National Quail Symposium Proceedings

Volume 6 Article 5

2009

The GWCT Partridge Count Scheme: A Volunteer-Based Monitoring and Conservation Promotion Scheme

Julie Ewald
The Game & Wildlife Conservation Trust

Nevile Kingon
The Game & Wildlife Conservation Trust

Hugues Santin-Janin
The Game & Wildlife Conservation Trust

The GWCT Partridge Count Scheme: a Volunteer-Based Monitoring and Conservation Promotion Scheme

Julie Ewald[1], **Nevile Kingdon, Hugues Santin-Janin**

The Game & Wildlife Conservation Trust, Fordingbridge SP6 1EF, UK

The Game & Wildlife Conservation Trust's (GWCT) Partridge Count Scheme (PCS) is a volunteer-based monitoring system serving as a means for delivering conservation and 'best practice' advice to participants (farmers, land managers and gamekeepers). Originally designed to monitor numbers of grey partridge (*Perdix perdix*) on UK shooting estates, it has been expanded to include participants primarily interested in conservation in response to the UK government's Grey Partridge Species Action Plan. The PCS is also an invaluable tool for examining trends in partridge abundance and population parameters. We examined trends in annual Grey Partridge production (autumn counts available from 1933) and breeding abundance (spring counts available from 1952). We compared trends of production and breeding abundance from old participants to trends from recently joined participants and interpreted the results relative to the Grey Partridge Species Action Plan. We also discuss the provision of data back to PCS participants and future plans for conservation advice and collaboration with other organizations, in particular the UK government's Department for the Environment, Farming and Rural Affairs.

Citation: Ewald J, Kingdon N, Santin-Janin H. 2009. The GWCT partridge count scheme: a volunteer-based monitoring and conservation promotion scheme. Pages 27 - 37 in Cederbaum SB, Faircloth BC, Terhune TM, Thompson JJ, Carroll JP, eds. Gamebird 2006: Quail VI and Perdix XII. 31 May - 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, GA, USA.

Key words: gray partridge, Partridge Count Scheme, *Perdix perdix*, UK

Introduction

The Game & Wildlife Conservation Trust's Partridge Count Scheme (PCS) collates information on the annual abundance and breeding success of grey partridges based on counts of pairs in spring and counts of young and old birds in the autumn by volunteer contributors to the scheme. From 1933 to 1998, the scheme mainly involved around 100 shooting estates in eastern and southern England (Potts 1980, Potts and Aebischer 1995). It had evolved from work carried out across a number of grey partridge shooting estates in the 1930s by staff at the Bureau of Animal Population at Oxford University (Middleton 1934, 1935*a*). Data was not only collected on abundance and breeding success - measured from bird counts - but on many of the estates the fate of individual nests was monitored (Middleton 1935*a*). As pheasants (*Phasianus colchicus*) have replaced grey partridge as the main quarry species in lowland Britain (Tapper 1992), nest finding as a gamekeeper activity is now a rarity. Calculations of grey partridge population parameters are now used to give a measure of nesting success (Potts 1986, Potts and Aebischer 1995), based on work begun using information from the early PCS (Middleton 1935*b*) and other sources (Blank and Ash 1958, Blank et al. 1967).

From early on information gained through the PCS was used to draw conclusions on grey partridge numbers across the UK's shooting estates (Middleton 1934, 1935*b*, 1937). Using this data, publications of the time highlight the same concerns expressed more recently when discussing declines in grey partridge numbers (loss of gamekeepering - Middleton 1947, Potts 1980), (the effects of intensive farming - Middleton and Ash 1964, Potts 1980, Potts and Aebischer 1995).

Recent expansion of the PCS arose in response to a renewed interest in addressing the continued decline of grey partridge numbers in the UK (Marchant et al. 1990). With being named 'lead partner' for the Grey Partridge Biodiversity Action Plan (Anony-

[1]**Correspondence**: jewald@gwct.org.uk

mous 1995) the Game & Wildlife Conservation Trust (GWCT) launched the Partridge Recovery Program, with three main strands: raising awareness, setting targets and motivating by example (Aebischer 2009). As part of this, The GWCT made the decision in 1998 to expand the membership of The PCS. The expanded PCS would provide practical support and advice to farmers and landowners, who would need to undertake the management necessary to meet the targets and also give some means of monitoring progress towards the BAP targets on land within the scheme. We report the results of that expansion, recent trends in count data and illustrate how we are utilizing the PCS as one of the strands in the Partridge Recovery Program.

