The impacts on bird diversity of re-wilding an intensive farm – a focus on the nightingale *Luscinia megarhynchos*

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ABSTRACT

Nightingale populations are dramatically declining due to loss of woodland understorey habitat, through ineffective management and over-browsing by deer. Their recent habitat shift to scrubland and hedgerow raises the potential of focusing conservation effort for this bird on agricultural landscapes. Comparing an extensively grazed farm with intensive farms we found higher numbers of nightingale territories and paired nightingales on extensive land due to increased habitat provision. Hedgerow width was found to positively affect nightingale distribution with territories only found in vegetation of 8 metres or more in width. Within these territories, paired nightingales had a preference for blackthorn. Our results provide clear evidence for thriving farmland nightingale populations. We advise the reclassification of the nightingale to a farmland bird to enable conservation management effort on agricultural landscapes. Specialised hedgerow management schemes are suggested to broaden hedge widths to provide increased nightingale habitat.

INTRODUCTION

Agricultural land covers 70% of England (Tscharntke et al. 2005, Angus et al. 2009) and supports 50% of all European species (Guerrero et al. 2011). The habitat and biodiversity it provides are crucial to conservation. Intensification of agriculture has, however, been a primary factor in the loss of habitat and wildlife of agro-ecosystems (Fuller et al. 2005, Smith et al. 2010). In particular, agricultural intensification has caused dramatic declines in European bird populations many of whose numbers have nearly halved across Europe since 1980 (Vickery et al. 2001, Butler et al. 2010, Eschen et al. 2012). An example of this is the nightingale, *Luscinia megarhynchos,* an amber listed species in the UK (Eaton et al. 2009), which has declined by more than 90% since 1967 (BTO unpublished figures). These declines are thought to be due to the loss of habitat resulting from agricultural intensification (Hewson et al. 2005). By understanding the habitat features, or management techniques, which determine the distribution of breeding nightingales, more informed policy could be introduced to prevent further decline of this species.

Agriculture is not generally thought to be compatible with conservation. However, prior to agricultural intensification, traditional low-intensity farming greatly promoted habitat diversity (Tscharntke et al. 2005). Extensive agriculture differs from intensive methods in that it relies on lower fertilizer, labour and economic inputs per farmed acreage (Brambilla et al. 2007).

Decrease in fertilizer and pesticide use leads to increased plant and invertebrate diversity compared with non-organic and intensive farms (Bengtsson et al. 2005, Fuller et al. 2005, Smith et al. 2010). Inorganic chemicals can directly affect birds, causing increased mortality; and indirectly, by reducing food supplies (Newton 2004). In extensive pastoral systems sward diversity and architecture are increased compared to intensive agriculture through selective grazing and trampling, as well as dung deposition (Helden et al. 2010, Eschen et al. 2012). This also results in higher plant and invertebrate diversity (Brickle et al. 2000, Kruess and Tscharntke 2002, Eschen et al. 2012). In intensive pastoral systems non-organic anti-helminthics such as Avermectin excreted in livestock feces act as an insecticide, dramatically reducing the abundance of invertebrates in dung, a major food source for birds (Strong 1993).

In addition, un-cropped or marginal land provided by extensive agriculture acts as an important resource for birds (Fuller et al. 2005, Woodhouse et al. 2005, Wright et al. 2012). Removal of hedges to increase field size and farming efficiency has resulted in the loss of important semi-natural habitat on farmland. On most agricultural land these can be some of the only suitable breeding habitat (Fuller et al. 2001, Newton 2004).

Through these numerous factors, extensive farming techniques provide higher levels of habitat heterogeneity and complexity, which are crucial factors in determining bird species richness (Kruess and Tscharntke 2002, Batary et al. 2010, Smith et al. 2010, Eschen et al. 2012), for review see Benton et al. (2003). More than half of Europe's most highly valued biotopes occur on extensive farmland (Bignal and McCracken 1996), yet this practice is declining (Woodhouse et al. 2005, Eschen et al. 2012).

Nightingales are insectivorous birds that have very specific habitat requirements. The loss of their primary habitat in the form of understorey woodland is thought to have resulted in a contraction of their range towards the South East that is contrary to the shift expected due to climate change (Wilson et al. 2002a). A relationship has been demonstrated between increased deer abundance and a decrease in the population of woodland bird species; but the strongest is displayed in nightingales (Newson et al. 2012). They now rely increasingly on scrub-dominated habitat associated with secondary succession (Wilson et al. 2002a, Hewson et al. 2005, Wilson et al. 2005). They require both dense understorey scrub (against predation) and bare ground beneath the vegetation in which their invertebrate food sources are found (see fig.1)(Wilson et al. 2005).

Extensive grazing provides a complex balance between new growth and open habitat with an increase in scrub (Fuller et al. 2007). Lower grazing pressures and hedgerow management levels enable field boundaries to grow larger, providing predation cover, nesting habitat, and a good invertebrate food source for nightingales (Hinsley and Bellamy 2000, Marshall and Moonen 2002). Hinsley et al. (1999) found broader hedges to support higher levels of bird species richness and abundance. Numerous other studies have found height and volume to be more significant in determining abundance and richness (for review see Hinsley and Bellamy 2000).

