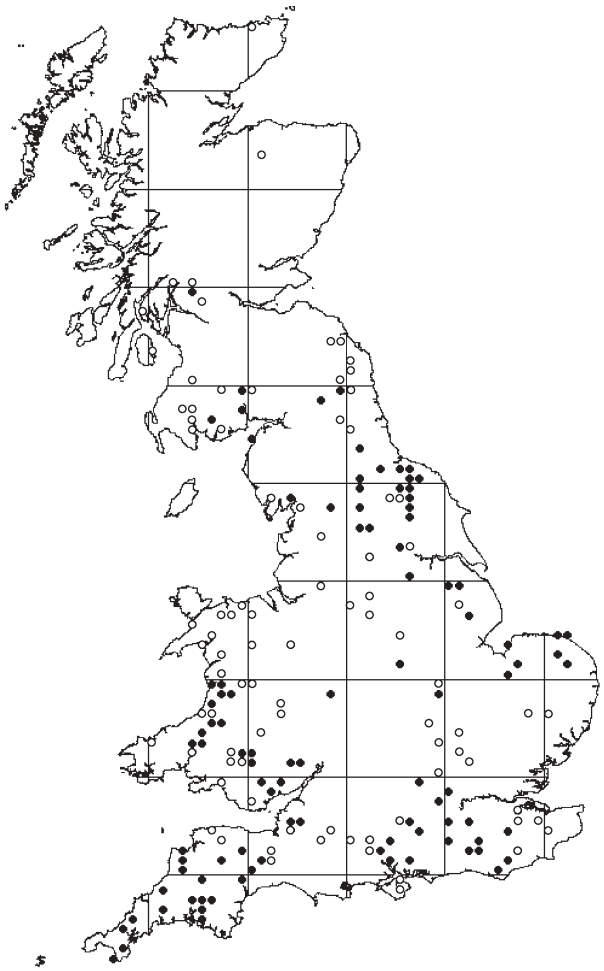

Figure 4. Changes in male distribution since 1992: ○, not present in 2004; ●, new in 2004.

veyed compared to surveyed squares. At the 10-km scale, there has been a marginal 4% decline in occupancy since 1992 (Table 2).

In eastern England, 81% of the potentially suitable habitat was sampled and the true population size is estimated at 774 churring males (Table 1). A 40% increase in Norfolk and a 27% increase in Lincolnshire were partially offset by an 11% decline in Suffolk (Appendix). The overall increase in population size for eastern England was 8%. There was a 51% increase in range, at the 10-km scale, particularly in north Norfolk (Figs 5 and 6).

In southeast and southwest England, over 90% of potentially suitable Nightjar habitat was covered by the 2004 survey (Table 1). These two regions together held 65% of the UK Nightjar population (almost 3000 males). They supported respective population increases of 47% and 48% since 1992 (Appendix), and range expansions, at the 10-km level, of 10% and 19% respectively (Table 2). The densities of males, per hectare of suitable habitat, were especially high in southwest England (Table 1). Habitat composition was broadly similar between surveyed and unsurveyed squares (r = 0.91), being dominated by heathland or open forestry (Fig. 2). Respective population adjustments of 7% and 9% for southeast and southwest England (Table 1) accounted for there being 40% less habitat per square in unsurveyed than in surveyed squares (Fig. 2).