Study Area

The Partridge Count Scheme (PCS) membership is comprised of farmers, landowners and shooting syndicate members throughout Great Britain, with the intention of undertaking partridge counts on land under their management. Prior to 1999, most members had an interest in the shooting of grey partridges, either actively or in the recent past. In 1998 the PCS was expanded to Great Britain as a whole and currently (spring 2006) there are 1889 registered participants within the scheme.

Methods

Target Setting

Maps showing the extent of the area to be counted are requested when a contributor registers with the PCS; these are digitized into a GIS (Mapinfo Version 8) and are used to provide an individualized BAP targets for each count area. Targets are calculated using the method outlined in Tapper (1999), revised by Aebischer (2009). Calculating targets based on landscape characteristics allowed us to set both local (farm) and county-level targets so that farmers and local government can assess progress in their area towards the UK-wide goal of 150,000 pairs in 2010.

Data Collection Protocol

The Partridge Count Scheme (PCS) database contains information from autumn stubble counts of grey partridge and red-legged partridges from 1933 to 2005 and from 1951 to 2006 for spring pair counts. All counts are carried out by volunteers - usually the gamekeepers, farmers, managers or owners of the shoots, farms and estates who are registered with the PCS. All counters are encouraged to follow a standard method of counting as per Potts (1986) with a recommendation that counts are not undertaken in winds stronger than Beaufort Force 3 (Gentle Breeze - Leaves and small twigs in constant motion; wind extends light flag). Spring counts take place in March/April and the number of both pairs and single birds are noted. Autumn counts are undertaken post-harvest from late August through October, with the number of males, females and young in each covey recorded. The longitude and latitude of the centre of each counted area was also recorded (in British National Grid projection). Information from the counts is returned to The Game & Wildlife Conservation Trust's PCS coordinator and then entered into a Microsoft 2003 Access database.

Information on seven different types of habitat management undertaken on the contributing estates has been collated for areas where counts were undertaken in both spring and autumn of 2005 - the first year where this data is available. This includes whether or not an estate had any of the following: conservation headlands, beetle banks, uncut grass margins, additional food provided, typically grain, in either autumn or spring, game cover crops, planted as either brood-rearing or over-winter cover. We also recorded information on whether or not grey partridges had been released for either conservation or shooting. Additionally, the density of gamekeepers (per km^2) was calculated, as was the shooting pressure (proportion of the grey partridges available in autumn that were shot).

Statistical Analyses

We compared the farm/estate target and the number of spring pairs counted in 2005. For those

estates who had a target of zero - no suitable habitat for grey partridges - we only considered that they had reached their target if they had counted at least one pair of partridges in the spring of 2005, otherwise they were discounted from the analysis.

Chi-square analysis was used to compare the number of new and long-term contributors that released partridges, had implemented the seven surveyed habitat managements, and the proportion of each that had successfully met their BAP targets. A t-test of the ln-transformed area counted (transformed to stabilize the variance) and the proportion of the autumn stock shot (transformed to angles) was used to compare the size of the counted areas and the relative effect of shooting on the two types of contributors.

A generalized linear model with Poisson error logarithmic link function and ln(area counted) as offset to the number of gamekeepers was used to compare the density of gamekeepers and of the number of birds shot over the area counted between long-term and new contributors. As count data are not normally distributed, we used a generalized linear model with Poisson error logarithmic link function and ln(area counted) as offset of the number of spring pairs recorded in the spring of 2005 to determine which of the seven surveyed types of habitat management as well as shooting pressure, had a significant effect on abundance (Aitkin et al. 1992, Dobson 2002, Seavy et al. 2005). We controlled for whether or not a site was a long-term or new contributor, had released partridges, geographical location (entered as the interaction of easting and northing) and gamekeeper density. Forward stepwise selection (at $P < 0.05$) was used to select the most parsimonious model. A similar approach, using a generalized linear model with binomial error was used to determine which, if any, of the seven surveyed managements influenced whether or not a site met its BAP targets in 2005, again controlling for type of contributor, geographical location and gamekeeper density. The generalized linear modeling was carried out in Genstat version 8.2 (Lawes Agricultural Trust), with Systat version 10 (SPSS Inc.) used for t-tests and chi-square analysis.