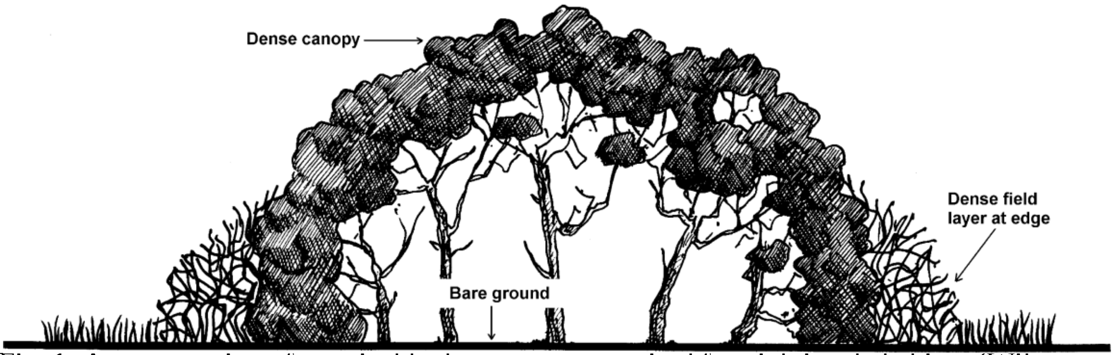

Fig. 1: A cross section of a typical hedge structure required for nightingale habitat. (Wilson et al. 2005)

Frans Vera's wood-pasture hypothesis states that during the post-glacial period grazing by large herbivores was essential for the maintenance of natural vegetation, consisting of mosaics of large and small grasslands, scrub, solitary trees and woodland (Vera 2000). Reduction in grazing pressure should provide higher habitat heterogeneity and create a more invertebrate-rich habitat as well as more complex breeding habitat for farmland birds (Wilson et al. 2005).

Agri-environment schemes (AES) are considered one of the most important measures in reversing biodiversity loss in agricultural areas (Kleijn et al. 2006, Batary et al. 2010). Uptake of AES is often highest in areas where biodiversity is still relatively high through Entry Level Stewardships which provide small scale management (Kleijn and Sutherland 2003). Many species, however, rely on large areas of un-fragmented habitat especially extensively managed land (Kleijn et al. 2006). Rather than focusing on small-scale entry level schemes, more emphasis must be put on reducing the intensity of agricultural methods on intensive farms, which make up the majority of agricultural land and is where most biodiversity loss occurs (Kleijn et al. 2006).

The Knepp Castle Estate, a privately owned farm in West Sussex, was awarded a Higher-Level Stewardship AES in 2001. The grant supports the creation of an extensive grazing system on land that used to be managed intensively for arable and dairy farming. Inspired by Frans Veras' project at Oostvaardersplassen (The Netherlands), near-naturalistic grazing is practiced. Land is divorced from agricultural use, natural processes are encouraged to maintain the diversity of the habitats and vegetation is free to vary naturally with variations in the physical environment (Carver 2007).

In obligation to the HLS scheme the site must be monitored for change, a baseline survey in 2005 found there to be 14 amber listed species and 8 red listed species on the estate (Greenaway 2006). During the late 1990's 2 nightingale territories were consistently heard at Knepp Estate for 3 years but disappeared before the start of the re-wilding scheme (Pers. Comm. Charlie Burrell). To understand how the management techniques differ from conventional intensive methods a comparative study between Knepp and intensive farms must be carried out. This is a unique opportunity to be able to study the overall ecosystem recovery from intensive farming and how this may affect biodiversity. This is the only project of its kind in England to be funded so far.

Using the Knepp Estate and two neighbouring intensive farms this study aims to determine the effects of near-naturalistic grazing on nightingale habitat provision. We predict extensive grazing systems to support significantly higher levels of nightingale habitat than surrounding arable farms, and therefore higher levels of paired nightingales than intensive farmland. It is predicted that nightingale territories will be significantly more abundant in outgrown hedgerows. With this information we will investigate the feasibility of the potential changes to policy relating to the increase in nightingale habitat.

METHODS

Study site

The Study site is located in West Sussex at Knepp Castle Estate (TQ 156 213), and surrounding areas. The Knepp Estate is grazed at low intensity by cattle, pigs and deer. The 3600 acres of the site is divided into three main sections in which differing grazing regimes exist (see fig 2). The south section (1200 acres) experiences the highest intensity grazing (see appendix 1.1 for livestock numbers) and consists of outgrown hedgerows, woods and scrubland. The middle and north sections are less heavily grazed parkland habitat. Two external sites were chosen for their proximity to the Knepp Estate and for their land use resembling that of Knepp Estate prior to the re-wilding project. Court Farm is a privately owned 600 acre mixed arable farm (TQ 122 233) whilst Loch Estate (TQ 162 193) is a 2000 acre commercially run arable farm. Both external sites are located within 4 miles of the Knepp Estate.