Breeding range, occupation and distribution

The change in the breeding range and density of Nightjars at the 10-km scale, compared with 1992, is shown in Figs 5 and 6. Nightjars were recorded in 275 10-km squares in 2004 compared to 268 in 1992 (Table 2), a 2.6% increase. Range expansion occurred mainly in south and west Wales, southern and eastern England

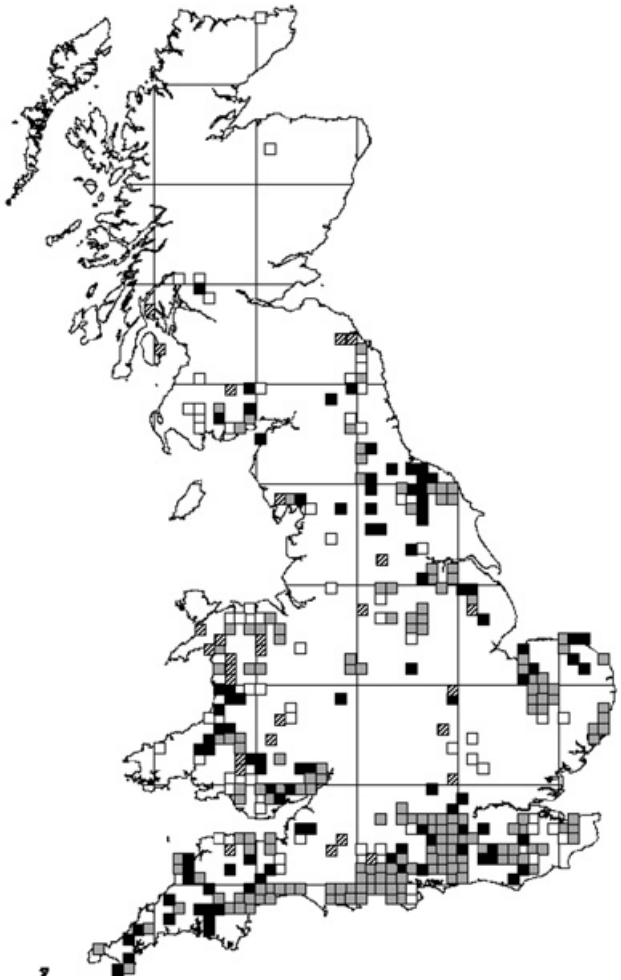

Figure 5. Change in occupation of 10-km squares (1992 versus 2004): □, loss; ■, no change; ■, gain; ▨, not surveyed in 2004.

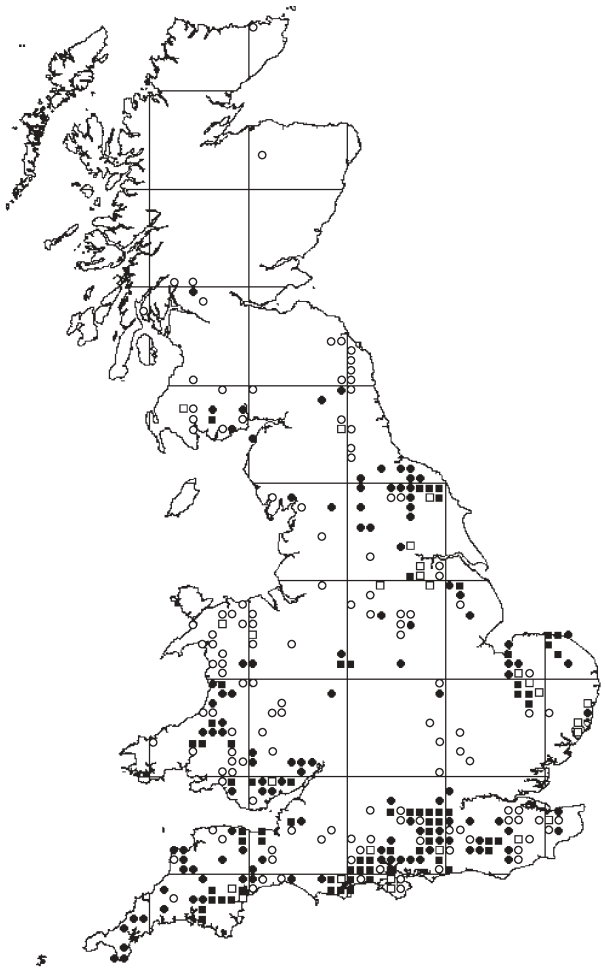

Figure 6. Actual changes in number of males per 10-km square: ■, gain of ≥6; ●, gain of 1–5; ○, loss of 1–5; □, loss of ≥6.

and north Yorkshire. Range contraction in northwest Britain was detectable largely north of a line from north Wales to Durham (Table 2, Figs 5 and 6).