Analysis of Trends in Abundance and Production

Annual indices of abundance were calculated by fitting a generalized linear model with Poisson error logarithmic link function and ln(area counted) as offset to the number of spring pairs recorded from 1951 to 2006, using site and year as factors, including only those sites that had returned counts for more than one year. Separate models were fitted to long-term and new contributors and these were compared for those years (from 1999) where data was available for both, using likelihood ratio tests, adjusted for over dispersion. The average young-to-old ratios indices were calculated as annual weighted means using the number of old birds as weights and analyzed by weighted analysis of variance. Previously (Potts 1980, Potts and Aebischer 1995) annual chick survival rates derived from autumn counts has been used to measure annual production, but the steady decline in the number of broods due to declining numbers necessitated a switch to young-to-old ratio as a measure of production.

From 1999 onwards, trends in the calculated annual indices for abundance and young-to-old ratios were examined for long-term and new contributors separately, using linear regression, weighted by the number of counts in each. For long-term contributors, a linear trend was compared to a quadratic trend for densities from 1995 (the beginning of the BAP). All generalized linear modeling and analysis of variance was carried out in Genstat version 8.2 (Lawes Agricultural Trust), with Systat version 10 (SPSS Inc.) used for the linear regression of annual indices.

Results

The expansion in the PCS membership is obvious when the number of returned counts in both spring and autumn is examined on a yearly basis (Figure 1). Although limited autumn counts were available before the 2nd World War, significant participation occurred from 1957 with spring counts in-

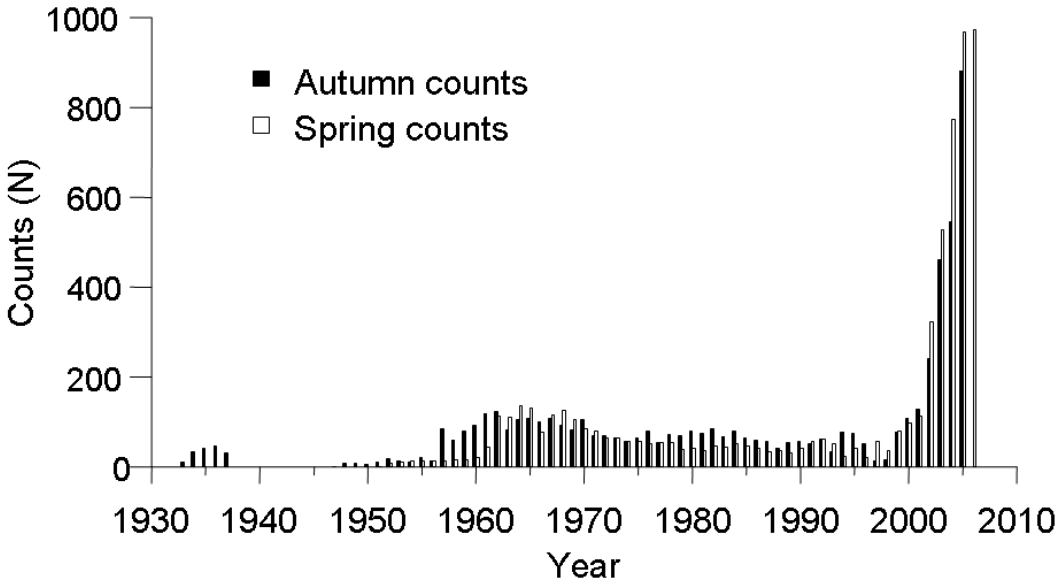

Figure 1: Increases in the number of both spring and autumn counts returned for members of the Partridge Count Scheme.

creasing in 1962. The number of submitted counts was relatively high in the 1960s, but only an average of 40 counts/year were returned in the mid-1990s. The success of the recent expansion of the scheme is evident, with a steady increase in counts returned from 2002 onwards. In 2005, the last completed year, 967 spring counts and 882 autumn counts were returned. The total area covered by the spring counts in 2005 was 3,165 km^2 on mainly cropped land in lowland Britain; this works out at roughly 5% of the UK arable area (total of 57,770 km^2 - Department for Environment, Food and Rural Affairs 2005*a*). A total of 9,752 grey partridge spring pairs were counted, comprising 15% of the 65,000 spring pairs that is the estimated UK population (Aebischer 2009).

Comparing Contributors

We compared the size and habitat and partridge management that was undertaken by long-term and new contributors who returned counts in both spring and autumn 2005 (Table 1). Sites that were long-term contributors were larger, had higher densities of gamekeepers, and their managers were more likely to undertake spring feeding and grey partridge releases for the purposes of conserving grey partridges and to established un-mown grass banks and conservation headlands. This may support the assumption that the long-term contributors had been undertaking at least some of the management needed for grey partridges, prior to the expansion of the scheme in 1999. Relative shooting pressure is similar on the two types of contributors, though the actual number shot on the areas managed by the long-term contributors is higher.

