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Nightjar *Caprimulgus europaeus* and Woodlark *Lullula arborea* – recovering species in Britain?

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The Nightjar *Caprimulgus europaeus* and Woodlark *Lullula arborea* are identified as species of conservation concern at both a UK and a European level on account of historical declines in their population sizes and ranges. The UK populations of both species have increased significantly in recent decades and this paper reviews the extent, nature and causes of these population changes, based on evidence from national surveys and autecological studies. It also considers the future prospects of both species in the face of likely changes to their preferred habitats in Britain. Nightjar numbers have increased greatly since the national survey in 1981, when the British population was estimated at only 2100 churring males, with an estimated 3400 in 1992 and 4606 (± 913) in 2004. Population recovery has been closely associated with their colonization of clear-fell areas in planted forests. Over 57% of the calling ('churring') males recorded were in planted forests in 2004. Woodlark numbers have also made a substantial recovery from a low level of just 250 territories in 1986 to 1426–1552 territories in 1997. Over 85% of the Woodlark territories recorded in 1997 were on heathland or in planted forests. Despite these increases, both species continue to occupy only part of their much more extensive former breeding ranges. The recovery of these species has coincided with the availability of suitable open ground habitat resulting from the felling of forests planted in the late 1920s and 1930s, often on former heathland habitats, the clearance and restocking of areas damaged by storms in October 1987 and January 1990 and the restoration of heathland habitats. Forests and heathlands support the majority of the breeding populations of Nightjars and Woodlarks, although there are regional variations in their relative importance. The prospects for further recovery may be limited due to a reduction of open ground habitat following restocking of planted forests, including those damaged in the storms of 1987 and 1990, the effects of recreational disturbance and, at least locally, poor Woodlark breeding productivity due to predation.

The Nightjar *Caprimulgus europaeus* and Woodlark *Lullula arborea* are identified as species of conservation concern at both a UK and a European level. Both are priority species of the UK Biodiversity Action Plan (HMSO 1998) and red-listed birds of conservation concern, because of their historical declines in range, such that over 50% of their respective UK populations occur on no more than ten sites (Gregory *et al.* 2002). The global populations of both species are concentrated in Europe and both birds are regarded as Species of European Conservation Concern (SPEC 2) as a consequence of historical population declines (Hagemeijer & Blair 1997, BirdLife International 2004). In addition, both are listed on Annex I of the EU 'Birds' Directive (*Directive on the conservation of wild birds* 79/409/EEC) and so should be the subject of 'special conservation measures concerning their habitat' by EU member states.

Nightjars are primarily crepuscular and nocturnal, being most active around dusk and dawn, are long-distance migrants and only visit Britain to breed during

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May–August (Cramp & Simmons 1985). Woodlarks are partial migrants (Sitters 1986, Wernham *et al.* 2002). Both are insectivorous and nest on the ground, preferring open-ground habitats. Historically, they occurred primarily on heathland, in woodland clearings, on downland, at the interface between woodlands and the open-ground habitats and, in the case of Woodlark, on rough pastureland (Holloway 1996, Brown & Grice 2005). Their distributions are mostly associated with light sandy soils in lowland Britain (Sitters 1986, Gibbons *et al.* 1993).

The long-term and substantial loss, degradation and fragmentation of lowland heathland habitats (Moore 1962, Webb 1990, Farrell 1993, Rose *et al.* 2000) has been the major factor associated with the dramatic population declines of both species. The Woodlark's range has also contracted on farmland and chalk downland. Formerly, the Nightjar occurred widely throughout Britain and Ireland, whereas the Woodlark always had a more southerly distribution, largely restricted to England and Wales, and was only a very local resident in Ireland (Thom 1986, Hutchinson 1989, Holloway 1996, Brown & Grice 2005). Both species had already shown marked range contraction, and presumably therefore declines in numbers, by the time of the first Atlas of breeding birds (Sharrock 1976), and further range contractions were indicated in the second Atlas (Gibbons *et al.* 1993). Nightjars are presumed lost from Northern Ireland with the last confirmed breeding in 1987 (Hutchinson 1989), and are very rare in the Republic of Ireland. Woodlarks remain entirely absent as a breeding species in Ireland (Gibbons *et al.* 1993).

There have been several surveys of these species in Britain since the 1968–72 Atlas (Sharrock 1976), providing the basis for assessment of recent changes in population size and distribution. This paper reviews the extent, nature and causes of population changes in these two species over the last 35 years based on the evidence provided by national surveys and studies of the birds' ecological requirements. It then considers the future prospects for both species in the face of likely changes to the quality and quantity of their favoured habitats in Britain.

CHANGES IN DISTRIBUTION AND ABUNDANCE

Dedicated surveys of these species in Britain took place in 1981, 1992 and 2004 for Nightjar (Gribble 1983, Morris *et al.* 1994, Conway *et al.* 2007), and in 1986 and 1997 for Woodlark (Sitters 1986, Sitters *et al.* 1996, Wotton & Gillings 2000). A further survey of Woodlarks took place in 2006, but the results were not available to include them in this paper. These repeat surveys have provided snapshots of the geographical distribution and population size for both species at approximately decennial intervals since the 1968–72 Atlas (Sharrock 1976).

Nightjars seemingly reached their low point around the time of the 1981 survey, when there were an estimated 2100 churring males in just 241 10-km squares (Gribble 1983). A steady recovery in numbers occurred thereafter, reaching an estimated 4606 (95% confidence limits 3693–5519) churring males in 275 10-km squares by the time of the 2004 survey (Conway *et al.* 2007). This contrasts with the 562 10-km squares occupied in the late 1960s/early 1970s (Sharrock 1976), indicating that they are still well short of recovering their former range (Fig. 1). In 2004, the main increases in population size were in southeast and southwest England, still the core of the British population, but there were also declines, for example in Suffolk, eastern England (Conway *et al.* 2007), indicating regional variation across Britain.