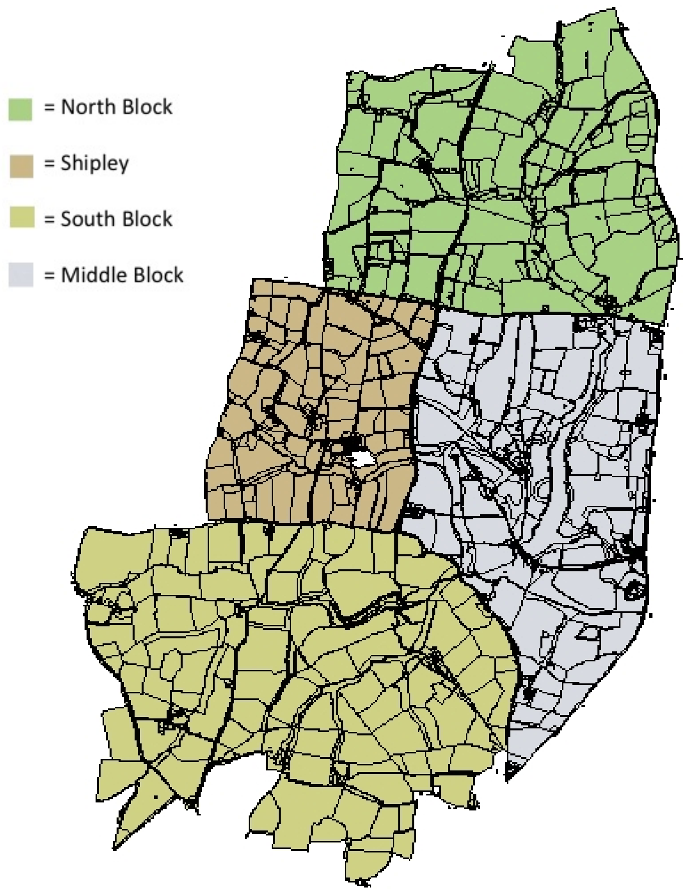

Figure 2. The Knepp estate; different colours show different management strategies in each block. The middle block was not surveyed due to it being the private family home and garden.

Nightingale territories

To survey for male nightingale territories the Knepp study area and intensively farmed sites were sub-divided and sub-sites numbered. Each site was visited twice according to a random number sequence between the 7th -20th May 2012 from dawn to 9am.

During visits, the site was systematically surveyed for male nightingale territories. All hedgerows were walked at a slow pace to listen for singing male nightingales. Where no obvious habitat existed at the field edge, the observer listened for song from a central location within each field. When nightingale song was heard, the singing bird was located and a GPS marking made and labeled. Nightingales are extremely territorial birds and territories are rarely closer than 50m; therefore individual territories could be confidently mapped without the potential for duplication (Holt et al. 2010).

To determine the main habitat features of nightingale territories a number of measures were taken at each territory. Territories were re-located using GPS and the width (measured from the edge of the woody vegetation) and height (average within 5m of the territory) of the hedgerow was estimated to the nearest metre. The distance of the leafy vegetation from the ground was recorded in feet (browse height). Percentage cover of Hawthorn *(Crataegus monogyna)*, Blackthorn *(Prunus spiniosa*) and Sallow *(Salix* species) was taken within a 5m range of the territory. This was also carried out at 100 random locations throughout the study site. These were allocated by generating random x and y coordinates of a 100m grid superimposed on the sites and the nearest point on a field margin taken.

ArcGIS (version 9.2; ESRI, 2009) was used to map all nightingale territories and vegetation sample points as well as field boundaries and water bodies. The near-distance feature was used to determine distance of each nightingale territory and random vegetation sample to the nearest water body as Merrit (1979) found many nightingale sites to be near water.

Paired nightingales

To determine which male nightingales had acquired mates, all territories found were visited at night. Territories were visited from 12 to 2.30 am from the 21st May to 4th June 2012. Territories were re-located with a GPS, and 10 minutes were spent at each location to listen for singing males. It was recorded whether or not each male was singing, paired nightingales have been found to cease nocturnal singing and to resume it if their mate deserts them (Amrhein et al. 2002). Males singing at night during this period therefore were presumed unpaired.

Questionnaire

A questionnaire (see appendix 1.1) was used to determine the opinions of famers and landowners with respect to nightingale conservation. There were a total of seven land-owner participants from local farms to act as a pilot study to gain an understanding of the potential success of implementing an agri-environment scheme for nightingale habitat provision.

Analysis

All statistical analyses were performed using R software (R Development Core Team, 2011). The effect of extensive and intensive farming techniques on paired numbers of nightingales was tested with a chi-squared test. Numbers of territories and paired birds on extensive and intensive land were totaled and compared using a contingency table.

To test the determinants of nightingale distribution, generalized linear models were generated with nightingale presence and paired status as the response variables in two separate models. All variables measured were included in the model, hedge height, width, percentage composition of hawthorn, blackthorn and sallow, browse height and distance to nearest water body. The nightingale presence model had a sample size of 140, whilst the paired nightingale model had a sample size of 45. Both models used a binomial error distribution (Crawley 2007).

