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## The status of the UK breeding European Turtle Dove *Streptopelia turtur* population in 2021

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### ABSTRACT

**Capsule:** The first UK European Turtle Dove *Streptopelia turtur* survey, in 2021, estimated the breeding population at 2092 territories.

**Aims:** Changes in European Turtle Dove abundance in the UK have been monitored through schemes like the BTO/JNCC/RSPB Breeding Bird Survey, however, sample size is now too low to calculate robust trends going forward. The aims of this volunteer-based survey were to provide a new UK population estimate and create a baseline to monitor future population trends.

**Methods:** A stratified random sample of one-kilometre squares were surveyed within the core counties for the species. Elsewhere, one-kilometre squares containing recent European Turtle Dove records were targeted. The survey used a two-visit territory mapping approach, with observers asked to get within 200 metres of potentially suitable nesting or foraging habitat. Visits were undertaken in the early morning, to coincide with peak vocal activity, from 11 May to 31 July.

**Results:** The UK population estimate in 2021 was 2092 territories (95% confidence limits, 1559–2782). The species has become increasingly restricted to eastern and southeastern England, with 62.5% of the population estimated to occur in three counties: Kent (682 territories; 32.6%), Suffolk (326; 15.6%) and Essex (300; 14.3%). Additional hotspots occurred in other counties in eastern England, up to North Yorkshire.

**Conclusion:** This result suggests a 98% decline in abundance since the 1968–1972 breeding atlas, similar to trends identified from UK bird monitoring schemes, and a substantial contraction in range since the 2007–2011 bird atlas. The temporary cessation of hunting along their European western flyway provides a vital window of opportunity to scale up the delivery of high-quality breeding habitat and increase food availability in the UK. The survey should be repeated in 2026, and regularly thereafter, to help monitor the effectiveness of conservation interventions.

### ARTICLE HISTORY

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The European Turtle Dove *Streptopelia turtur* (hereafter Turtle Dove) is a summer migrant to their European breeding grounds (Cramps & Perrins 1994). Having undergone dramatic declines over recent decades, it is one of the United Kingdom's (UK) highest bird conservation priorities, and represents one of six globally threatened species to regularly breed in the UK (Stanbury *et al.* 2021).

In the UK, the Turtle Dove is classified as a farmland specialist (Gibbons *et al.* 1993). In the early nineteenth century, the population was concentrated in eastern and southeast England, but then went through a period of expansion north and westwards, likely in response to increases in arable cultivation (Brown &

Grice 2005, Holloway 1996). The UK Turtle Dove population probably peaked by 1970 (Brown & Grice 2005). During the 1968–1972 breeding atlas (Sharrock 1976) the UK population was estimated at 125,000 pairs, and their range extended into southwest England, eastern Wales, and northwards into Lancashire, northeast England and the Scottish Borders.

Since then, the population has undergone a population crash, declining in abundance by 99% (85% confidence limits (CL): –99%––98%) between 1967 and 2020 (Massimino *et al.* 2022). The UK population was estimated to be down to 75,000 territories during the 1988–1991 breeding bird atlas (Gibbons *et al.* 1993, Stone *et al.* 1997), 44,000

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territories in 2000 (Baker *et al.* 2006), 14,000 territories in 2009 (Musgrove *et al.* 2013), and 3600 territories in 2016 (Woodward *et al.* 2020). The population has continued to decline, with a 50% (95% CL: –68%––26%) decrease between 2016 and 2021 alone (Heywood *et al.* 2023). The decline in abundance has been accompanied by a severe contraction in breeding range (–51% between 1968–1972 and 2008–2011 breeding atlases), away from western and northern areas (Balmer *et al.* 2013).

The UK trend has been mirrored across much of their European range, with an estimated decline in abundance of –85% between 1980 and 2021 (PECBMS 2022), and a 2% range loss, particularly in the west and north, recorded between the two breeding atlases in the 1980s and 2013–2017 (Keller *et al.* 2020). As a consequence, the Turtle Dove is classified as Vulnerable to extinction at both a European (BirdLife International 2021) and global (IUCN 2022) scale.

Research has pointed towards two main drivers behind the declines in the UK population: poor breeding productivity and unsustainable levels of hunting on migration routes elsewhere in Europe (Fisher *et al.* 2018). Turtle Doves are obligate granivores and are associated with farmland in the UK. A change in diet from mainly the seeds of wild non-cultivated arable plants in the 1960s to mainly cultivated seed crops by the late 1990s has coincided with a shortened breeding period, and a reduction in the number of nesting attempts per pair per year, and hence young fledged (Browne & Aebischer 2004). The Turtle Dove is a widespread quarry species, and up to an estimated 1.1 million were shot in Western Europe annually before 2018; a level of hunting that is considered unsustainable (Lormée *et al.* 2020). All Turtle Doves that breed in the UK pass along the western flyway, through France, Spain and Portugal, on their autumn migration to spend the non-breeding season in sub-Saharan western Africa, and therefore are exposed to this hazard (Lormée *et al.* 2020; Fisher *et al.* 2018).

Conservation action is targeting both main drivers of Turtle Dove decline. The development and publication of the International Species Action Plan (Fisher *et al.* 2018), further research (Bacon *et al.* 2023, Lormée *et al.* 2020) and international collaboration led to a hunting moratorium along the western flyway in 2021, with a technical recommendation of this lasting to at least 2024 (Carboneras 2022a). On their breeding grounds local initiatives, such as Operation Turtle Dove (<https://www.operationturtledove.org/>), a partnership between the Royal Society for the

Protection of Birds (RSPB), Fair to Nature, Pensthorpe Conservation Trust and Natural England, are working with land managers to create and protect important Turtle Dove breeding habitats, through the provision of seed plots for foraging, supplementary feeding sites, freshwater sources and dense scrub for nesting.