Woodlarks have shown more marked fluctuations in numbers with substantial decreases following severe winters, such as 1962/63 and 1981/82 (Sitters *et al.* 1996). The population reached its nadir in 1986, when there were an estimated 250 territories in just 35 10-km squares (Sitters *et al.* 1996). Since then, they have recovered substantially with 1426–1552 territories being estimated in 1997, although there was only a small recovery in range to 95 10-km squares (Wotton & Gillings 2000). Most of this recovery was by consolidation in the core parts of the range identified in 1986 (Sitters *et al.* 1996), notably in Breckland and the Suffolk Sandlings (Fig. 2). Both species therefore continue to occupy only part of their much more extensive breeding ranges of 35 years ago.

CAUSES OF RANGE CONTRACTION AND DECLINE

Habitat loss and change

There have been substantial losses of semi-natural habitats such as heathland and deciduous woodland to built development, including roads, agriculture and forestry (Moore 1962, Spencer & Kirby 1992, Farrell 1993). Heathland losses were underway in the early 19th century, but increased during the post-War years, perhaps best documented for Dorset,

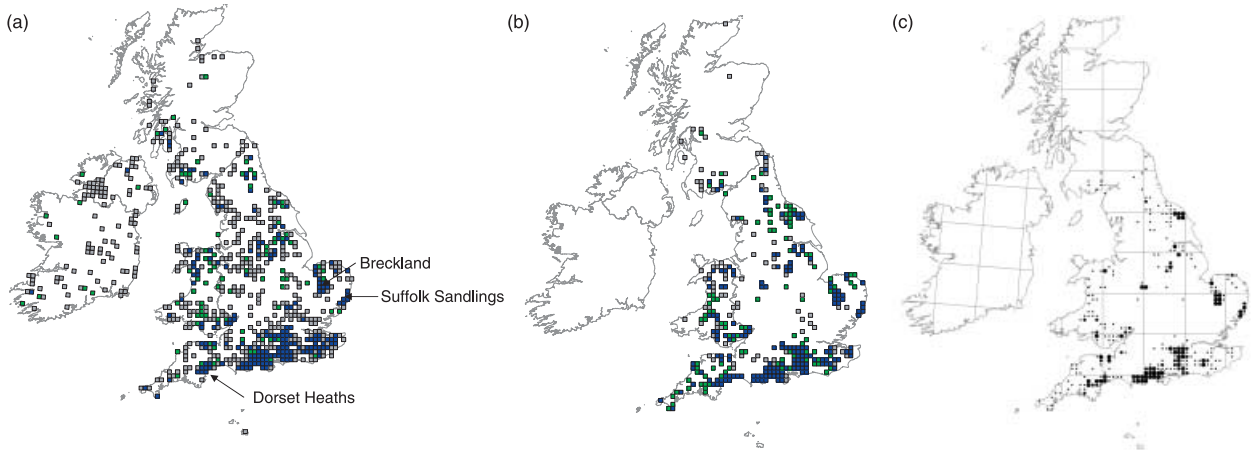

Figure 1. Distribution of Nightjars in Britain: (a) change between 1968–72 and 1988–91 (from Sharrock 1976, Gibbons *et al*. 1993) (blue squares 1968–72 & 1988–91, green squares 1988–91 only, grey squares 1968–72 only); (b) change between 1992 and 2004 (from Morris *et al*. 1994, Conway *et al*. 2007) (blue squares 1992 & 2004, green squares 2004 only, grey squares 1992 only); (c) relative abundance and distribution in 2004 (after Conway *et al*. 2007) (small dots: 1–9, medium dots: 10–19, large dots: 20+).

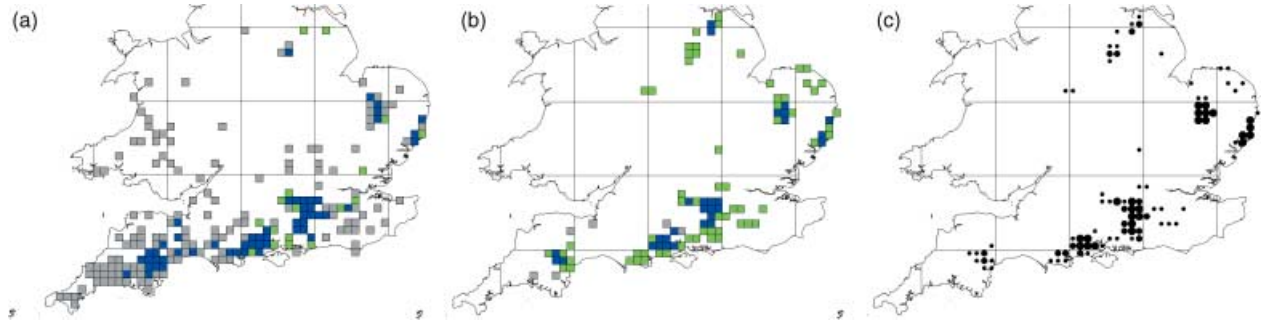

Figure 2. Distribution of Woodlark territories in Britain: (a) change between 1968–72 and 1988–91 (from Sharrock 1976, Gibbons *et al*. 1993) (blue squares 1968–72 & 1988–91, green squares 1988–91 only, grey squares 1968–72 only); (b) change between 1986 and 1997 (from Sitters *et al*. 1996, Wotton & Gillings 2000) (blue squares 1986 & 1997, green squares 1997 only, grey squares 1986 only); (c) relative abundance and distribution in 1997 (after Wotton & Gillings 2000) – the dot size indicates the number of territories located within each 10-km square: (smallest to largest) 1–9, 10–19, 20–39, 40–69, 70+ territories.

where by 1960 10 500 ha (28%) were in agricultural use, 8900 ha (23%) had been lost to urban development and 7700 ha (20%) had been planted as forest (Moore 1962). The extent and nature of losses show regional variation, but continued into the 1980s, albeit at lower levels than in previous decades (Webb 1990, Farrell 1993). As well as direct loss, fragmentation and diminution of patch size have also taken place, and successional change to scrub transformed much of the remaining heathland as it ceased to have economic and social value (Webb 1990, Rose *et al*. 2000). Rabbit grazing was important in maintaining the Breckland heaths as favourable habitat for Woodlarks and the reduction of rabbits, due to myxomatosis during the 1950s, was a contributory factor in the Woodlark's decline (Dolman & Sutherland 1992). Further changes have taken place as nutrient enrichment, largely attributed to pollution loads in rainfall (Marrs 1993, Barr 1997), has favoured the transition from ericaceous shrub to grass heath. The resulting dense sward on some grass heaths makes them less suitable for foraging Woodlarks in particular (Sitters 1986, Bowden 1990).