Models were produced by fitting all the biologically relevant variables and simplifying by the stepwise removal of non-significant terms. Factors with the least significant *p*-value were removed until only significant terms remained. The new model was compared to the previous model at each step and tested for a significant difference in explained deviance using an ANOVA. Explained deviance for each term was calculated by removing the term from the model and subtracting the residual deviance from the model when the term was included from the residual deviance when the term was removed then dividing the difference by the null deviance.

RESULTS

Nightingale distribution

During the study a total of 43 nightingale territories were found 67% of which were paired, 34 territories on the Knepp Estate and a further 9 on neighbouring intensive farmland. On extensive land 79% were paired birds and 22% were paired on intensive land (Fig 4.1). Paired nightingales were found to be significantly more abundant on extensive farmland than intensive land (χ^2 = 8.87, d.f = 1, P = 0.002).

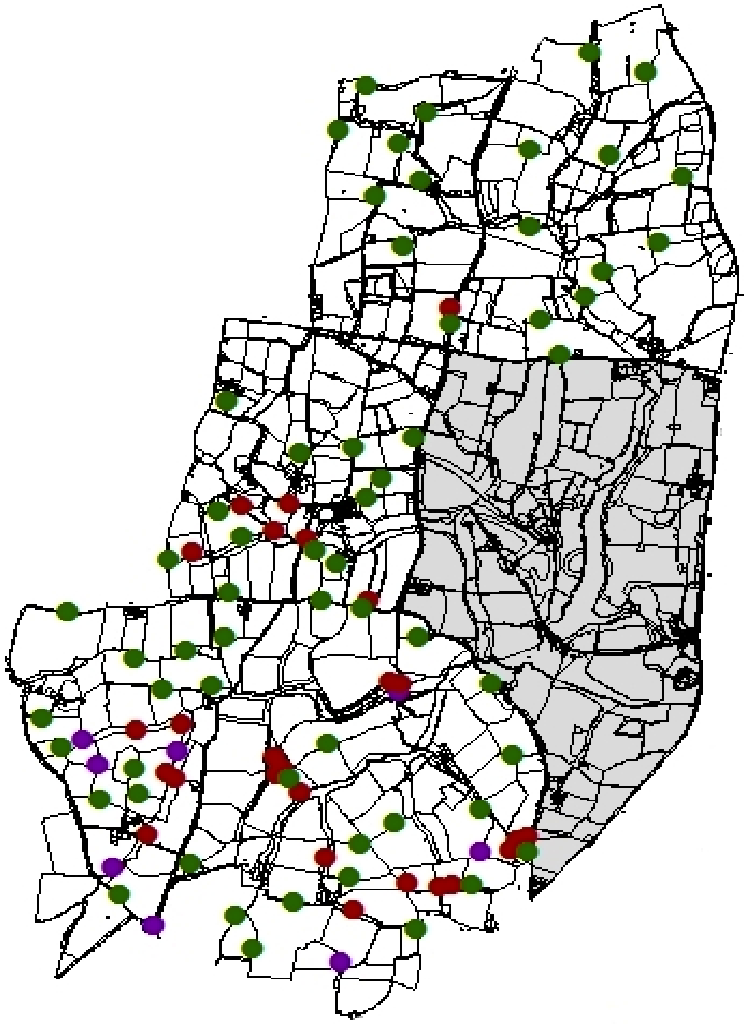

Figure 3. A Map of all vegetation sample points and nightingale territories found on the Knepp Estate. Green points represent the location of randomly selected vegetation samples. Red points represent territories in which nightingales were found paired. Purple points represent nightingale territories in which birds were un-paired.

All territories found in Shipley village and the north block of Knepp were paired. However this only comprised of 7 birds. The south block held the largest number of territories (see Figure 4.1), whilst territories were only found on one of the intensive farms. Nightingale territory distribution was positively related to field margin width, (width: $p<0.0001$, 6.46 ±1.6, % deviance explained = 56, n=140). No nightingales were found in margins of less than 8m in width (see fig 4.2). Nightingale distribution was also negatively affected by browse height (Browse height: P=0.01, -1.02 ±0.4, % deviance explained = 5, n=140). No other term was found to significantly affect nightingale distribution.

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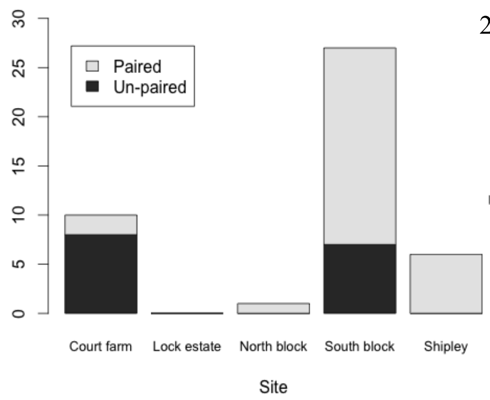