Habitat associations

Based on data derived from the initial site selection process (generated largely via inventories, stock maps and GIS data), and in comparison with the 1992 site selection process, at least 59% of churring male Nightjars in Britain were associated with 1-km squares containing heathland (mean = 0.074 males/ha; 95% CL = 0.046). Meanwhile, 55% of churring males were associated with 1-km squares containing forestry plantations (planted and unplanted; mean = 0.048 males/ha; 95% CL = 0.026) and 10.2% (337) with mixed or broadleaved woodland (habitat categories were not mutually exclusive).

Observer-recorded habitat composition

From within 1-km squares, observers returned 3303 records of habitat composition within a 50-m radius of each churring male Nightjar. Of these, 55.1% were associated with woodlands (all woodlands combined, but with <3% within broadleaved woods; Table 3). Also, in 2004, at least 51% of males were associated with heathland (especially dry heathland; see Table 3 and below). Overall, there was a 21% increase in the number of male-occupied sites that contained heathland (but a decline in Scotland), and a 9% increase in number of male-occupied sites that contained forest plantations (planted and unplanted areas) since 1992. On a regional basis, all males in Scotland were located in forestry plantations and none was associated with heathland. For other regions, the respective percentages of woodland and heathland were: 91% and 16%

Table 3. Composition of habitat within 50 m of churring male Nightjars in 2004.

	Woodland								Heathland			
	Unplanted		Broadleaved		Conifer		Mixed		Dry		Wet	
Region (*n* males)	% M	% D	% M	% D	% M	% D	% M	% D	% M	% D	% M	% D
Scotland (25)	4	–11	0	0	88	45	8	3	0	–22	0	–9
Northern England (212)	20	11	2	2	73	39	11	9	18	–4	2	–27
Midlands (73)	41	30	7	1	36	–10	12	–2	41	23	0	–1
Wales (203)	31	15	4	5	60	0	8	–1	15	0	4	–3
Eastern England (532)	14	–2	1	2	64	11	8	4	37	10	3	–1
Southeast (1261)	11	0	4	0	21	–3	9	4	60	20	10	–5
Southwest (997)	11	–4	2	1	42	7	3	0	64	24	11	–6
Total 2004 (3303)	13.8		2.9		40.8		7.3		51.0		8.1	
Total 1992 (3560)[a]	10.7		4.7		38.6		7.8		31.2		6.9	

Percentage of males (% M) associated with each habitat category and the percentage difference (% D) in this association since 1992 (i.e. % in 2004 minus % in 1992[a]). Note that the habitat categories are not mutually exclusive. Males frequently occupied more than one habitat type and thus the total percentage for each row may not sum to 100%. [a]Data from Morris *et al.* (1994).

for northern England, 81% and 37% for the Midlands, 80% and 15% for Wales, 76% and 35% for eastern England, 37% and 59% for southeast England, and 50% and 52% for southwest England. In southeast and southwest England, heathland or 'unplanted' habitats within forestry were dominant, compared to young plantations, and occupied at least 57% and 77% of suitable habitat for each region, respectively.