Nightjars forage over a range of habitat types in the vicinity of their nesting area including woodland, woodland edge, wetland and heathland and may

travel some distance from their nest-sites, depending on the availability and proximity of suitable or preferred feeding habitat (Ravenscroft 1989, Alexander & Cresswell 1996). Thus, the documented change and loss in woodland (e.g. Spencer & Kirby 1992) and wetland (e.g. Fojt 1994a, 1994b, Gilbert *et al.* 1996, Lindsay & Immirzi 1996) are also likely to have been detrimental for Nightjars.

Weather and climate change

Climate change and variations in weather have been suggested as possible factors in the declines of both species (Sitters 1986, Morris *et al.* 1994). Whilst Woodlarks have been known to suffer high rates of mortality during severe winter weather, the evidence for this factor determining long-term population trends remains equivocal. The severe winter of 1962/63 had a devastating impact on Woodlarks on southern heathlands and the 1981/82 winter had similarly adverse effects on birds in southern England, although little detrimental effect was apparent in East Anglia (Sitters *et al.* 1996). Equally, Sitters (1986) cites the general pattern of increase during the 1940s in spite of several severe winters, notably that of 1947.

Woodlarks return early to their breeding sites, from late January onwards, with most on territory by late February or early March (Payn 1978, Sitters 1986). The majority of first clutches are laid by the end of March, with a peak corresponding to the week ending 28 March (Mallord 2005, Wright 2006). Weather conditions in spring affect the length of the breeding season, with a 1 °C reduction in mean early spring temperatures delaying breeding by 2.6 days and causing a 2% decline in productivity in Breckland (Wright 2006). Woodlark clutches were larger in years when rainfall was low and temperature high during the egg-laying and prelaying periods and nest success increased with higher temperatures during the nesting period. The number of chicks fledged per egg laid, in successful nests, was greater when the weather was drier during the brood stage (Wright 2006). However, there is no clear evidence that the effects of weather conditions on productivity are responsible for the observed long-term changes in range or population size, and the response by both Woodlarks and Nightjars to habitat availability indicates that climate change has not been a major factor in their declines.

As long-distance migrants, Nightjars escape the vagaries of British winter weather. However, factors operating on their wintering grounds or along migration routes might have affected this species, given reported declines for common long-distance migrant woodland birds (Fuller *et al.* 2005, Amar *et al.* 2006, Sanderson *et al.* 2006).

FACTORS AIDING RECOVERY

Population increases in both Nightjars and Woodlarks have coincided with the increased availability of suitable habitat, initially within planted forests. The first large-scale planting of forests occurred in the late 1920s and 1930s. These forests matured and were felled during the late 1970s to 1980s, substantially increasing the availability of open ground habitat (e.g. Ravenscroft 1989), and both species colonized the resulting clear-fells and subsequent young restocks. The area of open ground was augmented by storm damage in October 1987 and January 1990, the effects of which varied regionally. For example, in East Anglia, forest stands of all ages in Rendlesham and Tunstall Forests were heavily wind damaged, with a loss of 80–90% of the 2500 ha forest area (F. Currie pers. comm.). The extent of habitat suitable for Nightjars and Woodlarks in forests was probably greater during the 1980s than at any time since the first commercial plantings of forests. Additionally, conservation efforts to restore heathland further increased the availability of habitat from the late 1980s. Woodlarks recolonized heathland as it became available even when the population density in planted forests was still low (Wright 2006).

Nightjars prefer forest areas with a ground cover of litter (dead leaves, twigs, etc.), moss, short grass, bracken and shrubs (Bowden & Green 1991). These conditions prevail in clear-fells and young restocks, which are readily colonized by Nightjars and provide a combination of nest clearings, nest cover, scattered song posts and foraging habitat, notably in restocks of 3–5 years old and less than 2 m in height (Ravenscroft 1989, Bowden & Green 1991). Thereafter, Nightjar density declines with forest stand age, few birds remaining once the trees reach 15–20 years old (Bowden & Green 1991), when complete canopy closure occurs. The forestry practices of inter-row ploughing or the application of selective herbicides to suppress the growth of invasive plants during the first few years of tree growth extend the suitability of restocks for Nightjars (Ravenscroft 1989).

Woodlarks nest in clumps of vegetation, especially grass and heather (Mallord *et al.* in press), and require short, sparse vegetation, less than 5 cm high,

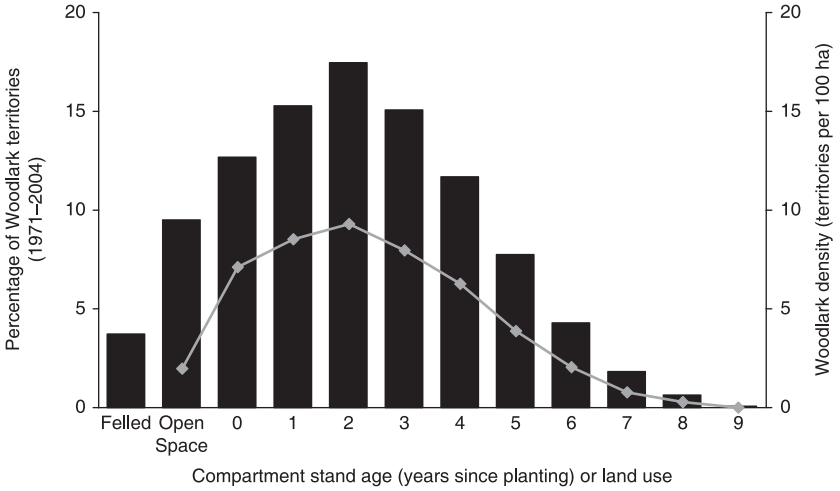

Figure 3. The effect of tree age on the density of Woodlark territories in planted forests 1971–2004 (after Wright 2006). Bars show the percentage of all Woodlark territories found in Thetford Forest from 1971 to 2004 that were found in stands of each age category or land use. The line shows the average density of Woodlark territories in stands of each category over the same time period. Open space comprises permanent open space.