Management, Abundance and BAP Targets

We found no difference between long-term and new contributors in the proportion that reached or exceeded their individualized BAP targets (χ^2 = 2.87, P = 0.090), with 58% overall meeting or exceeding their individualized targets. In 2005, higher spring pair densities were found on areas where spring feeding ($F_{1,568}$ = 9.34, P = 0.002) and the planting of brood-rearing cover took place ($F_{1,568}$ = 11.41, $P < 0.001$) and lower densities were found on areas that planted over-winter cover ($F_{1,568}$ = 5.17, P = 0.023), after controlling for geographical location ($F_{1,568}$ = 49.81, $P < 0.001$), partridge releasing

Table 1: Characteristics of the counted areas from long-term and new PCS contributors, with comparisons in the management undertaken on the two different types of contributors where both spring and autumn counts were undertaken in 2005.

		Contributer Type		Statistics	
		Long-standing	New		
N		75 (10.8%)	620 (89.2%)	$P < 0.001$	$t_{691} = 8.12$
Area (km^2)		5.9	2.9	$P = 0.905$	$F_{1,504} = 0.01$
Autumn Stocks Shot		12.5%	13.5%	$P = 0.106$	$t_{493} = 1.62$
Number Shot/km^2		2.4	1.3	$P < 0.001$	$F_{1,504} = 14.35$
Gamekeeper/km^2		0.19	0.15	$P < 0.001$	$\chi^2 = 86.68$
Releasing	Conservation	25 (33.8%)	37 (6.0%)	$P < 0.001$	$\chi^2 = 86.68$
	Shooting	3 (4.1%)	23 (3.7%)	$P = 0.411$	$\chi^2 = 0.68$
Over-winter	Cover	40 (53.3%)	402 (64.8%)	$P = 0.141$	$\chi^2 = 2.16$
	Autumn Feeding	55 (73.3%)	434 (70.0%)	$P = 0.252$	$\chi^2 = 1.31$
Nesting Period	Spring Feeding	56 (74.7%)	385 (62.1%)	$P = 0.010$	$\chi^2 = 6.59$
	Uncut Grass Margins	56 (74.7%)	412 (66.5%)	$P = 0.042$	$\chi^2 = 4.13$
	Beetle Banks	28 (37.3%)	164 (26.5%)	$P = 0.101$	$\chi^2 = 2.68$
Chick Rearing	Brood-rearing Cover	27 (36.0%)	222 (35.8%)	$P = 0.514$	$\chi^2 = 0.43$
	Conservation Headlands	45 (60.0%)	294 (47.4%)	$P = 0.023$	$\chi^2 = 5.16$

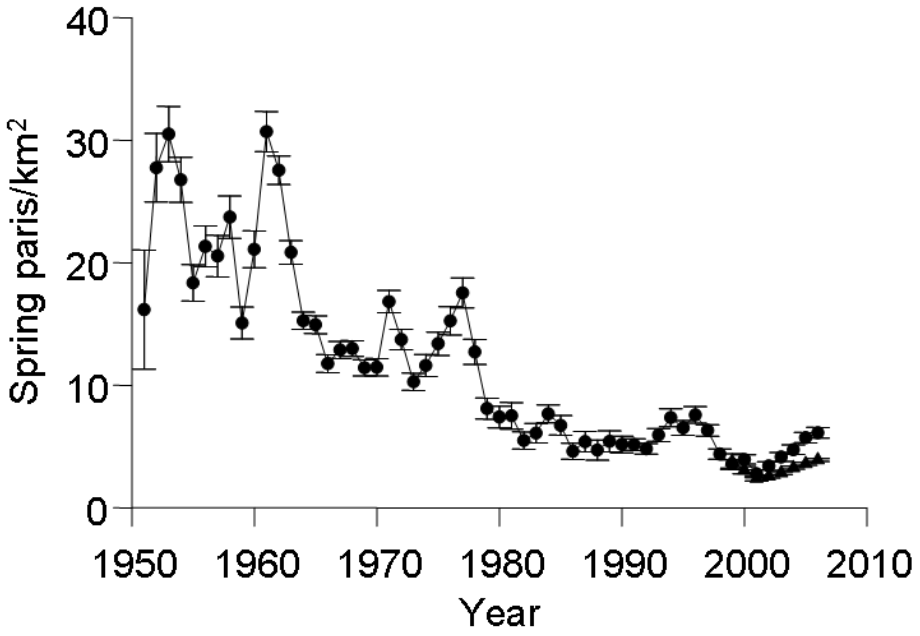

Figure 2: Trends in grey partridge abundance for long-term and new contributors to the PCS. The abundance reported by long-term contributors is higher than that of new contributors.