Trends in Turtle Dove breeding abundance in the UK were monitored from the mid-1960s by the British Trust for Ornithology (BTO)/Joint Nature Conservation Committee (JNCC) Common Birds Census (CBC), however, since 1994, this has been superseded by the BTO/JNCC/RSPB Breeding Bird Survey (BBS). The BBS monitoring scheme uses a stratified random sample of one kilometre Ordnance Survey (OS) grid squares as its sampling unit and an average of at least 30 occupied squares are required to calculate a reliable trend in abundance (Heywood *et al.* 2023). Due to the rapid population decline in recent years, the sample size for the Turtle Dove now falls below this threshold; the species was recorded in just six and 11 squares in 2020 and 2021, respectively (D. Balmer pers. comm.).

The Rare Breeding Birds Panel (RBBP) collate breeding data on species with fewer than 2000 breeding pairs in the UK, and the Turtle Dove was added to their species list from the 2018 breeding season onwards. However, the current level of recording is considered to be too low to document trends in the population; for example, a maximum of 619 pairs were reported in 2020 (Eaton *et al.* 2022). Although recording through the RBBP may improve with time, a more comprehensive and robust survey was urgently needed to identify changes in abundance that might signify a continuation or slowing of the current population decline.

This paper reports on the results of the first UK Turtle Dove survey, carried out in 2021. The objectives of the survey were to obtain revised national and county level Turtle Dove population estimates, and for this to act as a baseline to monitor both future trends and the effectiveness of conservation action.

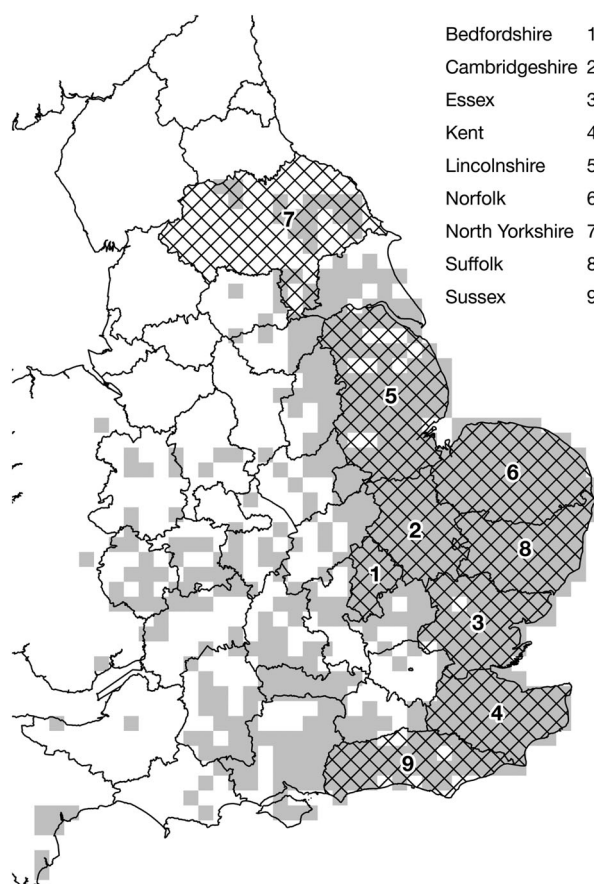
## Methods

### Sampling strategy

The survey strategy was based on units of  $1 \times 1 \text{ km}^2$  OS grid squares within ceremonial counties (hereafter referred to as counties) across the defined Turtle Dove breeding range in the UK. The sampling strategy differed between ‘core’ counties which were believed

to hold most of the population, and ‘edge’ counties, where the species is now scarce (Figure 1).

Within core counties (Table 1) the survey followed best practice guidelines (Voříšek *et al.* 2008) and used a stratified random sampling design. Stratum 1 used 1 km<sup>2</sup> OS grid squares with ‘recent’ breeding season (mid-May to mid-August) records of Turtle Dove, where ‘recent’ was defined as between 2015 and 2020 for all counties, except Lincolnshire which had collated data available for the period 2010 to 2020. Recent records were obtained from county bird recorders, BirdTrack (BTO/RSPB/BirdWatch Ireland/Scottish Ornithologists’ Club/Welsh Ornithological Society 2022), RBBP and local Turtle Dove projects. Stratum 2 used 1 km<sup>2</sup> OS grid squares within occupied tetrads (2 × 2 km<sup>2</sup>) from Bird Atlas 2007–2011 (Balmer *et al.* 2013), excluding those within Stratum 1. Stratum 3 used 1 km<sup>2</sup> OS grid squares in occupied 10 × 10 km<sup>2</sup> squares from Bird Atlas 2007–2011 (Balmer *et al.* 2013), excluding those within Stratum 1 and 2.



**Figure 1.** Location of UK Turtle Dove survey core counties (hatched and numbered). Grey shading shows the 2007–2011 range by 10 × 10 km<sup>2</sup> square (possible, probable and confirmed breeding; Balmer *et al.* 2013).

Within each stratum, squares were randomly selected by county, with the higher sampling intensity applied to stratum 1, followed by stratum 2 and then stratum 3, so that survey effort was distributed proportionately to the chances of occupancy, with the objective of improving survey precision (Table 1). The number of squares selected across the different county stratum levels did vary according to expert local advice. In most cases a minimum of 50 squares were selected. Based on declining records in recent years, only strata 1 and 2 were sampled in Bedfordshire and only stratum 1 in Lincolnshire and North Yorkshire.