combined with areas of bare ground for foraging (Sitters 1986, Bowden 1990, Mallord *et al.* 2006). In such areas, it appears to be easier for Woodlarks to find their invertebrate prey which they pick from the surface of the soil or vegetation. Thus, clear-fells and young restocks, with abundant disturbed, bare ground and short vegetation provide ideal foraging conditions for Woodlarks and they rapidly colonize these habitats (Bowden & Hoblyn 1990). Studies in Thetford Forest (East Anglia) show that peak breeding densities of Woodlarks occur in stands of 1–3 years old (Fig. 3), declining thereafter until, by the time they reach 6–7 years old, the stands generally cease to be suitable owing to the growth of the field layer vegetation (Bowden & Hoblyn 1990, Wotton & Gillings 2000, Wright 2006). As with the Nightjar, management can be applied to extend the time for which the field layer is suitable for Woodlarks. Improved management and restoration of traditional heathland habitats have also greatly benefited the Woodlark, with the reinstatement of grazing and the clearance of dense scrub and trees creating better conditions for foraging (Wotton & Gillings 2000). Between 1997 and the end of 2004, over £26 million had been spent on heathland conservation, leading to the active management/restoration of over 42 200 ha of lowland heathland habitat and the re-creation of 2334 ha in the UK (unpublished Natural England data). The extent to which open, grazed heathland habitats are being restored is illustrated by the proportion (64%) of heathland Sites of Special Scientific Interest (SSSI) that are in either favourable condition or recovering to favourable condition (JNCC 2006). Heather of a range of growth stages and heights is an important feature of Nightjar territories (Berry 1979). Both species utilize scattered trees and snags as song perches. A mosaic of heathland comprising a range of vegetation age and structure provides suitable conditions for both species.

Forests and heathland support the majority of the populations of Nightjars and Woodlarks, although there are regional variations in their relative importance. Most of the Nightjars in southeast and southwest England occur on dry heath, but elsewhere most occur in forests (Table 1; after Conway *et al.* 2007). In the case of Woodlarks, a high percentage occur on heaths in southern England, whilst planted forests are important in eastern England particularly in Breckland. In the Suffolk Sandlings, Woodlarks occupy both planted forests and heathland, including grass heaths, in similar proportions (Table 2; after Wotton & Gillings 2000). Wright (2006) found clutch size and breeding success to be similar in both habitats in Breckland.

In recent years, an increase has been noted in the occurrence of winter flocks of Woodlarks on rotational set-aside stubbles in Breckland (Atkinson 2001), notably barley stubble (Wright *et al.* in press). The

Table 1. Habitat composition recorded within 50 m of churring male Nightjars in 2004 (after Conway *et al.* 2007). The table shows the percentage of males associated with each habitat category, by region, and in total compared with 1992. NB: habitat categories are not mutually exclusive.

	Woodland percentage males				Heath percentage males	
Region (*n* males)	Unplanted open ground	Planted conifer	Broadleaf woodland	Mixed woodland	Dry heath	Wet heath
Scotland (25)	4	88	0	8	0	0
N England (212)	20	73	2	11	18	2
Midlands (73)	41	36	7	12	41	0
Wales (203)	31	60	4	8	15	4
E England (532)	14	64	1	8	37	3
SE England (1261)	11	21	4	9	60	10
SW England (997)	11	42	2	3	64	11
2004 total (3303)	13.8	40.8	2.9	7.3	51.0	8.1
1992 total (3560)	10.7	38.6	4.7	7.8	31.2	6.9

Table 2. Number of Woodlark territories recorded in 1997, compared with 1986, in relation to different habitats and land uses (within-region percentages in parentheses) (after Wotton & Gillings 2000). The balance of the 100% comprises a variety of other, minor habitats.

Region	Planted conifers	Agriculture/set-aside	Horticulture	Heathland	Grass
Devon	1 (2%)	52 (98%)	0	0	0
Dorset/New Forest/SW Hants	38 (13%)	1 (<1%)	6 (2%)	242 (81%)	6 (2%)
NE Hants/Surrey/Berks/W Sussex	72 (18%)	9 (2%)	13 (3%)	287 (72%)	9 (2%)
Suffolk Sandlings	113 (46%)	17 (7%)	0	70 (29%)	45 (18%)
Breckland	342 (78%)	4 (1%)	1 (<1%)	89 (20%)	1 (<1%)
Notts/Lincs	35 (52%)	2 (3%)	1 (1.5%)	15 (22%)	2 (3%)
Other	13 (34%)	0	0	20 (53%)	1 (3%)
Total 1997 (1537)	614 (40%)	85 (5.5%)	21 (1%)	723 (47%)	64 (4%)
Total 1986 (182)	76 (42%)	9 (5%)	20 (11%)	71 (39%)	0

use of winter stubbles has been recorded previously (Payn 1978, Sitters 1986), but the extent was unknown. Their increased use for breeding is now becoming apparent, possibly as an overspill from planted forests (Wright *et al.* in press). In mainland Europe, Woodlarks tend to use farmland habitats a lot more than in Britain, for example the use of farmland near to forests in Germany (Schaefer & Vogel 2000). There is probably a huge amount of unused suitable habitat in all counties in the form of farmland. However, in East Anglia and Dorset for example, relatively short dispersal distances (and perhaps some degree of conspecific attraction) has meant that birds have been slow to spread out of their core forest and heathland habitats (Mallord 2005, Wright 2006). In Devon, farmland has always been the main habitat for Woodlarks with a clear increase in recent decades (Table 2, after Wotton & Gillings 2000).