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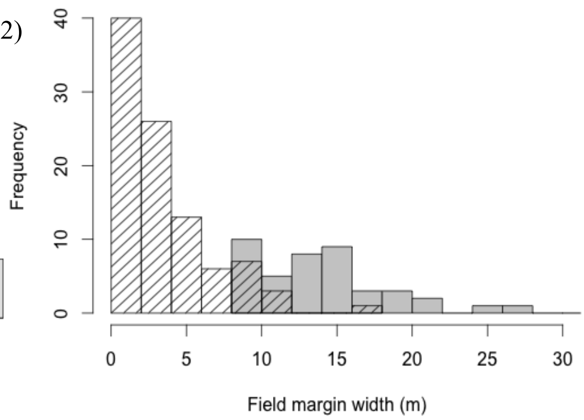

Figure 4. 1 Frequency of paired and un-paired nightingales present at each study site. Court Farm and Lock Estate are intensively farmed, whilst the remaining three are part of the Knepp Estate. **Figure 4.2 Field margin width of nightingale territories and randomly selected vegetation points.** Filled grey bars represent where nightingale territories were found whilst cross-hatched bars represent randomly selected vegetation points.

Paired nightingales

The distribution of paired nightingales was positively related to blackthorn percentage composition within their territories (see Fig 5) (Blackthorn: p<0.01, 0.04±0.01, % deviance explained = 19, n=45).

Site was also found to influence paired nightingale distribution, significantly more paired nightingales were found in the southern block than other sites (South: p<0.01, 3.19±1.2, % deviance explained = 34, n=45).

Table 1: Models testing the effect of habitat features on nightingale distribution (i) and the distribution of paired nightingales (ii).

Response	Coefficients	Estimate	Standard error	z value	P value	Explained Deviance
(i) Nightingale presence	(Intercept)	-13.80	3.81	-3.63	<0.001***	
	Width	6.47	1.67	3.89	<0.001***	56%
	Browse height	-1.03	0.42	-2.45	0.014*	5%
(ii) Nightingales paired	(Intercept)	-4.20	1.53	-2.74	<0.01**	
	Blackthorn	0.05	0.02	2.61	<0.01**	19%
	Site Lock	-18.71	6522.64	0.00	0.99	
	Site North	22.29	6522.64	0.00	0.99	
	Site South	3.20	1.20	2.66	<0.01**	34%
	Site Shipley	20.97	2313.97	0.01	0.99	

Non significant terms were deleted from the model as stated in the methods. Minimum adequate terms are included in the table. Maximal models are found in the appendix 1.4. Significance : ‘***’ ≤ 0.001; ‘**’ ≤ 0.01; ‘*’ ≤ 0.05; ‘.’ ≤ 0.1

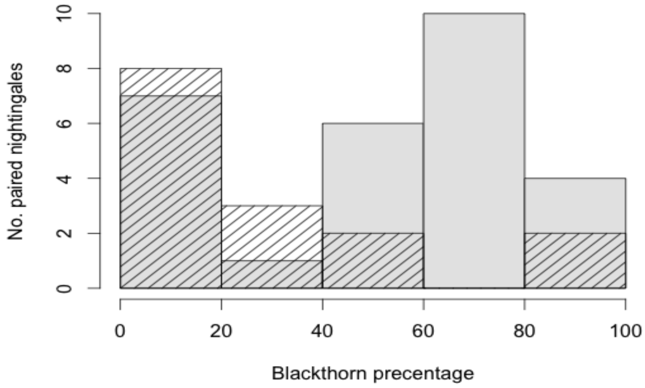

Figure 5. Percentage of Blackthorn in paired and un-paired nightingale territories. Hatched bars represent un-paired nightingales and solid bars are paired birds.

DISCUSSION

Using a comparison of intensive and extensive agricultural systems this study presents evidence for nightingale habitat provision on agricultural landscapes and shows the benefit of extensive grazing systems over intensive agriculture for the nightingale. By changing the land management from an intensive system to its current extensive management regime, Knepp has increased nightingale territories from 2 to 34 in 10 years (Greenaway 2006). By providing more suitable nightingale habitat the Knepp Estate supported significantly more paired nightingales than neighbouring intensive farms. Amrhein et al. (2002, 2007) found roughly half of all nightingales paired. However our study found 67% were paired and over 80% paired on the Knepp Estate, suggesting improved breeding habitat.

Hedgerow width had a large positive effect on nightingale distribution. Nightingale territories were only ever found in scrub or field margins of 8 metres or more in width. This implies a critical width is required for the establishment of the nightingale habitat requirements. This broad width is needed to enable the central portion of the hedge to establish maturity and provide a portion of open ground beneath the hedge canopy. Similarly hedge width has been found to be a strong predictor of bird abundance in many farmland bird species (for review see Hinsley and Bellamy 2000). Many passerines rely on large areas of hedgerow to breed, roost and forage (Hinsley and Bellamy 2000).