($F_{1,56}$ = 5.93, P = 0.003), gamekeeper density ($F_{1,568}$ = 0.01, P = 0.993) and whether or not an area was a long-term or new contributor to the PCS ($F_{1,571}$ = 51.31, $P < 0.001$). None of the seven surveyed habitat managements or shooting pressure were significantly associated with whether or not a contributor reached their BAP target, after controlling for geographical location ($F_{1,526}$ = 31.15, $P < 0.001$), releasing ($F_{1,526}$ = 1.51, P = 0.222), gamekeeper density ($F_{1,526}$ = 1.94, P = 0.164) and whether or not the area was a long-term or new contributor ($F_{1,526}$ = 2.51, P =0.113) to the PCS (Table 1).

Changes in Grey Partridge Abundance

The information on grey partridge numbers provided by the members of the PCS scheme is one means of monitoring grey partridge abundance. The annual changes in the abundance of grey partridge (counted spring pairs/km^2) from 1999 to 2006 were compared between old and new contributors (Figure 2). The pattern of change between the long-term and new contributors did not differ, ($F_{28,4491}$ = 0.63, P = 0.937), though long-term contributors had a higher abundance than the new contributors ($F_{1,2376}$ = 1631.71, $P < 0.001$). Annual indices were calculated for new and long-term contributors. New and long-term contributors showed differing trends in annual indices of abundance over the short time period (1999 to 2006) that data exists for both (comparison in trends - $F_{1,12}$ = 5.57, P = 0.036). Restricting the analysis to those years since increases in abundance began (2000 to 2006), showed no significant difference in the trends of long-term and new contributors ($F_{1,10}$ = 4.55, P = 0.059), with the abundance on long-term sites significantly higher than those on new sites ($F_{1,11}$ = 17.77, P = 0.001). The abundance reported by long-term contributors has increased by an average rate of 19% while that of the new contributors has increased by 8%. The annual abundance reported by long-term contributors since 1995 -beginning of BAP - did not fit a linear model ($F_{1,10}$ = 0.97, P = 0.347) but did fit a quadratic model, ($F_{2,9}$ = 18.38, P = 0.001), indicating that on these sites over this time period there has been a decrease and then

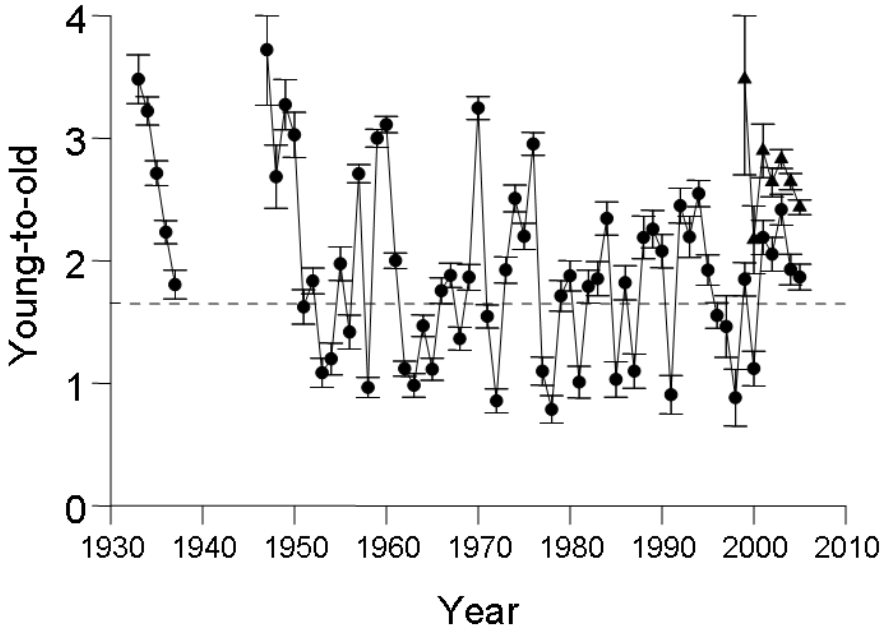

Figure 3: Trends in young-to-old ratio for long-term and new contributors to the PCS. The level needed (1.65 on average) to maintain grey partridge densities is shown as a broken line.

increase in abundance.