POTENTIAL LIMITATIONS TO FURTHER RECOVERY

Slow recolonization

Nightjars and Woodlarks, but especially the latter, appear to be slow in regaining their former range. It is not clear whether there is simply a time-lag or whether there are constraints to achieving range recovery, as raised by Sitters *et al.* (1996). Woodlarks, in particular, are more likely to colonize areas already occupied by other Woodlarks, which slows the pace of range expansion. Mallord (2005), working in Dorset, showed that the probability of a heathland site being colonized by Woodlarks declined as the number of birds present within 4 km of that site declined. A distance of 4 km was chosen as a measure of isolation because 75% of all local recruits settled

within 4 km of their natal site. Localized surveys of Woodlarks since 1997 indicate that there has been further range expansion, suggesting that time is a major factor in re-establishment. Regarding Nightjars, other limiting factors are likely, especially in those areas which have yet to be recolonized, despite the availability of apparently suitable forest habitat. In such cases it is possible that the availability of foraging habitat and invertebrate prey is limiting, factors which merit further investigation.

Habitat management

In planted forests, both Woodlarks and Nightjars readily occupy clear-fells, young restocks and permanent open spaces. The extent of clear-fell/restock habitat in forests has decreased in recent years from a peak following the storm damage in the late 1980s and early 1990s. However, forest restructuring through forest design planning provides a continuity of new clear-fell and restock areas and a constant supply of both open ground habitat for these species and saw-logs for the timber industry whilst also meeting the UKWAS (UK Woodland Assurance Scheme) requirement for 5–10% of forest area to be maintained as mature forest. [Forests that are designated Special Protection Areas (SPAs) under the EU Birds Directive for their open ground bird habitats are exempted from greater requirements for mature forest retention.] During the 50–60-year harvesting cycle in these rotational clear-fell forests, approximately 30–40% of the forest at any one time comprises habitat suitable for Nightjar and Woodlark.

Nest predation

Recent declines of Woodlarks have been noted in the Suffolk Sandlings, and in Thetford Forest, Breckland (Fig. 4). Wright (2006) suggests that the main mechanism for this decline in Breckland may be high nest predation rates, which have increased continuously since 1970. Since 2000, predation loss has caused annual productivity to fall below 3.6 fledglings per breeding pair, which is the level required to sustain the population assuming average annual mortality rates calculated for colour-ringed adults and first-year birds (Wright 2006). Further study is required to determine which predator species are responsible, although anecdotal observations indicate that a range of avian and mammalian predators, as well as Adders *Vipera berus*, are potential predators of Woodlark nests (Wright 2006).

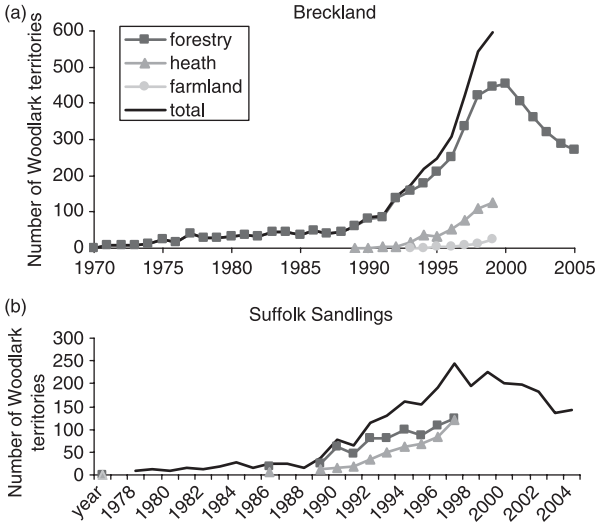

Figure 4. Regional comparisons of Woodlark territories by habitat for (a) Breckland and (b) Suffolk Sandlings (after Wotton & Gillings 2000, Wright, East Anglia, 2006).

Disturbance

The distribution of Woodlarks on Dorset heaths was significantly affected by the presence of people and dogs (Mallord *et al.* 2006). Lower densities were found on those sites with higher numbers of visitors. Within sites open to public access, birds only settled to breed in areas with low numbers of visitors. Heavily disturbed areas were used only for foraging, although the habitat was suitable for both foraging and nesting. The probability of suitable habitat being colonized was reduced to below 50% at around eight disturbance events per hour. However, there was no effect of disturbance on nest survival, and productivity was actually higher on more disturbed heaths due to strong density-dependence operating on various stages throughout the breeding cycle, including influencing rates of local recruitment (Mallord 2005). Modelling of this population under different access scenarios (Mallord *et al.* 2006) demonstrated that disturbance is already affecting the Woodlark population but further negative effects would require large increases in visitor pressure (which was not predicted under The Countryside and Rights of Way Act 2000), and would be dependent on changes in the spatial distribution of people. Under current access arrangements, a doubling of visitor numbers had little effect, while the same number of people distributed evenly across all sites led to a major negative impact on the population.

Studies of Nightjars have found a significant reduction in breeding densities on heathland sites in Dorset close to urban development (Liley & Clarke 2003). Further studies carried out to identify the cause of this effect showed that the breeding success of Nightjars is significantly lower close to paths (Murison 2002, Langston *et al.* 2007). The proximate cause of decreased breeding success on these heaths is nest failure, most frequently due to diurnal egg predation. Nightjar eggs were exposed to an increased risk of predation when an incubating bird was flushed from the nest during daylight as a result of disturbance, for example close approach by a dog or person walking across the heath (Woodfield & Langston 2004, Langston *et al.* 2007). Failed Nightjar nests occurred in areas of short vegetation and had significantly lower vegetation cover (Murison 2002, Langston *et al.* 2007). The predator involved was often thought to be Carrion Crow C*orvus corone* (Murison 2002).

DISCUSSION AND RECOMMENDATIONS

Monitoring

Surveys over the past 35 years have highlighted changes in population sizes and geographical ranges for Nightjars and Woodlarks, documenting their declines and signs of recovery. The results of these surveys have informed research priorities and conservation measures. This is an ongoing process, requiring further periodic surveys to monitor temporal and spatial changes in the populations of Nightjars and Woodlarks in Britain. These surveys are also required to assess the performance of sites designated as being of particular importance for the conservation of these species (SPAs), to determine the adequacy of the protected sites network for these species, and to assess the effectiveness of site-based conservation measures. To meet these combined objectives, surveys will require a combination of stratified random sampling and site-based monitoring.