In plantations, there was a statistically significant association of males with three tree height categories, 1–2 m, 2–4 m and >4 m (general linear models (GLM) with Poisson error terms: deviance/df = 1.3; likelihood ratio (LR): $\chi^2_1 = 5.4$, $P < 0.02$; $\chi^2_1 = 3.7$, $P < 0.05$; $\chi^2_1 = 19.7$, $P < 0.01$, respectively). On heathland, a higher proportion of males were associated with dry heath than with wet heath (GLM (binomial error terms): LR: $\chi^2_1 = 28.3$, $P < 0.002$; Table 3). A significantly higher proportion of males (34%) was associated with >50% cover of heather, compared to bracken (11.4%) or grass (9.2%: LR: $\chi^2_2 = 36.1$, $P < 0.001$; Fig. 7). Bracken was present on 85% of sites in the Midlands and was also the commonest component in Wales (35%). A significantly higher number of males was located by forest rides and edges compared to habitats without these two features (LR: $\chi^2_1 = 13.8$, $P < 0.002$; $\chi^2_1 = 24.2$, $P < 0.001$, respectively).

DISCUSSION

Population estimate and caveats

The main purpose of the 2004 survey was to give an accurate account of the status of Nightjars in the UK. For habitats, the survey design could provide data that was only indicative rather than definitive, but nonetheless comparable with 1992.

In terms of assessing the accuracy and comparability of population changes between 1992 and 2004, several important factors need to be considered. Visit frequency was standardized between the 1992 and 2004 surveys. Area coverage was probably higher in 2004 than 1992 (affecting precision), but accurate coverage figures are only available for 2004. In terms of defining territories, Morris *et al.* (1994) used observers to estimate the number of males on a site. This can be prone to inaccuracy and especially overestimation due to individual males moving unseen between song-posts. In 2004, we used expert opinion to create a threshold of 350 m to differentiate between male territories at times when males were not recorded simultaneously. The threshold was important to reduce random error between observers and to provide a standardized method of delineating territories for comparison with future surveys. Thus, Bowden & Green (1994) found that 400 m could typically delineate territories within a forest plantation. In plantations in the Netherlands, Bult (2002) recommended that males detected beyond 300 m be classed as different individuals. In the 2004 survey, the median distance between simultaneously calling males was 314 m (mean = 360 m). The 350-m threshold accounts also for heathland populations, where densities may be higher than in plantations (Lake 2004). For these reasons, it was not considered appropriate to apply a further 'blanket' adjustment, of +12%, to the national total (Morris *et al.* 1994) to compensate for a potential underestimate of using a

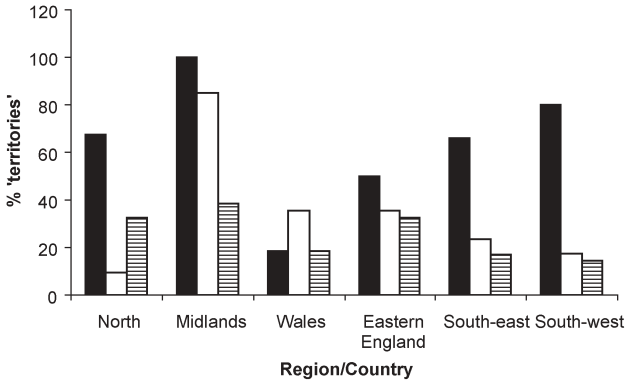

Figure 7. Regional summary of the association of male Nightjars (50-m radius of churring birds) with vegetation composition of heathland: ■, >50% heather; □, >50% bracken; ■, >50% grass (*n* = 1383 males).

two-visit survey. The figure of 4606 males for 2004 therefore remains the best estimate, based on close scrutiny of regional mean values (Table 1), but is likely, if anything, to be a conservative underestimate.

Meeting conservation objectives for Nightjars

The total of 4131 recorded males (and the adjusted total of 4606) in 2004 means that the UKBAP target of increasing the population to 4000 males by 2003 (Anon. 1998) was met. Between 1992 and 2004, the adjusted population of Nightjars in the UK increased by at least 36%, about half of the increase reported between 1981 and 1992 (75%). The requirements of UKBAP for Nightjars include the following: to maintain a population of at least 3400 calling males (*target reached*); to increase the population to 4000 males by 2003 (*target reached* – see above); to halt the range decline at 268 occupied 10-km squares (*target reached*); to increase the total range of churring males to at least 280 10-km squares by 2003 (*target probably not reached*); within 20 years (from 1997), to restore Nightjars to areas of former range, in southwest England, the west Midlands, northwest England, southwest Scotland and Northern Ireland (*target not met, with the exception of southwest England and also Cannock Chase, where the 2004 population exceeded by 30% the 2005 local BAP target of 50 males (*Webb & Smith 2002*)*).