Across the three strata, 40 randomly selected squares were assessed as having no suitable Turtle Dove breeding habitat, for example, squares that were entirely within urban areas or saltmarsh. These squares were removed from the survey list but were retained in the dataset and specified as holding zero Turtle Dove territories.

In addition to the three strata, extra non-random squares were surveyed within core counties. These were mostly part of existing Turtle Dove monitoring projects, for example, squares in Turtle Dove Friendly Zones, or were self-selected by surveyors.

Away from the core counties, the survey used a non-random approach and aimed to cover as many 1 km<sup>2</sup> squares with recent Turtle Dove records (2015–2020) as possible. Data sources and date thresholds were the same as stratum 1 above. Again, surveyors could self-select additional squares if they wished.

Much of the survey work was undertaken by volunteers. The proposed survey squares were shown on a dedicated online webhub, where interested volunteers could request squares to survey. These were then allocated to the surveyor. Three professional fieldworkers were employed to help increase coverage in three of the core counties: Suffolk, Essex and Kent.

### Survey methods

The survey used a two-visit territory mapping method, similar to the approach used for other equivalent single-species UK national surveys, e.g. European Nightjar *Caprimulgus europaeus* (Conway *et al.* 2007), Dartford Warbler *Sylvia undata* (Wotton *et al.* 2009), Woodlark *Lullula arborea* (Conway *et al.* 2009), Ring Ouzel *Turdus torquatus* (Wotton *et al.* 2016) and Cirl Bunting *Emberiza cirlus* (Jeffs *et al.* 2018). The first visit was between 11th May and 20th June and the second between 21st June and 31st July, with a minimum of four weeks between visits.

Calladine *et al.* (1999) showed that peak Turtle Dove activity occurs within the first two hours after sunrise,

**Table 1.** A summary of the stratified sampling strategy for the 2021 national survey within the core Turtle Dove counties.

	Stratum 1		Stratum 2		Stratum 3	
	N° of 1 km <sup>2</sup> squares in stratum	Random sample size	N° of 1 km <sup>2</sup> squares in stratum	Random sample size	N° of 1 km <sup>2</sup> squares in stratum	Random sample size
Bedfordshire	67	67	298	25	NA	
Cambridgeshire	129	50	1016	50	2258	50
Essex	99	50	844	50	2711	50
Kent	281	150	1436	75	2164	50
Lincolnshire	237	237	NA		NA	
Norfolk	247	100	1192	50	4008	50
North Yorkshire	187	50	NA		NA	
Suffolk	373	50	1719	50	1783	50
Sussex	266	50	627	50	2384	50
Total	1886	804	7132	350	15308	300

NA = Stratum not sampled within the county.

with approximately 70% of singing males detected during a single visit in that period. After this period, vocal activity decreases markedly which reduces the detection rate. For this study, surveyors were instructed to conduct visits between sunrise and 09:00 h to coincide with peak vocal activity. Surveying was avoided in poor weather such as high winds (Beaufort force 4 and above), continuous rain or fog.

All Turtle Dove registrations were plotted on survey maps for each visit using standard activity codes (Bibby *et al.* 2000) and information summarized on a survey form. Birds present in suitable nesting or foraging habitat but showing no signs of breeding behaviour were also recorded, as were birds in flight. For each registration, surveyors were asked to record a single dominant habitat type, and multiple secondary (if applicable) habitat types within a 25 m radius of its location using level 1 and 2 habitat codes from Crick (1992).

Survey squares were covered by walking public rights of way (including roads and footpaths), and areas of public open access, with the aim of getting to within 200 m of all potentially suitable nesting or foraging habitat, e.g. scrub, woodlands and hedgerows, extensively managed grassland, bare/fallow ground, intervention seed plots and standing water (Dunn *et al.* 2021, Dunn & Morris 2012, Browne & Aebischer 2004). Access permission was arranged with landowners where this could not be achieved from publicly accessible land alone.

### Data analysis

All Turtle Dove registrations were georeferenced from the survey maps using ArcGIS Pro 2.8.1 (ESRI 2021). Field observations were analysed to produce a maximum and minimum number of territories within each 1 km<sup>2</sup> square, based on the interpretation of breeding activity described in Bibby *et al.* (2000). The minimum number comprised ‘confirmed’ and

‘probable’ territories, those that contained active nests, apparent pairs *in situ*, singing males and birds displaying or showing agitation and other territorial behaviour. The maximum figure included ‘possible’ territories, those that only comprised of birds showing no signs of breeding activity, such as adults being present, feeding or birds only recorded in flight. The presence of fledged juveniles on their own was not taken as evidence of a territory. Singing male Turtle Doves recorded on one visit only were classed as ‘probable’ territories. It is acknowledged that this is different from the definition used for ‘probable breeding’ in atlases (Balmer *et al.* 2013, Hagemeijer & Blair 1997). We followed expert advice (A.J. Morris pers. comm.) and classed adjacent Turtle Dove territories as different when territorial birds were more than 500 m apart, or separated by over 1 km for non-territorial birds, on different visits. Although Turtle Doves have been recorded foraging across large areas in the UK (e.g. home ranges of up to 1140 ha, Browne & Aebischer 2003), most use a smaller spatial area. Dunn *et al.* (2021) predicted home ranges (based on 90% Minimum convex polygons) to be 3.89 ha for females and 3.49 ha for males.

Turtle Doves potentially from the same territory were occasionally recorded in multiple 1 km<sup>2</sup> squares. Territories overlapping squares were analysed using the following rules. Territories which overlapped two survey squares were allocated to the square containing the central location of the registrations. If the territory overlapped both a survey and non-survey square, and the central location of the registrations fell inside the survey square, it was included in both the minimum and maximum counts, however, if the fell outside the survey square, we took a conservative approach and excluded it from both counts.