Nesting close to the ground requires dense habitat and protection from predation (Wilson et al. 2005, Holt et al. 2010), yet also needs open ground for invertebrate foraging (Cramp 1988). For this reason browse height was expected to negatively affect nightingale distribution, as deer browsing has been found to significantly affect nightingale distribution both experimentally and in observational studies (Fuller 2001, Fuller et al. 2007, Holt et al. 2010). We found nightingale territory distribution to be negatively affected by browse height, but this only accounted for 5% of the variation in their territory distribution. This paper therefore highlights a simple measure of primary importance for nightingale habitat requirement. Field margin width explains over 50% of the variation in nightingale distribution, which is an ideal result for use in the management of nightingale habitat provision.

Within appropriate nightingale territory habitat a larger proportion of blackthorn *Prunus spinosa* increased the likelihood of birds to be paired. Blackthorn is especially thorny and un-palatable to grazers, which aids in predation evasion. Croxton et al. (2004) also found that it sprouts larger number of root suckers than other hedgerow species causing it to increase the width and density of hedgerow faster than other species. This is advantageous for breeding habitat as hedges can more rapidly be transformed to have thick and broad understorey as needed by nightingales.

The majority of nightingale territories were found in scrub or hedgerow habitat (86%) rather than woodland. This reinforces the noticeable shift in nightingale habitat type from understorey woodland (Fuller et al. 2007). Whitebread (1996) showed there to be a 70% reduction in coppiced woodland from 1947-80 and a subsequent doubling in scrub area over the same time period. Unfortunately there is no recent regional data to show this trend continuing, yet in the 1999 BTO survey ‘impenetrable scrub’ was a common feature of nightingale territories in Sussex (Newham and Sennitt 2000).

The Knepp Estate south block had significantly more paired nightingales than other sites. This effect is likely due to an unmeasured variable specific to this block, which is improving breeding habitat, such as increased scrub cover. Aggressive and early arriving males tend to have greater pairing success; this suggests ‘better’ territories are more attractive to prospecting females (Kunc et al. 2006, Amrhein et al. 2007). The south block may provide this ‘better’ habitat to females or could draw higher quality males, which are more attractive to females. Prospecting females make investigative flights at night attracted by nocturnal male singing, often stopping at several male territories (Kunc et al. 2006, Roth et al. 2009). Areas with higher densities of singing males may therefore be a benefit to attracting females.

Implications for conservation management

Hedgerows are often considered sub-optimal habitat, yet in many cases field margins comprise the majority or the only semi-natural habitat available across agricultural land (Fuller et al. 2001, Marshall and Moonen 2002). Given the large percentage of Britain taken up by agricultural land and reduction in adequate understorey woodland management (Fuller et al. 2007) we propose to use the findings to implement hedgerow management schemes targeted at nightingale habitat provision and conservation. This is not an alternative to woodland management, but a complimentary measure to woodland coppicing and management techniques (Fuller et al. 2001).

Stakeholder responses showed the majority of participants are happy to leave field margins to grow to 8 metres or more and if such an option existed under ELS or HLS schemes they would subscribe to it. Several land-owners were able to identify less profitable areas of their land which would be suitable to leave to grow broader, such as field corners. This provides provisional participatory support for an agri-environment scheme based on our findings. Hedgerow management schemes already exist in which field margins are cropped on rotation, which enables easier estimations of costing and implementation.

Exclusion fencing is the logical form of management against over browsing by deer in woodland (Newson et al. 2012); yet this is costly. Compensating for hedgerow management is a cheaper option (see appendix 1.3 for calculations). We therefore propose a hedge management scheme where eligible farms within the geographical range of the nightingale are provided compensation for field margins grown out to 8m in width or more. This can be achieved through a combination of cutting on rotation and coppicing to restore width. To maintain the thick base care must be taken to prevent ploughing too close to the field margins (RSPB, 2008).

Broadening of hedgerows would not exclusively benefit the nightingale. Several red-listed species, such as the willow tit, marsh tit and woodcock, primarily regarded as woodland birds are also associated with scrub layer and understory vegetation, therefore they may benefit from similar management techniques as the nightingale. Equally the red backed shrike also depends very much on extensively farmed environments (Brambilla et al. 2007, Fuller et al. 2007).

Simple changes in agricultural policy have been shown to reverse population declines in species such as the corncrake (*Crex crex*) and the stone curlew (*Burhinus oedicnemus)* (O'Brien et al. 2006, Wilson et al. 2009). With the rapid decline in nightingale numbers, effective management is urgently required to compensate for this loss. The speed of recovery of the Knepp Estate population provides strong evidence for the use of farmland management as a conservation strategy for the nightingale. Positive support from land-owners for such schemes encourages the implementation of hedgerow management aimed at nightingale conservation.

Further work

Grazing is essential to the maintenance of the Knepp Estate habitat. Without it the associated habitat is hard to maintain (Croxton et al. 2004). Further work is needed to understand how to create and maintain nightingale habitat without extensive grazing management, determining what coppicing rotation or management of field margins needs to be implemented. This is important for mitigation purposes such as in the case of the development site (Lodge Hill, Kent) in which 5000 houses threaten the only other region in England where nightingale numbers are known to be increasing (Pers. Comm. Richard Saunders, Natural England).