The proposed actions listed by the UKBAP for Nightjars include the designation of statutory nature conservation sites. This has been achieved to a great extent, with the majority of core Nightjar areas in Sites of Special Scientific Interest (SSSI) and Special Protection Areas (SPAs) (JNCC 2005). Specifically, this has provided a focus for appropriate restoration and re-creation of heathland and increasingly sympathetic management of key forests (Anon. 1998). Restoration or re-creation schemes have been most prevalent in southern England (chiefly on heathland) and North Yorkshire (chiefly in forest plantations, though not within SPA here), where the most significant population increases have occurred. In England and Wales overall, the range of Nightjars is stable, with little increase at the 10-km scale since 1992. Population changes between 1992 and 2004 appear to have been largely due to local consolidation and expansion around core areas, particularly in the south and east of England.

Notable changes occurred in southwest England, where Nightjars expanded their population and range into south Devon and Cornwall, following heathland restoration and management effort. In Dorset, there has been active heathland restoration since 1989, through the RSPB Dorset Heathland Project. Between 2000 and 2004, there has been 1560 ha of heathland restoration and 116 ha of heathland re-creation, through Tomorrow's Heathland Heritage (Munns pers. comm.). By contrast, in North Yorkshire, where the Nightjar population has doubled between 1992 and 2004, and new 10-km squares have become occupied, sympathetic forest management is the most significant factor (Walker pers comm.). Meanwhile, in eastern England there has been an overall population increase despite evidence that some localized populations may have peaked. In Thetford Forest, Nightjars declined from 420 males in 1998 (Evans 2002) to 349 males in 2004, following an earlier peak in the availability in clear-fell areas, but the 2004 total is still a near 10% increase on the 1992 Thetford Forest total of 319 males. However, around 13 000 ha of rotational clear-fell and replanted habitat are potentially still available to Nightjars, annually (Gibbons pers. comm.), so the population should remain stable, notwithstanding potential influences from abroad.

In northern England there has been a shallow population decline since 1992. This may have been partly due to wet and windy conditions during the second half of June, which influenced survey efficiency, especially in Northumberland and Durham (Cadwallender pers. comm.). But increases in North Yorkshire underline the primary influence on Nightjar abundance and distribution of habitat provision (larger clearings via rotational felling; Scott *et al.* 1998), where a higher proportion of birds was located on both planted and unplanted areas of forest in 2004 than in

1992.

Nightjars were recorded mainly on unplanted clear-fells within plantations in the Midlands and Wales too, although the Midlands, northwest England and especially Scotland are associated with regional declines, which suggests that the long-term aim of restoring breeding Nightjars to areas of former range will have fallen short of its target.

In Scotland, a further range reduction is likely to have occurred. The 23% population decline is probably real, given that core sites, according to data from 1992 and local information, were adequately surveyed (Appendix). In Scotland as a whole, the population is difficult to assess due to remote and scattered areas of potentially suitable habitat, that receive relatively low survey coverage beyond the southwest region. But no recent reports of breeding Nightjars were received from 'well-watched' locations in Argyll or Strathspey, suggesting that a continued, long-term range contraction in Scotland has occurred. All the males in Scotland were located within forest plantations in 2004. It is possible that declines here are due to changes in breeding habitat quality, but the availability of foraging habitat could be just as limiting (Rollie pers. comm.) and the importance of these requirements can only be determined through detailed study.