Turtle Dove records collected on an *ad-hoc* basis (e.g. surveyors carrying out an optional additional visit to a survey square, or birds recorded while surveyors were moving between sites) were kept



separate from those collected during the dedicated survey visits but were included in the final territory totals for that square and, therefore, the calculation of population estimates.

A minority of survey squares (8.8%) received only one visit. As Turtle Dove occupancy rates within these 145 squares (15.9%) were similar to those receiving at least two visits (16.1%), they were not treated differently in the analyses.

### Population estimates

Owing to a lack of data on the survey efficiency of a two-visit method, it was not possible to undertake a formal calibration between the number of Turtle Dove territories identified during the survey fieldwork, and the 'true' population size, however, we know that the method does detect more than 70% of singing males, as this is the proportion found during a single visit (Calladine *et al.* 1999). Minimum and maximum population estimates were calculated for each of the core counties, using guidance in Gregory *et al.* (2004). In each case, estimates were produced separately for up to three strata, by multiplying the mean density of territories from the random sample squares by the total area of the stratum. Additional non-random squares were excluded as many were located in Turtle Dove project areas and, therefore, had a greater than average probability of occupancy. County strata population estimates were produced by summing the individual stratum estimates. UK strata population estimates were then created by summing the county estimates.

Individual county stratum confidence limits around both the minimum and maximum population estimates were calculated by using a bootstrapping procedure (Efron & Tibshirani 1986) in R version 4.2.0 (R Core Team 2017). We followed the staged process in Gregory *et al.* (2004), whereby for each county stratum we first resampled ( $n$  = sample size) with replacement, at random from the squares surveyed, excluding non-random squares. The mean density from this resample was then multiplied by the area of the stratum not surveyed to estimate the Turtle Dove population within that proportion of the stratum. This figure was then added to the actual number of Turtle Dove territories located within both random and non-random squares. This process was repeated to create 999 estimates of the population, and the 2.5th and 97.5th percentiles from these replicates taken to create the 95% confidence limits for that county stratum. Where replicate estimates were lower than the number of territories found during the

survey, including from non-random squares, the latter figure was used.

County strata confidence limits were then calculated by summing the unsorted bootstrap estimates from the individual stratum for each of the 999 replicates, with the 2.5th and 97.5th percentiles taken as the 95% confidence limits. The UK level strata confidence limits were produced using a similar approach, by summing the randomly sorted bootstrap estimates for each of the three separate stratum and then using these data to create the confidence limits. Away from sampled strata, including in non-core counties, it was assumed that all Turtle Dove territories were found during the survey. These were added to the strata estimates to produce county and UK population estimates and confidence limits.

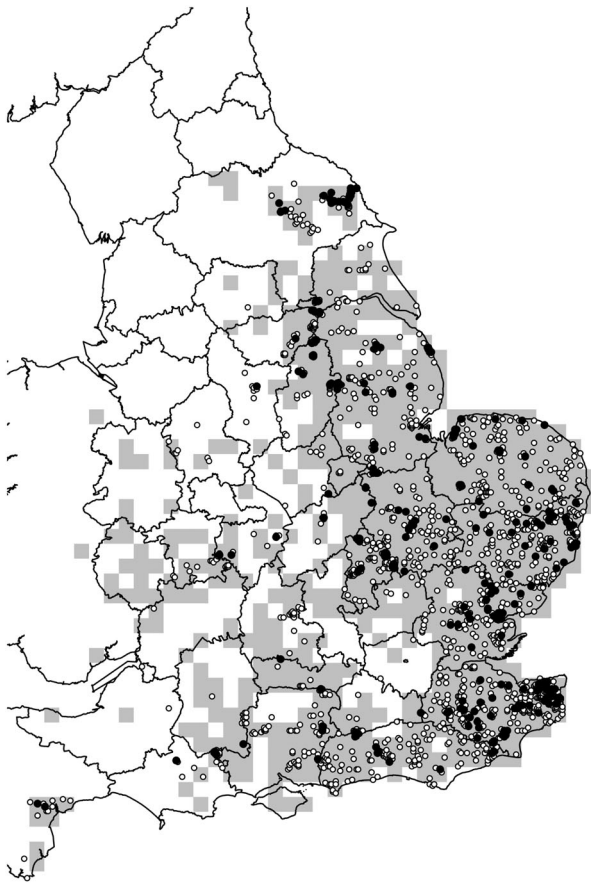
We decided to use our maximum territory figure (i.e. including possible territories) to represent the final population size for a survey square and, therefore, to estimate the county and UK population sizes. A two-visit method provides few opportunities to pick up breeding behaviour and excluding non-territorial birds was considered too conservative an approach, which is likely to lead to under estimation. A two-visit method is also unlikely to locate all territories in an area.

### Turtle Dove breeding range in 2021

As the survey did not use an atlas-type approach and coverage in 2021 was not comprehensive, it was not possible to carry out a formal assessment of Turtle Dove breeding range change since the Bird Atlas 2007–2011 (Balmer *et al.* 2013), however, the survey data were used to highlight apparent spatial concentrations. To improve the distributional data, these were supplemented by non-survey Turtle Dove records submitted to BirdTrack (BTO/RSPB/BirdWatch Ireland/SOC/WOS 2022), eBird (eBird 2022) as well as other *ad-hoc* records. Additional records were only included if they fell within the survey period. We did not filter the records by breeding evidence, therefore, it is acknowledged that they may include late passage migrants, particularly in coastal locations. In addition, we did not account for variation in survey effort across the country.