Priorities for conservation action

The first priority for both species is to maintain and enhance the existing forest and heathland habitats. Careful planning of rotational forest management, via Forest Design Plans, particularly in the larger 5000–20 000-ha Forestry Commission forests established in heathland districts such as Thetford Forest, will be crucial in providing continuity of clear-fell and young restock habitat in a mosaic of different aged stands. The varied age structure will accommodate both Nightjars and Woodlarks, with Nightjars occupying individual restocks for longer than Woodlarks before moving to new clear-fells or young restocks elsewhere within the forest. Management of the ground vegetation, including inter-row ploughing or selective herbicide application in young restocks, combined with areas of vegetation stripping and livestock grazing in areas of permanent open space, will be necessary to provide the bare and sparsely vegetated ground required by Woodlarks. Further initiatives within Forest Design Plans, including increasing the length of woodland edge and enhancing wetland areas, will benefit foraging Nightjars. Woodland edges are also used by birds generally as a means of escape from predators (e.g. Schaefer & Vogel 2000). Research is needed to improve our understanding of the importance of forest management for both Woodlark and Nightjar, including an assessment of the influence of tree age and structure on adjoining forest coupes and the proximity of suitable foraging habitat on occupancy and breeding productivity.

On lowland heathland it will be necessary to ensure that, as part of rotational vegetation management, an appropriate proportion of early-successional habitat is provided for Woodlarks, through combinations of cutting, burning or grazing. Meanwhile, Nightjars will benefit from the presence of old, over-mature heather in which nest gaps form. Since the 1980s, management has been undertaken to restore degraded heathland to favourable condition, which needs to continue to ensure that heathland is managed to prevent and reverse succession to dense scrub and woodland. Isolated trees for song-posts should be incorporated into any management of heathland (Symes & Day 2003).

There is an ongoing requirement for further restoration of heathlands, including those within planted forests, to reverse the effects of fragmentation, and to provide stepping stones to facilitate range expansion and re-colonization by heathland species. Restoration and re-creation are needed, not only in the core areas of southern England, where much of the recent heathland restoration has been targeted, but elsewhere within the historical range of both species. Achieving a significant expansion of the Nightjar's range, in particular, is likely to require other measures beyond the provision of nesting and foraging habitats within heathlands and forests. Further understanding of the role of foraging habitat in population processes

is needed, but enhancing its availability and quality in the wider countryside, including woodland edge/clearings and wetlands, is likely to be important and will depend on targeting of the agri-environment schemes.

Disturbance – visitor management

Visitor access should be considered as part of any management plan for heathland and forest sites. Recent research in southern England (Underhill-Day & Liley 2007) has yielded useful information about visitor behaviour, including distances walked and penetration on to heathland. Gaining an understanding of the behaviour of visitors to a site will be helpful in deciding where best to locate heathland habitat restoration for Nightjars and Woodlarks. Restoration of heaths on the urban fringe is likely to be a less effective means of delivering habitat and hence range expansion for Nightjars because they avoid settling on heathland within 250–500 m of developed land (Liley & Clarke 2003).

The increase in urban development around heathland is of great concern, especially because of the recently understood effects of disturbance on both Nightjars and Woodlarks. A strategic approach to built development to prevent further isolation and fragmentation of heaths, in which the potential for increased recreational access is mitigated by the provision of new green spaces close to homes, is urgently required.

Climate change

Climate change may have had, and may continue to have, effects on both species, but the nature of these is equivocal. Climate change predictions point to increased spring rainfall (Hulme *et al.* 2002), which could be detrimental to early nests in particular. This may have implications for Woodlarks, as those juveniles that fledge from nests initiated later in the season have a lower rate of local recruitment (Mallord 2005). Increased temperatures (Harrison *et al.* 2001) could be beneficial for Woodlarks, by increasing breeding productivity, but are also likely to stimulate grass growth, which could reduce their foraging habitat. Recent mild winters may have benefited Woodlarks, but equally, extreme winters may set back progress. However, the continued availability of suitable habitat should facilitate a reasonably rapid recovery from such setbacks. Future climate change scenarios are likely to see the climate space for both species extend northwards in Britain, with no predicted contraction of range in the south (Harrison *et al.* 2001, Huntley *et al.* in press), thereby facilitating their range expansion into suitable habitat.

Food availability

One effect of climate change could be to change the abundance, availability or timing of key food resources. Nightjars are insectivorous, predominantly taking larger moths (Cramp & Simmons 1985, Bowden & Green 1991), whilst caterpillars, beetles and spiders form an important component of the Woodlark's diet during the breeding season (Cramp 1988, Bowden 1990). Overall moth abundance has declined and population trends for 226 of 337 moth species, for which trend analysis was possible, are downwards over the 35 years for which the Rothamsted network of light traps has been operational (Fox *et al.* 2006). Changes in the extent and quality of suitable habitat are among the prime suspects driving these declines (Fox *et al.* 2006). The widespread intensification of agricultural practices (such as the increased use of agrochemicals) and the loss and degradation of wetland habitats are all likely to have contributed to these recently recorded declines in invertebrate abundance. Climate change has also been implicated in the only case study so far of a moth population decline, that for the Garden Tiger *Arctia caja* (Conrad *et al.* 2002, 2003). There are no equivalent datasets to provide information for other invertebrate taxa, but changes in food supply could have affected both Nightjars and Woodlarks.

CONCLUSIONS

There are signs of recovery for both Nightjars and Woodlarks, with a steady increase in the size of populations for both species in Britain, although range expansion is still limited. The distributions of both species fall well short of their recent historical ranges. The declines were most closely associated with habitat loss, degradation and fragmentation. The road to recovery to date has been attributable to the availability of open ground habitat in the management cycle of planted forests, enhanced by storm damage in the late 1980s and early 1990s, together with restoration of lowland heathland. Heathland restoration and maintenance and sympathetic Forest Design Plans remain essential for providing suitable habitat. There is also a potentially important role for agri-environment schemes, notably in the provision

of foraging habitats for Nightjars. Pressures from built developments around heathlands are increasing, necessitating a strategic approach to planning that ensures that conservation measures for these species, and other biodiversity, are not undermined.