Interestingly, in the western half of the Midlands (including Staffordshire), only one record of Nightjars was reported outside Cannock Chase, despite former records of breeding elsewhere in Staffordshire (in fact in 2005, at a new site not surveyed in 2004, five males were recorded, that may have been present since 2003). The Cannock Chase population itself may have peaked at around 75 churring males in 2002 (Bennett *et al.* 2002), so potentially encouraging regional expansion. In the East Midlands, meanwhile, a decline within the Nottinghamshire 'stronghold' may infer that issues such as disturbance might be worth investigating (Murison 2002, Liley & Clarke 2003, Woodfield & Langston 2004).

In Wales, a population increase of 24% since 1992, despite scattered changes in distribution, is largely due to increases in Carmarthenshire, Ceredigion and Glamorgan. In contrast, slightly lower population totals were registered for North Wales, although survey coverage was lower there than in 1992. Around 80% of the males in Wales were recorded in forest plantations, including a higher proportion on unplanted areas than in 1992.

In practice, there was no systematic survey coverage in Northern Ireland for Nightjars in 2004. Local information was acquired but no birds have been reported since 1987 (Hutchinson 1989). Nightjars are unlikely to have made a significant, unnoticed recovery since 1992. Nevertheless, potential habitat exists ('cut-over' raised bogs), and recolonization should not be discounted in future conservation objectives, given that the species was formerly widespread in distribution (Gibbons *et al.* 1993).

Habitat associations

In 2004, the key purpose of gathering habitat data was to monitor broad-scale changes in association with broad habitat categories, heathland and forestry. Otherwise, a regionally controlled analysis was difficult and potentially misleading in mainly reflecting song-post locations of churring males (hence relationships with forest tree age categories and forest edge; Ravenscroft 1989, Bowden & Green 1998). Habitat availability could not be calculated and different habitats were not always mutually exclusive within Nightjar territories.

Therefore, in 2004 there was still a clear dependency on both pine forest plantations and heathland, each supporting around 40% and 55% of the national population, respectively (see also the regional accounts above). This reflected a 20% increase for dry heathland (a visual rather than biological definition) and only a marginal increase in pine forest plantations (which in 2004 represented over 80% of all forest records). Heathland may also support higher densities of Nightjars than forest plantations (Lake 2004), but association may be tempered by sward condition since there was a stronger association with heather or, to a lesser extent, bracken than grassy heath in 2004. An understanding of the preferred ground conditions of Nightjars in forest plantations (Bowden & Green 1998) may be important in efforts to re-establish its status in places where it is has declined against the national trend.

Conclusions

Although Nightjars are African migrants, the continued increase in the national population is probably attributable to habitat protection, management and restoration or re-creation of preferred breeding habitats. Long-term projects on the Dorset Heaths, Thames Basin Heaths and in East Anglia (north Norfolk, Suffolk Sandlings and Brecklands) have improved Nightjar breeding habitats by reducing scrub encroach-

ment and altering the condition of the heather sward. In England, the Government's target to return 95% of all SSSIs to favourable condition by 2010 (Defra 2002) should ensure that improvements are maintained. Meanwhile, forest habitats still held over 50% of the national Nightjar population, and so forest management continues to be an important consideration for the conservation of this species.