## Results

National Turtle Dove Survey data were returned for 1644 1 km<sup>2</sup> squares across England (Figure 2). Of the 1339 squares surveyed in the nine core counties, 72.1% were within our stratified random sampling strategy: 534 were within stratum 1 – recent records;



**Figure 2.** Occupied (black dots) and unoccupied (white dots) UK Turtle Dove survey squares in 2021, based on maximum count. One additional unoccupied square was surveyed in Cornwall (not shown on this map). Grey shading depicts 2007–2011 range (possible, probable and confirmed breeding; Balmer *et al.* 2013). The location of 14 survey squares was excluded as the data were considered sensitive.

241 in stratum 2 – occupied atlas tetrads, and 191 in stratum 3 – occupied atlas  $10 \times 10 \text{ km}^2$  squares (Table 2). Overall sampling intensities across these three strata were 28.3%, 3.4% and 1.2%, respectively, but varied by county; for example, within stratum 1, 88.1% of squares were surveyed in Bedfordshire, but only 9.4% in Suffolk. An additional 373 non-random squares were surveyed within the core counties, with 45 of these being outside the surveyed strata for that county (Table 2). Away from the core counties, 305 squares were covered across 25 counties (Table 3).

During the survey, a minimum of 313 and maximum of 332 Turtle Dove territories were identified within the core counties. Kent held the highest number of territories recorded (min 95, max 100; Table 2), followed by Norfolk (min 43, max 46) and Suffolk (min 34, max 35), although the differences in area and sampling intensity across the different strata means these figures are not directly comparable.

**Table 2.** Summary of 1 km<sup>2</sup> squares surveyed, and minimum and maximum number of Turtle Dove territories found within the core counties in 2021.

	Stratum 1 – Recent records			Stratum 2 – Occupied Atlas tetrads			Stratum 3 – Occupied Atlas 10 x 10 km <sup>2</sup>			Additional squares within sampled stratum			Additional squares outside sampled stratum			Total territories recorded (min–max)
	N° of squares surveyed	Final sampling intensity (%)	Territories recorded (min–max)	N° of squares surveyed	Final sampling intensity (%)	Territories recorded (min–max)	N° of squares surveyed	Territories recorded (min–max)	Territories recorded (min–max)	N° of squares surveyed	Territories recorded (min–max)	N° of squares surveyed	Territories recorded (min–max)	Total squares surveyed		
Bedfordshire	59	88.1	28–28	17	5.7	0	NA			0	0	2	1–1	78	29–29	
Cambridgeshire	39	30.2	12–13	28	2.8	4–5	24	1.1	1.1	0–0	4	5–5	0	95	21–23	
Essex	42	42.4	19–21	35	4.1	5–7	33	1.2	1.2	1–1	40	6–7	0	150	31–36	
Kent	111	39.5	41–43	54	3.8	6–8	30	1.4	1.4	5–5	105	43–44	0	300	95–100	
Lincolnshire	117	49.4	18–19	NA			NA				0	0	27	14–14	32–33	
Norfolk	53	21.5	4–6	34	2.9	5–5	34	0.8	0.8	0–0	54	34–35	0	175	43–46	
North Yorkshire	41	21.9	15–17	NA			NA				0	0	16	2–2	57	
Suffolk	35	9.4	3–3	37	2.2	4–4	33	1.9	1.9	1–2	96	26–26	0	201	34–35	
Sussex	37	13.9	5–5	36	5.7	1–1	37	1.6	1.6	1–1	29	4–4	0	139	11–11	
All core counties	534	28.3	145–155	241	3.4	25–30	191	1.2	1.2	8–9	328	118–121	45	1339	313–332	

**Table 3.** Summary of 1 km<sup>2</sup> squares surveyed, and minimum and maximum number of Turtle Dove territories found away from core counties in 2021.

County	N <sup>o</sup> of squares surveyed	Territories recorded (min–max)
Hampshire	84	13–14
Nottinghamshire	31	12–12
South Yorkshire	29	6–6
Northamptonshire	9	4–4
Warwickshire	11	2–3
East Riding of Yorkshire	20	2–2
Surrey	17	2–2
Devon	13	2–2
Wiltshire	3	2–2
Leicestershire and Rutland	12	1–1
Dorset	11	1–1
Derbyshire	8	1–1
Berkshire	4	1–1
Oxfordshire	17	0
Worcestershire	14	0
Hertfordshire	6	0
Staffordshire	6	0
Greater London	3	0
Bristol	1	0
Buckinghamshire	1	0
Cornwall	1	0
Gloucestershire	1	0
Shropshire	1	0
Somerset	1	0
West Yorkshire	1	0
Total	305	49–51

Away from the nine core counties, a minimum of 49 and a maximum of 51 Turtle Dove territories were located, mainly in Hampshire (min 13, max 14) Nottinghamshire (12), and South Yorkshire (6). Few Turtle Dove territories were recorded elsewhere, with Northamptonshire, Warwickshire, East Riding of Yorkshire, Surrey, Devon, Wiltshire, Leicestershire & Rutland, Dorset, Derbyshire and Berkshire each holding between one and four territories. No Turtle Dove territories were located elsewhere.

Of the 383 Turtle Dove territories recorded across all survey squares, 28 had registrations that straddled two survey squares and eight overlapped non-survey squares. Two additional territories were excluded from

the results as, although birds were recorded in the survey squares, the centre of the registrations fell outside.