Trends in Grey Partridge Yearly Production

Grey partridge annual production, measured as young-to-old ratio, was compared between old and new contributors that had returned more than one count (Figure 3). The pattern of change did not differ significantly between new and long-term contributors ($F_{21,4502} = 0.43$, $P = 0.988$) with the new contributors having higher young-to-old ratios than the long-term contributors ($F_{1,1449} = 56.58$, $P < 0.001$). There were no trends in young-to-old ratio over the last six years for either type of contributor ($F_{1,11} = 0.01$, $P = 0.978$), though the annual indices for new contributors were higher than those of old contributors ($F_{1,11} = 16.19$, $P = 0.002$). From 2001, annual indices of young-to-old ratios for both types of contributors have been above the 1.65 level that is a prerequisite for stability in grey partridge numbers - dependent on levels of over-winter survival (Potts and Aebischer 1991).

Discussion

Expanding the PCS has increased the number of land managers who receive information about grey partridge research and advice on how to increase the number of grey partridges by 20 fold. This expansion contributes towards one of the key objectives set for Lead Partners of BAP species (raise awareness and promote management that will address declines in the BAP species of interest). This is an important consideration as changes will have to be made on farmland across the whole of the UK, not on a few scattered shooting estates to address the long-term widespread declines in grey partridge. Officials from England's Department for Environment, Food and Rural Affairs (DEFRA) are using some of the local partridge groups as "points of contact" to actively target farmers applying for agri-environment schemes, specifically Countryside Stewardship and the Higher Level Scheme within the new Environmental Stewardship (ES) options (Department for Environment, Food and Rural Affairs 2005*b*). Membership of the PCS is viewed in a

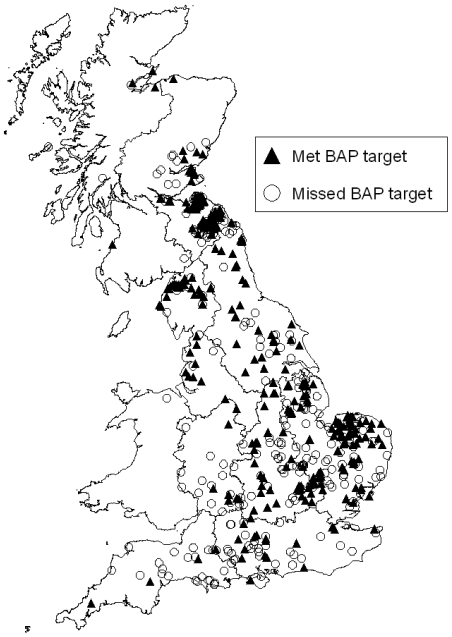

Figure 4: Distribution of counted areas in spring 2005, labeled as to whether or not they met their BAP targets.

positive light by DEFRA officials and members' applications for grants to cover management for grey partridges are given a higher priority. An example of this type of cooperation is found in Cumbria, a county in northwest England - where the local DEFRA official has encouraged the recipients of Countryside Stewardship grants to join the PCS. In 2005 (Figure 4) it is noticeable that a majority of PCS members in Cumbria met their BAP targets, something that was not necessarily the case in other western counties of England.

Had the members of the PCS met the initial target of halting the decline of grey partridges on their areas by 2005?

An examination of the trends in spring counts for both types of contributors from 2001 onwards indicate increases in abundance from that time (Figure 2). On the areas managed by PCS contributors, the decline has been halted and there are the beginnings of a recovery. How does this relate to Great Britain as a whole? A comparison of the percentage of Great the UK counted through the PCS in 2005 (5%) and the percentage of the expected current populations of grey partridges counted (15%) underlines the fact that the members of Partridge Count Scheme do not represent a random sample of farms and estates across the UK; they are a self-selected interested minority. As such they will have made more of an effort on halting the decline, so might be expected to be a best case scenario of what is happening across the UK as a whole. Comparisons with other national monitoring schemes may suggest that trends seen in the long-term contributors of the PCS are reflected in these other schemes, with some evidence of leveling off in grey partridge declines (Aebischer 2009, Raven and Noble 2006).

What do the results from the PCS monitoring suggest in regard to the second BAP target, that of reaching 150,000 pairs by 2010?