The modest range distribution of Nightjars is cause for concern, particularly for northwest Britain. Limiting factors may include a sporadic availability of nesting habitat in some forest areas, the quality of available habitats (sward condition), regional differences in the timing of forest operations, losses of foraging areas, and uncultivated ground due to agricultural intensification. Predictions regarding climatic changes are equivocal, leading perhaps to wetter spring conditions (which could chill chicks and lead to higher mortality), but drier summers (Hume *et al.* 2002), improved insect abundance (Green *et al.* 2001) and higher chick survival or productivity. Wider countryside issues will certainly need to be addressed, perhaps through agri-environment measures, to increase the area of uncultivated land or woodland edge habitats that can support invertebrate prey. This, and re-creation of breeding habitat, may be essential for Nightjars to recolonize areas of central England. Meanwhile, maintaining heathland habitats in the face of increased pressure from housing development and human disturbance in southern and central England will be challenging (Murison 2002, Liley & Clarke 2003, Woodfield & Langston 2004). A priority in Wales is to maintain forest populations, in the face of targets for 50% of the public forest estate to be converted to continuous canopy cover. Overall, the results of the next national survey in 2016 will be very important, to assess whether populations have been maintained or have peaked in the core areas and whether agri-environment measures will help birds recolonize areas previously occupied in the 1960s and 1970s.

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APPENDIX

Comparison of the unadjusted number of males by county for 1992 and 2004.

		Total		Change	
Region	County	1992	2004	No. males	%
Scotland	Dumfries and Galloway	31	25	–6	–19
	Strathclyde 1992	6	0	–6	[–]
	Grampian (Moray)	1	0	–1	[–]
	Caithness	1	0	–1	[–]
	Stirling (Central 1992)	2	2	0	0
Total		**41**	**27**	**–14**	**–34**
Northern England	Cleveland	0	2	2	[+]
	Cumbria	6	6	0	0
	Durham	19	16	–3	–16
	East Yorkshire (Humberside 1992)	18	8	–10	–56
	Greater Manchester	1	0	–1	[–]
	Lancashire	1	0	–1	[–]
	North Yorkshire	114	229	115	101
	Northumberland	43	10	–33	–78
	South Yorkshire	89	37	–52	–58
	West Yorkshire	1	0	–1	[–]
Total		**292**	**308**	**16**	**5**
Midlands	Buckinghamshire	1	1	0	0
	Derbyshire	4	3	–1	–25
	Gloucestershire	12	18	6	50
	Herefordshire (and Worcestershire)	1	0	–1	[–]
	Leicestershire and Rutland	0	2	2	[+]
	Northamptonshire	3	1	–2	–67
	Nottinghamshire	73	66	–7	–10
	Oxfordshire	0	2	2	[+]
	Shropshire	1	0	–1	[–]
	Staffordshire	29	66	37	128
Total		**124**	**159**	**35**	**28**
Wales (old counties)	Clwyd	39	35	–4	–10
	Dyfed	11	55	44	400
	Glamorgan (S, Mid, W)	33	56	23	70
	(S Glamorgan)	*(1)*	*(0)*	*(–1)*	[–]
	(Mid Glamorgan)	*(3)*	*(18)*	*(15)*	*(500)*
	(W Glamorgan)	*(29)*	*(46)*	*(17)*	*(59)*
	Gwent	28	48	20	71
	Gwynedd	45	15	–30	–67
	Powys	32	35	3	9
Total		**188**	**244**	**56**	**30**
Eastern England	Bedfordshire	4	0	–4	[–]
	Lincolnshire	41	52	11	27
	Norfolk	223	313	90	40
	Suffolk	317	284	–33	–11
Total		**585**	**649**	**64**	**11**
Southeast England	Berkshire	39	78	39	100
	Hampshire	514	781	267	52
	Hertfordshire	1	0	–1	[–]
	Isle of Wight	59	19	–40	–68
	Kent	79	45	–34	–43
	Surrey	133	302	169	127
	Sussex	175	243	68	39
Total		**1000**	**1468**	**468**	**47**
Southwest England	Cornwall	16	29	13	81
	Devon	230	333	103	45
	Dorset	536	751	215	40
	Somerset	57	158	101	177
	Wiltshire	24	5	–19	–79
Total		**863**	**1276**	**413**	**48**
Grand total		**3093**	**4131**	**1038**	**34**

Where counties have gained or lost breeding Nightjars between the 1992 and 2004 surveys, percentage change values are not valid and have been indicated by [–] for lost from and [+] for gained.