### National and county population estimates

Based on our maximum figure (including ‘possible’ territories), the UK breeding Turtle Dove population in 2021 was estimated at 2092 [95% CL, 1559–2782] territories (Table 4). Estimates for the individual core counties strata, along with their total size, were: stratum 1, recent records - 446 [95% CL, 404–533] territories (1886 km<sup>2</sup>), stratum 2, occupied atlas tetrads - 941 [95% CL, 579–1380] territories (7132 km<sup>2</sup>), and stratum 3, occupied atlas 10 × 10 km<sup>2</sup> squares - 638 [95% CL, 237–1217] territories (15,308 km<sup>2</sup>). Individual county stratum estimates are shown in online Table S1. Our conservative minimum UK population estimate, excluding ‘possible’ territories, was 1865 [95% CL, 1305–2609] territories (Table 4).

Nearly two-thirds (62.5%) of the UK Turtle Dove population in 2021 was estimated to occur in three counties. Kent had the largest remaining population at 682 (95% CL 301–1215) territories, representing a third (32.6%) of the UK breeding population, followed by Suffolk (326 territories, 95% CL 100–599, 15.6%) and Essex (300 territories, 95% CL 136–503, 14.3%). Mean densities (territories/10 km<sup>2</sup>) showed the same pattern, with values of 17.45, 8.46 and 7.60, respectively. Other counties to hold estimated populations of over 100 territories were Cambridgeshire (227 territories, 95% CL 55–453), Norfolk (223 territories, 95% CL 61–471) and Sussex (118 territories, 95% CL 27–288).

### Turtle Dove breeding range in the UK

Turtle Dove registrations from the national survey were combined with data submitted to BirdTrack, eBird and other sources over the same time window, to provide a

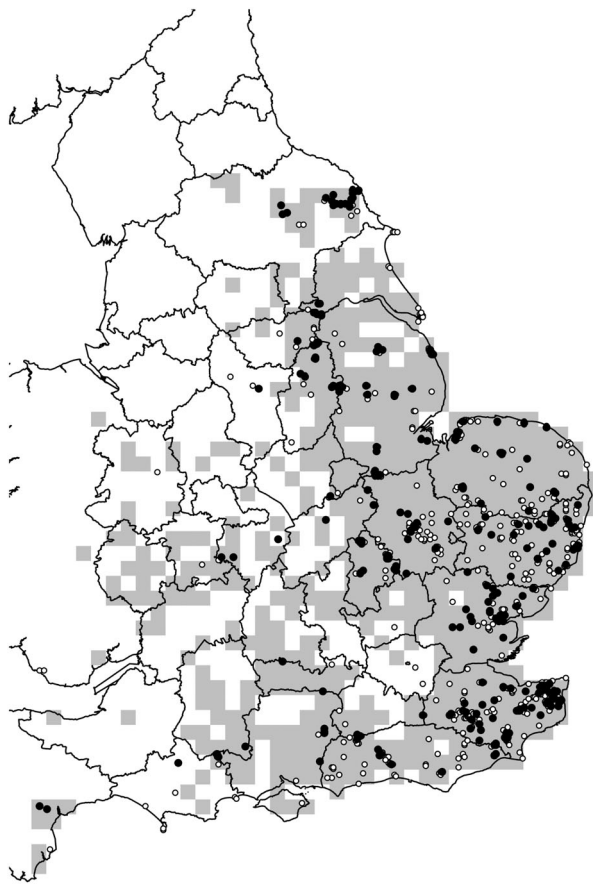
**Table 4.** Turtle Dove population estimates and densities in 2021, by county and for the UK. The 95% confidence limits for the population estimates, where applicable, are shown in parentheses. Estimates have been rounded to the nearest territory.

	Area (km <sup>2</sup> )	2021 minimum population estimate	2021 maximum population estimate	Mean minimum density (territories/10 × 10 km <sup>2</sup> )	Mean maximum density (territories /10 × 10 km <sup>2</sup> )
Kent	3908	624 (254–1188)	682 (301–1215)	15.97	17.45
Suffolk	3854	272 (70–536)	326 (100–599)	7.06	8.46
Essex	3948	248 (104–453)	300 (136–503)	6.28	7.60
Cambridgeshire	3397	188 (39–400)	227 (55–453)	5.53	6.68
Norfolk	5509	213 (49–451)	223 (61–471)	3.87	4.05
Sussex	3834	118 (27–288)	118 (27–288)	3.08	3.08
North Yorkshire	8680	70 (45–95)	80 (55–108)	0.81	0.92
Lincolnshire	7182	50 (41–62)	52 (42–65)	0.70	0.72
Bedfordshire	1235	33 (31–35)	33 (31–35)	2.67	2.67
Non-core counties*	NA	49	51	NA	NA
UK		1865 (1305–2609)	2092 (1559–2782)		

\*non-core county total from Table 3.



better understanding of the current UK breeding range (Figure 3). Important areas appear to be sections of the Low Weald (Kent), North Downs (Kent), North Kent Plain, northeast Essex, and north and east Suffolk. Small, sometimes well scattered, populations still occurred further west and north, particularly in sections of Cambridgeshire, Bedfordshire, south Norfolk, the north Norfolk coast, the North Yorkshire Moors National Park and Humberhead Levels in Yorkshire, Trent and Belvoir Vales in Nottinghamshire and Knepp Estate in Sussex (a complete survey there in 2021 estimated 20 territories; P. Green pers. comm.). It is, however, worth noting that as the survey used a sampling strategy in core counties, other hotspots, not picked up by the survey or supplementary records, may occur elsewhere.



**Figure 3.** UK Turtle Dove concentrations in 2021. Occupied 1 km<sup>2</sup> national survey squares (black dots) and additional 1 km<sup>2</sup> squares with supplementary records (white dots). Owing to incomplete and potential biases in coverage, the 2021 range should not be considered comprehensive. Supplementary records from elsewhere in the UK are not shown, as they were considered to be outside the species' breeding range. Some supplementary records, particularly from coastal sites, are likely to represent late passage migrants. Grey shading depicts the 2007–2011 range (possible, probable and confirmed breeding; Balmer *et al.* 2013).