To answer this question we must extrapolate from the measured yearly increases in abundance from 2000 to 2006 on areas managed by PCS contrib-

utors. As new contributors differed in their rate of increase from the long-term contributors and also as they report undertaking less management, their rate of increase is a perhaps a maximum estimate of what is possible across the country as a whole. If the current national population of grey partridges is 65,000 pairs (Aebischer 2009), and the population grows at 10% a year (best case scenario from above), this results in over 90,000 pairs in 2010. The same rate of growth results in over 150,000 pairs in 2015. Clearly the answer to above question is no. Even if increases in the grey partridge national population were to begin in 2006, current evidence from the PCS suggests it is extremely unlikely that the 150,000 target will be met by 2010 and gives one estimate - 2015, admittedly a best case scenario, of when this target might be met.

What type of management is the most effective at meeting the BAP targets?

From our analysis of the management undertaken by PCS contributors, no single type of management stands out as being particularly related to whether or not an individual contributor's BAP target is met. It is hoped that the widespread availability of options under the new ES schemes, such as the use of Conservation Headlands (Sotherton et al. 1993), Beetle Banks (Thomas et al. 2001), the planting of brood-rearing cover under the Wild Bird Seed Option, could make management that will benefit grey partridge more commonplace throughout Britain. This supports previous modeling work that indicated that reaching the target of 150,000 pairs would require increasing both the amount of insect-rich habitat and nesting cover (Aebischer and Ewald 2004). This should be borne in mind by farmers undertaking management; it is important to select options that fulfill both requirements. Our results however, do not take into account the length of time these management options have been in place, as information on habitat management has only really begun for PCS contributors.

It is apparent that a high proportion of PCS contributors in the West Midlands and South Central England failed to meet their BAP targets (Figure 4), indicating that more effort needs to be applied in these areas. We have set up local partridge groups in these areas (Aebischer 2009) and it is hoped that advice on a local level may be effective in improving grey partridge densities here. Large parts of the very southwest of England, Wales as a whole and western and northern Scotland have few or no active PCS members. We need to recruit more PCS members in these areas at the fringes of the range of the grey partridge (Gibbons et al. 1993).

Management Implications

The main implication from this work is that even though the first UK BAP target for grey partridge has been met on areas managed by PCS members and may also have been met nationally (Aebischer 2009, Raven and Noble 2006), it is highly unlikely that the second target - 150,000 pairs in the UK by 2010 - will be. This will require sustained effort on the part of conservation bodies, farmers and agricultural policy makers. The expanded PCS contributes towards this and will continue to do so, demonstrating the utility of volunteer-based monitoring programs in the conservation of declining species.

Acknowledgments

We would like to thank all of the contributors to the Partridge Count Scheme over its long history, both for their count information and the work they do to conserve grey partridges. Staff at the Game & Wildlife Conservation Trust contribute to the smooth running of the PCS and provide support to the local partridge groups. In particular we would like to thank N.J. Aebischer, S. Browne, J. Daplyn, N. Deckker, L. Ferguson, N. Graham, I. Lindsay, M. McKendry, N. Sotherton, H. Straker, M. Swan, P. Thompson, and M. Tickler. N.J. Aebischer commented on a draft of this manuscript and offered statistical advice. G.R. Potts ensured the continuation of the PCS through the 1970s into the late 1990s and, together with E. Darling (of Green Globe Consultancy), was involved in the initial expansion of the PCS in the late 1990s.

References

Aebischer, N. J. 2009. The GCT grey partridge recovery programme: A species action plan in action. Pages 291–301 *in* S. B. Cederbaum, B. C. Faircloth, T. M. Terhune, J. J. Thompson, and J. P. Carroll, editors. Gamebird 2006: Quail VI and Perdix XII. 31 May - 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, GA, USA.

Aebischer, N. J., and J. A. Ewald. 2004. Managing the UK grey partridge (*Perdix perdix*) recovery: Population change, reproduction, habitat and shooting. Ibis 146:(Suppl 2) 181–191.

Aitkin, M., D. Anderson, B. Francis, and J. Hinde. 1992. Statistical modelling in GLIM. Oxford Statistical Science Series., Clarendon Press, Oxford, UK.

Anonymous. 1995. Biodiversity: The UK Steering Group report, volume 2: Action plans. Her Majesty's Stationary Office (HMSO), London, UK.