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REFERENCES

Alexander, I. & Cresswell, B. 1996. Foraging by Nightjars *Caprimulgus europaeus* away from their nesting areas. *Ibis* **132**: 568–574.

Amar, A., Hewson, C.M., Thewlis, R.M., Smith, K.W., Fuller, R.J., Lindsell, J.A., Conway, G., Butler, S. & MacDonald, M. 2006. *What's Happening to Our Woodland Birds?* RSPB Research Report no. 19. BTO Research Report no. 169. Sandy: RSPB.

Atkinson, P. 2001. Woodlarks' winter harbour. *BTO News* **234**: 5.

Barr, C.J. (ed.) 1997. *Current Status and Prospects for Key Habitats in England: Part 1 Lowland Heath Landscapes*. London: Department for Environment, Transport & Regions (DETR).

Berry, R. 1979. Nightjar habitats and breeding in East Anglia. *Br. Birds* **72**: 207–218.

BirdLife International. 2004. *Birds in Europe: Population Estimates, Trends and Conservation Status*. BirdLife Conservation Series no. 12. Cambridge: BirdLife International.

Bowden, C.G.R. 1990. Selection and foraging habitats by woodlarks *Lullula arborea* nesting in pine plantations. *J. Appl. Ecol.* **27**: 410–419.

Bowden, C.G.R. & Green, R.E. 1991. *The Ecology of Nightjars on Pine Plantations in Thetford Forest*. Sandy: The RSPB.

Bowden, C. & Hoblyn, R. 1990. The increasing importance of conifer plantations for Woodlarks *Lullula arborea* in Britain: implications and consequences. *RSPB Conservation Rev.* **4**: 26–31.

Brown, A. & Grice, P. 2005. *Birds in England*. London: T.&A.D. Poyser/English Nature.

Conrad, K.F., Woiwood, I.P. & Perry, J.N. 2002. Long-term decline in abundance and distribution of the garden tiger moth (*Arctia caja*) in Great Britain. *Biol. Conserv.* **106**: 329–337.

Conrad, K.F., Woiwood, I.P. & Perry, J.N. 2003. East Atlantic teleconnection pattern and the decline of a common arctiid moth. *Global Change Biol.* **9**: 125–130.

Conway, G., Wotton, S., Henderson, I., Langston, R., Drewitt, A. & Currie, F. 2007. The status and distribution of European Nightjars *Caprimulgus europaeus* in the UK in 2004. *Bird Study* **54**: 98–111.

Cramp, S. (ed.) 1988. *The Birds of the Western Palearctic*, Vol. 5. Oxford: Oxford University Press.

Cramp, S. & Simmons, K. (eds) 1985. *The Birds of the Western Palearctic*, Vol. 4. Oxford: Oxford University Press.

Dolman, P.M. & Sutherland, W.J. 1992. The ecological changes of Breckland grass heaths and the consequences of management. *J. Appl. Ecol.* **29**: 402–413.

Farrell, L. 1993. *Lowland Heathland: the Extent of Habitat Change*. English Nature Science, no. 12. Peterborough: English Nature.

Fojt, W.J. 1994a. Dehydration and the threat to East Anglian fens, England. *Biol. Conserv.* **69**: 163–175.

Fojt, W. 1994b. The conservation of British Fens. *Br. Wildlife* **5**: 355–366.

Fox, R., Conrad, K.F., Parsons, M.S., Warren, M.S. & Woiwood, I.P. 2006. *The State of Britain's Larger Moths*. Wareham, Dorset: Butterfly Conservation and Rothamsted Research.

Fuller, R.J., Noble, D.G., Smith, K.W. & Vanhinsbergh, D. 2005. Recent declines in populations of woodland birds in Britain: a review of possible causes. *Br. Birds* **98**: 116–143.

Gibbons, D.W., Reid, J.B. & Chapman, R.A. 1993. *The New Atlas of Breeding Birds in Britain and Ireland: 1988–1991*. BTO/SOC/IWC. London: Poyser.

Gilbert, G., Painter, M. & Smith, K.W. 1996. An inventory of British Reedbeds in 1993. *RSPB Conservation Rev.* **10**: 39–44.

Gregory, R.D., Wilkinson, N.I., Noble, D.G., Robinson, J.A., Brown, A.F., Hughes, J., Procter, D., Gibbons, D.W. & Galbraith, C.A. 2002. The population status of birds in the United Kingdom, Channel Islands and Isle of Man: an analysis of conservation concern 2002–2007. *Br. Birds* **95**: 410–450.

Gribble, F.C. 1983. Nightjars in Britain and Ireland in 1981. *Bird Study* **30**: 165–176.

Hagemeijer, W.J.M. & Blair, M.J. (eds) 1997. *The EBCC Atlas of European Breeding Birds. Their Distribution and Abundance*. London: Poyser, for the European Bird Census Council.

Harrison, P.A., Berry, P.M. & Dawson, T.E. (eds) 2001. *Climate Change and Nature Conservation in Britain and Ireland: Modelling natural resource responses to climate change (the MONARCH project)*. Oxford: UKCIP Technical Report.

HMSO. 1998. *UK Biodiversity Group Tranche 2 Action Plans – Volume I: Vertebrates and vascular plants. Tranche 2, Volume I, 53*. London: HMSO.

Holloway, S. 1996. *The Historical Atlas of Breeding Birds in Britain and Ireland: 1875–1900*. London: Poyser.

Hulme, M., Jenkins, G.J., Lu, X., Turnpenny, J.R., Mitchell, T.D., Jones, R.G., Lowe, J., Murphy, J.M., Hassell, D., Boorman, P., McDonald, R. & Hill, S. 2002. *Climate Change Scenarios for the United Kingdom: the UKCIP02 Scientific Report*. Norwich: Tyndall Centre for Climate Change Research. University of East Anglia. www.ukcip.org.uk.

Huntley, B., Green, R.E., Collingham, Y.C. & Willis, S.G. 2007. *A Climatic Atlas of European Breeding Birds*. Barcelona: Lynx Edicions.