Due to methodological differences, it was not possible to carry out a formal assessment of breeding range change with the two previous breeding bird atlases: 1968–1972 (Sharrock 1976) and 2007–2011 (Balmer *et al.* 2013). However, as coverage away from core counties focussed on squares with recent records (2015–2020), it does suggest a further substantial contraction in range since 2007–2011 (Balmer *et al.* 2013), at least within these areas.

### Turtle Dove habitats

A total of 675 Turtle Dove registrations were noted during the survey. Of these, habitat data representing a single dominant type and multiple secondary habitats (if applicable) within a 25 m radius of the sightings were correctly recorded for 488 (72.3%) of registrations. No habitat data were noted for 161 registrations and 26 had incorrect codes used.

The most frequent dominant habitat type recorded was scrubland (46.3%), i.e. woody shrubs or young trees less than 5 m tall (Table 5), followed by woodland (22.5%), farmland (16.8%), human sites (9.2%) and waterbodies (5.1%). Notable subcategories were scrubland – regenerating natural or semi-natural woodland (38.3%) and woodland – broadleaved (14.8%).

When both dominant and secondary habitats were combined, scrubland was again noted against most registrations (60.2%), followed by farmland (53.7%), woodland (31.8%), waterbodies (29.3%) and human sites (16.4%). Notable subcategories were the same as dominant habitat (shown above), plus agriculturally unimproved farmland, rural human sites and mixed grass/tilled land.

### Discussion

Results from the UK's bird monitoring schemes show that the Turtle Dove has undergone the most severe decline of any UK bird species over the last fifty years, and the findings of this study provide further support for that trend. Our 2021 estimate of 2092 territories (95% CL 1559–2782) represents a 98.3% decline when compared to the population estimate, with no measure of error, of 125,000 pairs from the 1968–1972 breeding atlas (Sharrock 1976). This is in line with the combined UK BBS/CBC abundance trend of –99% (85% CL –99%–98%) between 1967 and 2020 (Massimino *et al.* 2022).

The national population was estimated to be 75,000 territories during the 2nd UK breeding atlas in 1988–1991 (Gibbons *et al.* 1993). Revised population estimates published since then by the Avian Population

**Table 5.** Dominant and secondary habitat types (based on Crick 1992) recorded within a 25 m radius of 488 Turtle Dove registrations in 2021. Note: surveyors only noted a single dominant habitat but could record multiple secondary habitat types if applicable. Level 1 habitat data (letter only) were recorded for 25 Turtle Dove registrations.

Code	Level 1	Level 2	Dominant habitat		Dominant and secondary habitats combined	
			N° of registrations	%	N° of registrations	%
A	Woodland (> 5 m tall)	All	110	22.5%	155	31.8%
A1		Broadleaved	72	14.8%	110	22.5%
A2		Coniferous	3	0.6%	4	0.8%
A3		Mixed (10% of each)	15	3.1%	23	4.7%
A4		Broadleaved water-logged	10	2.0%	11	2.3%
A6		Mixed water-logged	2	0.4%	8	1.6%
B	Scrubland (< 5 m tall)	All	226	46.3%	294	60.2%
B1		Regenerating natural or semi-natural woodland	187	38.3%	238	48.8%
B2		Downland (chalk)	5	1.0%	9	1.8%
B3		Heath scrub	13	2.7%	21	4.3%
B5		New plantation	4	0.8%	6	1.2%
B6		Clear-felled with or without new saplings	1	0.2%	1	0.2%
B7		Other	7	1.4%	11	2.3%
E	Farmland	All	82	16.8%	262	53.7%
E1		'Improved' grassland	10	2.0%	26	5.3%
E2		'Unimproved'	14	2.9%	112	23.0%
E3		Mixed grass/ tilled land	18	3.7%	59	12.1%
E4		Tilled land	20	4.1%	47	9.6%
E5		Orchard	4	0.8%	15	3.1%
E6		Other farming	10	2.0%	22	4.5%
F	Human sites	All	45	9.2%	80	16.4%
F1		Urban	0	0.0%	2	0.4%
F2		Suburban	3	0.6%	7	1.4%
F3		Rural	41	8.4%	68	13.9%
G	Waterbodies (freshwater)	All	25	5.1%	143	29.3%
G1		Pond (< 50 m <sup>2</sup> )	2	0.4%	19	3.9%
G2		Small waterbody (50-450 m <sup>2</sup> )	0	0.0%	26	5.3%
G3		Lake/unlined reservoir	0	0.0%	12	2.5%
G5		Gravel pit/sand pit	2	0.4%	22	4.5%
G6		Stream (< 3 m wide)	7	1.4%	30	6.1%
G7		River (> 3 m wide)	2	0.4%	15	3.1%
G8		Ditch with water (< 2 m wide)	2	0.4%	13	2.7%
G10		Large canal (> 5 m wide)	9	1.8%	12	2.5%

Estimates Panel (Stone *et al.* 1997, Baker *et al.* 2006, Musgrove *et al.* 2013, Woodward *et al.* 2020) have used trend-based extrapolations from this figure, with the most recent estimate of 3600 territories in 2016. This study suggests a 41.9% decline since then. Again, this is very close to the published BBS trend of –50% (95% CL –68%––26%) between 2016 and 2021 (Heywood *et al.* 2023). All this information suggests that although the BBS sample size for Turtle Dove is now below the threshold needed to calculate robust population trends going forward, it is still able to accurately estimate the severe past decline in abundance. The baseline provided by the 2021 national survey will help to monitor future trends and pick up small-scale changes in abundance, such as the hoped-for early signs of population stabilization and recovery.