Blank, T. H., and J. S. Ash. 1958. Factors controlling brood size in the partridge (*Perdix perdix*) on an estate in south England. Pages 39–41 *in* Proceedings of the 3rd Congress of the International Union of Game Biologists. Aarhus, DK.

Blank, T. H., T. R. E. Southwood, and D. J. Cross. 1967. The ecology of the partridge I. Outline of the population process with particular reference to chick mortality and nest density. Journal of Animal Ecology 36:549–556.

Department for Environment, Food and Rural Affairs. 2005*a*. Agriculture in the United Kingdom 2005. The Stationery Office, Norwich, UK.

Department for Environment, Food and Rural Affairs. 2005*b*. Environmental stewardship. Rural Development Service, London, UK.

Dobson, A. 2002. Introduction to generalized linear models. 2nd edition. CRC Texts in Statistical Science Series., Chapman & Hall, London, UK.

Gibbons, D. W., J. B. Reid, and R. A. Chapman. 1993. The new atlas of breeding birds in Britain and Ireland: 1988-1991. T. & A. D. Poyser, London, UK.

Marchant, J. H., R. Hudson, S. P. Carter, and P. Whittington. 1990. Population trends in British breeding birds. British Trust for Ornithology, Tring, UK.

Middleton, A. D. 1934. The population of partridges (*Perdix perdix*) in 1933 and 1934 in Great Britain. Journal of Animal Ecology 4:137–145.

Middleton, A. D. 1935*a*. Factors controlling the population of the partridge (*Perdix perdix*) in Great Britain. Pages 795–815 *in* Proceedings of the Zoological Society of London.

Middleton, A. D. 1935*b*. The population of partridges (*Perdix perdix*) in Great Britain during 1935. Journal of Animal Ecology 4:252–261.

Middleton, A. D. 1937. The population of partridges (*Perdix perdix*) in Great Britain during 1936. Journal of Animal Ecology 6:318–321.

Middleton, A. D. 1947. Game conservation on croplands in Great Britain. Pages 190–195 *in* Proceedings of United Nations SCCUR Conference on Wildlife & Fish Resources, Game and Fur Conservation Section. United Nations, New York, USA.

Middleton, A. D., and J. S. Ash. 1964. The conservation of game as a natural resource. Pages 1–14 *in* 'The Countryside in 1970' Study Conference. Her Majesty's Stationary Office (HMSO), London, UK.

Potts, G. R. 1980. The effects of modern agriculture, nest predation and game management on the population ecology of partridges (*Perdix perdix* and *Alectoris rufa*). Advances in Ecological Research 11:2–79.

Potts, G. R. 1986. The partridge: Pesticides, predation and conservation. Collins, London, UK.

Potts, G. R., and N. J. Aebischer. 1991. Modelling the population dynamics of the grey partridge: Conservation and management. Pages 373–390 *in* C. M. Perrin, J.-D. Lebreton, and G. J. M. Hirons, editors. Bird population studies: Their relevance to conservation management. Oxford University Press, Oxford, UK.

Potts, G. R., and N. J. Aebischer. 1995. Populations dynamics of the grey partridge (*Perdix perdix*) 1793 – 1993: Monitoring, modeling and management. Ibis 137:29–37.

Raven, M. J., and D. G. Noble. 2006. The Breeding Bird Survey 2005. BTO Research Report 439, British Trust for Ornithology, Thetford, UK.

Seavy, N. E., Q. Suhel, J. D. Alexander, and C. J. Ralph. 2005. Generalized linear models and point count data: Statistical considerations for the design and analysis of monitoring studies. Pages 744–753 *in* C. Ralph and T. Rich, editors. Bird conservation implementation and integration in the Americas. USDA Forest Service General Technical Report PSW-GTR-191.

Sotherton, N. W., P. A. Robertson, and S. D. Dowell. 1993. Manipulating pesticide use to increase the production of wild game birds in Britain. Pages 92–101 *in* K. E. Church and T. V. Dailey, editors. Quail III: National Quail Symposium. Kansas Department of Wildlife and Parks, Pratt, KS, USA.

Tapper, S. C. 1992. Game heritage: An ecological review from shooting and gamekeeping records. Game Conservancy Ltd., Fordingbridge, UK.

Tapper, S. C. 1999. A question of balance: Game animals and their role in the British countryside. The Game Conservancy Trust, Fordingbridge, UK.

Thomas, S. R., D. Goulson, and J. M. Holland. 2001. Resource provision for farmland gamebirds: The value of beetle banks. Annals of Applied Biology 139:111–118.