Whilst the cost of leaving hedgerows to grow out is low, stakeholders raised the issue that maintaining hedges over 5m in width can be costly (Pers. Comm. C. Burrell). Once hedges are left to mature, tree growth can cause nuisance, as there is reduced flexibility in removing trees from farmland (protection by DEFRA). Another problem raised in the questionnaires by landowners is that increased hedgerow width can increase rabbit numbers. At Knepp this is not a problem as it doesn't threaten profits but in most agricultural systems this reduces crop value (Dendy et al. 2004).

Given the relatively small and specific historic range of the nightingale (Wilson et al. 2002b) management can be targeted in very specific areas. This is often more successful than AES targeting species with larger geographical ranges (Whittingham et al. 2007). However, it is important to understand the limitations of this geographically small-scale study for broad scale nightingale conservation. Predictors from one geographical region can often have different affects in other areas (Whittingham et al. 2007). Further studies need to be carried out over a wider geographical area to gain an understanding of how nightingale habitat preferences change with region and how this limits their distribution.

This is also true of management strategies: land-owners have highlighted the different incentives of agri-environment scheme uptake in different regions. In West Sussex, where soil is relatively infertile, the financial incentive of broadening hedgerows is much greater than in Norfolk, where soil is much more fertile, and income lost to foregone farming is much greater (Pers. Comm. J. Feinnes).

To gain a more thorough understanding of how extensive farming techniques and habitat determine nightingale success, a measure of reproductive success must be taken. Mist netting and colour ringing could be used to determine breeding status and fledgling success should be calculated to determine reproductive success of the birds. More detailed hedgerow habitat measures during the winter, when breeding birds are absent, is important to determine the particular structure of broad hedges favoured by nightingales. Invertebrate sampling during the breeding season could be used to determine how habitat is limiting nightingales through food provision.

Currently categorised as a woodland species, the RSPB states that the existence of so few nightingales on agricultural landscapes mean that it can no longer categorized as a farmland bird (Pers. Comms. Tony Morris, RSPB). Before any agricultural policy can be implemented the nightingale must first be recognised as a farmland bird. This paper provides strong evidence for their inclusion as a farmland bird to enable agricultural policy to direct its conservation effort.

Conclusion

Few studies have considered extensive agricultural systems as management to increase habitat provision for bird species (Eschen et al. 2012). This study however shows the significant positive effects of extensive agricultural methods on nightingale numbers through increased habitat provision. Due to the multiple detrimental factors to biodiversity involved in agricultural intensification the general extensification of agricultural methods, such as at Knepp Estate, benefits nightingales through increased habitat provision. Specifically providing broader hedgerows, which support higher numbers of paired nightingales. This study demonstrates the importance of semi-open extensive grazing systems to a priority bird species and the role this can play in the nightingale's conservation effort.

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Appendix

1.1 Questionnaire

The questionnaire was answered by landowners and farmers. Three participants were interviewed in person whilst the other four were interviewed on the telephone.

1. Could you name the 3 most abundant birds on your land?

2. Have you noticed any birds increase?

3. Have you noticed any birds decrease?

4. Are birds on you land a:

   i) Nuisance
   ii) A sign of good health
   iii) A welcome addition
   iv) I don't notice them

5. Have you ever seen/heard a nightingale?

6. Would you recognise its call if you heard one?

7. Have you ever seen/heard one on your land?

8. Do you know if their population is

   i) Stable
   ii) Declining
   iii) Increasing
   iv) Don't know

9. Sex:
   i) Male
   ii) Female

10. Age:
    i) 25-35
    ii) 35-55
    iii) 55-85

11. Would you classify yourself as a:
    Commercial farmer
    Land-owner

12. How many acres do you farm?
    i) 50-100
    ii) 100-500
    iii) 500-2000
    iv) 2000+

13. Have you farmed the land for:
    i) Under 5 years
    ii) 5-10 years
    iii) Over 10 years

14. Would you describe your farm as:
    i) Mixed-farming
    ii) Grassland
    iii) Arable

15. Could you name your main stock/crops:

16. Do you subscribe to any agri-environment schemes?
    Yes No

17. If yes are these entry-level stewardship or higher-level stewardship?
    i) ELS
    ii) HLS
    iii) CSS

18. Do these include hedge management and 6m or 20m margins?

19. If not why?
    i) Not interested
    ii) Not applicable to my land
    iii) Other

20. How wide on average are the majority of your hedges currently?

21. Given nightingale habitat needs would you ever consider letting your field corners grow out?

22. Would you consider letting your hedges grow out to:
    i) 8m
    ii) 8-10m
    iii) 10-15m
    iv) None of the above

23. If not why?

24. If yes what support would you require?

25. Do you consider agriculture to have a commitment to conservation?

26. Do you think the two are compatible?

27. Given our results what do you think general opinions would be on trying to implement changes for conservation benefit of the nightingale on farmland would be?

1.2 Knepp Estate management.

Management in each section of the estate is slightly different to create varied habitat types.