Turtle Doves appear to be contracting back to their former stronghold of the early nineteenth century, in eastern England (Brown & Grice 2005, Holloway 1996). Eastern and southeastern England are the key regions for the species, particularly in the counties of Kent, Suffolk and Essex.

Many of the 2021 county population estimates have wide confidence limits. This is primarily due to the large areas covered by strata 2 and 3 (occupied atlas tetrads and 10 × 10 km<sup>2</sup> squares) and the resulting low sampling intensity. It was, however, important to include these areas within our survey design and not assume that Turtle Doves only occur within stratum 1 squares, i.e. those containing recent records. Indeed, low numbers of Turtle Dove territories were identified in strata 2 or 3 in all core counties, except Bedfordshire. Owing to the association between Turtle Doves and farmland, it was not possible to rule out large proportions of these strata as totally unsuitable breeding habitat, and thereby reduce the width of the confidence limits.

There is a lack of data available to compare with our county-level estimates. We estimated the Sussex population at 118 territories (95% CL 27–288) in 2021. A dedicated Turtle Dove survey there in 2019, put the population at around 80 territories, with a range of 50 to 100, but acknowledged that this may represent a small under-estimate (Smith & Green 2020). Estimates,

based largely on *ad-hoc* recording rather than systematic surveys, provided by county bird recorders to the RBBP for 2020 (Eaton *et al.* 2022) put the maximum total number of breeding pairs in the other core counties at: Kent (200–400), Yorkshire (110), Suffolk (106), Norfolk (80–125), Cambridgeshire (55), Lincolnshire (39), Essex (20) and Bedfordshire (12). Except for Yorkshire and Lincolnshire, all our estimates were higher. Elsewhere, our figures were similar to estimates for Devon (one), Berkshire (one), Derbyshire (two), Hampshire (13), Northamptonshire (three) and Wiltshire (one), lower than Surrey (five) and Warwickshire (five). We did not record any Turtle Doves in Buckinghamshire, Hertfordshire, Oxfordshire and Worcestershire in 2021 but birds were still present in these counties, albeit in very low numbers (1–4 pairs), in 2020. Two 1 km<sup>2</sup> squares in Worcestershire did contain supplementary records, e.g. from BirdTrack and eBird, of single birds in 2021. It is acknowledged that our survey may have missed a small number of territories in non-core counties.

Previous studies in the UK have highlighted the importance of established scrub, woodlands and hedgerows, extensively managed grassland, bare/fallow ground, intervention seed plots and standing water for breeding Turtle Doves (Carboneras *et al.* 2022, Dunn *et al.* 2021, Dunn *et al.* 2017, Dunn & Morris 2012, Browne & Aebischer 2004). The methodology used to record habitat for this survey was relatively simple, e.g. broad-scale dominant and secondary habitat types in a 25 m radius of registrations, and it was not possible to compare these data to counterfactual locations, however, the results appear consistent with previous studies and reinforce the importance of scrub, particularly our ‘regenerating natural or semi-natural woodland’ category.

### Conservation implications and recommendations

The conservation status of the Turtle Dove in the UK has recently been reviewed and the species was retained on the red list of UK Birds of Conservation Concern and classified as Critically Endangered under the International Union for Conservation of Nature (IUCN) Regional Red List process in Great Britain (Stanbury *et al.* 2021). As these categories identify species under the most severe level of threat, the new population estimate presented here reinforces the results of national monitoring schemes and is, therefore, unlikely to impact on future status assessments. The qualifying criteria for both assessments relate to severe declines in abundance, not population size.

It is hoped that the temporary cessation of unsustainable levels of hunting along their western flyway will have a beneficial impact on the northwest European breeding population, including Turtle Doves breeding in the UK. This represents a vital window of opportunity to stabilize and hopefully reverse the current decline, but to do so, conservation action is also needed on their breeding grounds.

Large-scale measures are needed to improve habitat quality and food availability to increase breeding productivity, and a package of suitable measures (including scrub/hedgerow management for nesting, food provision through supplementary feeding and arable plot management, and provision of water supplies) is available within the current agri-environment scheme available in England (Countryside Stewardship, Defra 2020). A successor scheme is due to launch in 2024, and it is vital that this builds upon the management interventions put in place through previous schemes and delivers a net increase in habitat and resource delivery across the current range.

Several active Turtle Dove projects are working to create, restore and manage important breeding habitats, in order to improve the annual productivity of breeding pairs in the UK. For example, Operation Turtle Dove is focussing conservation action within ‘Turtle Dove Friendly Zones’ in Kent, Essex and Suffolk, as well as in Sussex, Norfolk and Cambridgeshire. The aim of this project is to target the core of the remaining UK population, a broad-scale spatial strategy which is supported by the results from this study. The Turtle Dove registrations collected through the survey, or as supplementary records, should, however, be used to help fine-tune the targeting of interventions.

Dunn & Morris (2012) identified habitat features important for the Turtle Dove in the UK, but that study was confined to eastern England and is over a decade old. The species has continued to decline since then. Updating information on habitat selection might prove beneficial. The national survey provides a resource of 675 Turtle Dove registrations distributed across their UK range. We suggest that these locations can be used to model and predict current Turtle Dove occupancy away from areas covered in this study. This could then be used to help further improve the targeting of conservation action.

One of the aims of the survey was to act as a baseline to measure the effectiveness of conservation interventions. We therefore suggest that the survey be repeated in or near 2026, and at regular intervals thereafter, to assess changes in abundance at both at county and national level.

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