Hutchinson, C.D. 1989. *Birds in Ireland*. Irish Wildbird Conservancy. Calton, Staffs: T.&A.D. Poyser.

JNCC. 2006. *Common Standards Monitoring for Designated Sites: First Six Year Report*. Peterborough: Joint Nature Conservation Committee. www.jncc.gov.uk/page-3520.

Langston, R.H.W., Liley, D., Murison, G., Woodfield, E. & Clarke, R.T. 2007. What effects do walkers and dogs have on the distribution and productivity of breeding Nightjars *Caprimulgus europaeus*? *Ibis* **149** (Suppl. 1): 27–36.

Liley, D. & Clarke, R.T. 2003. The impact of urban development and human disturbance on the numbers of nightjar *Caprimulgus europaeus* on heathlands in Dorset, England. *Biol. Conserv*. **114**: 219–230.

Lindsay, R. & Immirzi, P. 1996. *An Inventory of Lowland Raised Bogs in Great Britain*. Scottish Natural Heritage Research Survey and Monitoring Report no. 78. Edinburgh: Scottish Natural Heritage.

Mallord, J.W. 2005. *Predicting the Consequences of Human Disturbance, Urbanisation and Fragmentation for a Woodlark* Lullula arborea *Population*. PhD thesis. Norwich: University of East Anglia.

Mallord, J.W., Dolman, P.M., Brown, A.F. & Sutherland, W.J. 2006. Linking recreational disturbance to population size in a ground-nesting passerine. *J. Appl. Ecol*. doi: 10.1111/j.1365-2664.2006.01242.x.

Mallord, J.W., Dolman, P.M., Brown, A.F. & Sutherland, W.J. 2007. Nest site characteristics of Woodlarks *Lullula arborea* breeding on heathlands in southern England – are there consequences for nest survival and productivity? *Bird Study* **54**: 307–314.

Marrs, R.H. 1993. An assessment of change in *Calluna* heathlands in Breckland, Eastern England, between 1983 and 1991. *Biol. Conserv*. **65**: 133–139.

Moore, N.W. 1962. The heaths of Dorset and their conservation. *J. Ecol*. **50**: 369–391.

Morris, A., Burges, D., Fuller, R.J., Evans, A.D. & Smith, K.W. 1994. The status and distribution of Nightjars *Caprimulgus europaeus* in Britain in 1992. A report to the British Trust for Ornithology. *Bird Study* **41**: 181–191.

Murison, G. 2002. *The Impact of Human Disturbance on the Breeding Success of Nightjar* Caprimulgus europaeus *on Heathlands in South Dorset, England*. English Nature Research Report no. 483. Peterborough: English Nature.

Payn, W.H. 1978. *The Birds of Suffolk*. Ipswich: Ancient House Press.

Ravenscroft, N.O.M. 1989. The status and habitat of the Nightjar *Caprimulgus europaeus* in coastal Suffolk. *Bird Study* **36**: 161–169.

Rose, R.J., Webb, N.R., Clarke, R.T. & Traynor, C.H. 2000. Changes in the heathlands in Dorset, England between 1987 and 1996. *Biol. Conserv*. **93**: 117–125.

Sanderson, F.J., Donald, P.F., Pain, D.J., Burfield, I.J. & van Bommel, F.P.J. 2006. Long term population declines in Afro-Palearctic migrant birds. *Biol. Conserv*. **131**: 93–105.

Schaefer, T. & Vogel, B. 2000. Why do woodlarks *Lullula arborea* need field-forest ecotones – an analysis of possible factors. *J. Ornithol*. **142**: 335–344.

Sharrock, J.T.R. 1976. *The Atlas of Breeding Birds in Britain and Ireland*. BTO/IWC. Calton, Staffs: Poyser.

Sitters, H.P. 1986. Woodlarks in Britain 1968–1983. *Br. Birds* **79**: 105–116.

Sitters, H.P., Fuller, R.J., Hoblyn, R.A., Wright, M.T., Cowie, N. & Bowden, C.G.R. 1996. The Woodlark *Lullula arborea* in Britain: population trends, distribution and habitat occupancy. *Bird Study* **43**: 172–187.

Spencer, J.W. & Kirby, K.J. 1992. An inventory of ancient woodland for England and Wales. *Biol. Conserv*. **62**: 77–93.

Symes, N.C. & Day, J. 2003. *A Practical Guide to the Restoration and Management of Lowland Heathland*. Sandy: The RSPB.

Thom, V.M. 1986. *Birds in Scotland*. Scottish Ornithologists' Club. Calton, Staffs: T.&A.D. Poyser.

Underhill-Day, J.C. & Liley, D. 2007. Visitor patterns on southern heaths: a review of visitor access patterns to heathlands in the UK and the relevance to Annex I bird species. *Ibis* **149** (Suppl. 1): 112–119.

Webb, N.R. 1990. Changes on the Heathlands of Dorset, England, between 1978 and 1987. *Biol. Conserv*. **51**: 273–286.

Wernham, C.V., Toms, M.P., Marchant, J.H., Clark, J.A., Siriwardena, G.M. & Baillie, S.R. (eds) 2002. *The Migration Atlas: Movements of the Birds of Britain and Ireland*. London: T.&A.D. Poyser.

Woodfield, E. & Langston, R. 2004. *A Study of the Effects on Breeding Nightjars of Disturbance Due to Human Access on Foot to Heathland*. RSPB Research Report no. 11. Sandy: The RSPB.

Wotton, S.R. & Gillings, S. 2000. The status of breeding Woodlarks *Lullula arborea* in Britain in 1997. *Bird Study* **47**: 212–224.

Wright, L.J. 2006. *Demography and Productivity of Woodlarks* Lullula arborea *in Breckland*. PhD thesis. Norwich: University of East Anglia.

Wright, L.J., Hoblyn, R.A., Sutherland, W.J. & Dolman, P.M. 2007. Reproductive success of Woodlarks *Lullula arborea* in traditional and recently colonised habitats. *Bird Study* **54**: 315–323.

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