North block
This area used to be arable farmland.
When re-wilding commenced the area was reseeded and is now grazed by 80 longhorn cattle and Wild Roe deer

South block
This area was originally arable and dairy farmland, the land was left to re-seed naturally after farming and not re-seeded. It is grazed by 140 longhorn cattle; 16 Exmoor ponies; 20 Tamworth pigs; 100 fallow deer and wild roe deer.

Shipley
Shipley village is included in the same management as the south block, but due to housing is under lower levels of grazing.

Middle block
This section of the estate consists of gardens and polo grounds therefore was not used in the study.

1.3 Management costs

The costs for deer fencing versus hedge management based on Entry Level Stewardship scheme costings through Natural England as well as estimates of landowners:

Hedge management		**Deer management**	
Compensation	**Reason**	**Compensation**	**Reason**
£400 /ha	Farming land lost	£7 /m	Fencing
		£430	Access gate
		£350	High seat
Total / ha	£400	£3,580	

1.4 Generalized linear models.

Maximal models for investigating the factors affecting nightingale presence and the distribution of paired nightingales.

Response	Coefficients:	Estimate	Standard Error	t value	Pr(>|t|)
Nightingale presence	(Intercept)	0.16	5.45	0.03	0.98
	Height	-3.83	1.50	-2.55	0.0121*
	Width	0.33	2.98	0.11	0.91
	Browse	-1.17	2.14	-0.55	0.59
	Bthorn	-0.02	0.01	-1.70	0.09
	Hthorn	-0.05	0.02	-2.49	0.014*
	Sallow	-0.13	0.05	-2.59	0.0107*
	siteL	-23.76	1498.43	-0.02	0.99
	siteNor	-4.21	4.29	-0.98	0.33
	siteS	-1.24	1.66	-0.75	0.46
	siteSh	-0.06	1.79	-0.03	0.97
	Height:Width	1.90	0.76	2.51	0.0134*
	Height:Browse	0.93	0.45	2.05	0.0425*
	Width:Browse	0.81	1.45	0.55	0.58

Response	Coefficients:	Estimate	Standard Error	t value	Pr(>|t|)
Paired nightingale	(Intercept)	29.55	72.00	0.41	0.68
	Height	-4.52	8.38	-0.54	0.59
	Width	-9.40	27.56	-0.34	0.74
	Browse	-28.67	56.65	-0.51	0.62
	siteNor	21.47	12120.00	0.00	1.00
	siteS	6.00	2.85	2.10	0.04*
	siteSh	28.00	3618.00	0.01	0.99
	Bthorn	0.04	0.04	1.00	0.33
	Hthorn	-0.08	0.07	-1.16	0.26
	Sallow	0.03	0.09	0.31	0.76
	Height:Width	1.28	3.19	0.40	0.69
	Height:Browse	1.16	7.26	0.16	0.87
	Width:Browse	12.20	21.10	0.58	0.57

Significance : '***' ≤ 0.001; '**' ≤ 0.01; '*' ≤ 0.05; '.' ≤ 0.1

1.5 Questionnaire results

Question	C. Passmore	J. Feinnes	J. Goring	R. Goring	J. Ford	D. Liverton	G. Rasch
	Participant						
1.a	Grey Partridge	Woodpigeon	Sparrow	Wood pigeon	Pigeon	Rook	Pigeon
1.b	Corn bunting	Blackbird	Pigeon	Carrion crow	Rooks	Blackbird	Jackdaw
1.c	Little egret	Chaffinch	Rook	Buzzard	Gulls	Yellowhammer	Bustards
2	no	Chaffinch	Buzzard	Buzzard	Rook	Sparrow	Jackdaw
3	Turtle dove	Tree sparrow	Turtle dove	Lapwing/Corn bunting	Buzzard	Cuckcoo	Small passarines
4	welcome addition	good health	welcome addition	welcome addition	nuicance/good health	welcome addition	good health
5	y	y	y	y	y	y	n
6	y	y	y	y	y	y	n
7	n	y	y	y	y	y	n
8	don't know	increasing	stable	declining	don't know	declining	don't know
9	M	M	M	M	M	M	M
10	55-85	55-85	55-85	55-85	35-55	55-85	35-55
11	Land-owner	Land-owner	Commercial farmer	Land-owner	Commercial farmer	Commercial farmer	Commercial farmer
12	500-2000	>2000	500-2000	>2000	100-500	100-500	500-2000
13	>10	>10	>10	>10	>10	>10	>10
14	mixed	mixed	mixed	arable	mixed	mixed	arable
15	cereals	winter wheat	wheat		beef+arable	grassland	corn
16	y	y	y	y	y	y	y
17	ELS + HLS	HLS	ELS + CSS	ELS + HLS	CSS+ELS+HLS	ELS + HLS	ELS
18	-	-	-	-	-	-	-
19	N/A no hedges	4m	2m	3m	3m	2m	10m
20	y	n	y	y	y	y	y
21	8m	8m	8-10m	8m	no	8-10m	8-10m
22	-	Reduces value of the land	-	-	-	-	-
23	Financial- same as corner management	Compensation	Financial- same as corner management	Would be part of ELS scheme	-	Financial- same as corner management	Would be part of ELS scheme
24	y	y	y	y	y	y	y