Conservation Evidence

Monitoring of ecosystem function at landscape -scale demonstrates temporal difference in invertebrate abundance in Kent and South-East England

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Summary

- A growing body of recent evidence[1] highlights population declines in insects and other invertebrates at global scales, the consequences of which are potentially catastrophic. Invertebrates are a critical component of ecosystem function, and all functional groups (herbivores, detritivores, parasitoids, predators and pollinators) are at risk. Without them life on earth would collapse.
- Considerable conservation effort is targeted at invertebrates. The focus of delivery of conservation action has shifted from site to landscape-scale, and practitioners seek to evidence landscape-scale outcomes of conservation action. Here we use an innovative invertebrate sampling technique conducted by citizen scientists to assess the difference in invertebrate abundance in the south-east of England over a 15 year timeframe.
- The *windscreen phenomenon*[2] is a term given to the anecdotal observation that people tend to find fewer insects squashed on the windscreens of their cars now, compared to a decade or several decades ago. This effect has been ascribed to major global declines in insect abundance. Using a standardised sampling grid termed a 'splatometer', members of the public were asked to record the number of insects and other invertebrates squashed on the number plate of their car, having first cleaned the number plate before commencing a journey.
- A national survey using this methoodology led by the RSPB took place in 2004, and by repeating the survey in Kent in 2019 we were able to compare the abundance of invertebrates between these points in time. Between 2004 (n=3838) and 2019 (n=667) there was a statistically significant differece in 'splat density' of the order of approximately 50%, from an average of 0.2 splats per mile to 0.1 splats per mile (Figures 1 & 3a). This differerence mirrors the patterns of decline widely reported by others[3],[4]. It should be noted that this observation is based on data from two points in time. Consequntly it does not constitute a trend and cannot be interpreted as a decline. Inter-annual variation in variables such as weather cannot be ruled out as factors influencing the observed pattern. More data over a number of years will be required to confirm the direction of any trend, however the observed pattern corrlates with examples of decline.
- We addressed two limitations of the 2004 survey. Firstly, in 2004 participants were not provided guidance on journey length, and a large number of long journeys spanning several counties resulted in the data providing poor spatial resolution of variation. Only variation between regions was resolved in the 2004 data, but by encouraging participants to submit data from both short and long journeys, we were able to map spatial variation in splat density within Kent (Figure 2).
- The second limitation we addressed concerned a criticism levelled at the methodology in terms of the effect of vehicle design on the rate of invertebrate sampling. Modern cars are more areodynamically designed than in the past, and changes over time may affect the numbers of insects getting squashed. We actively recruited classic car owners to take part in the survey, allowing us to collect data using cars ranging in age from 1957 to 2018. We found a small but statistically significant positive relationship between vehicle age and splat density, suggesting that modern cars squash more invertebrates that older cars (Figure 3b). This suggests that the signal from the difference in insect abundance is strong enough to be apparent inspite of more efficient sampling by newer vehicles.
- This study has the potential to add to the growing body of evidence for significant invertebrate declines in the UK, highlighting a significant effect in Kent and the south-east of the UK, and supports the case for conservation policy and practice to reverse declines and restore invertebrate populations.

[1] Goulson, D. (2019) Insect declines and why they matter. A report commissioned by the South West Wildlife Trusts. https://www.kentwildlifetrust.org.uk/sites/default/files/2020-01/Actions%20for%20Insects%20-%20Insect%20declines%20and%20why%20they%20matter.pdf
[2] https://en.wikipedia.org/wiki/Windshield_phenomenon
[3] Hallmann, CA, Sorg, M, Jongejans, E, Siepel, H, Hofland, N, Schwan, H, Stenmans, W, Müller, A, Sumser, H, Hörren, T, Goulson, D and de Kroon, H. (2017). More than 75 percent decline over 27 years in total flying insect biomass in protected areas. PlosONE 12.
[4] Fox, R., Parsons, M.S., Chapman, J.W., Woiwood, I.P. Warren, M.S. & Brooks, D.R. (2013). The state of Britain's larger moths 2013. Butterfly Conservation & Rothamsted Research Wareham, Dorset

Key findings

1. Invertebrate abundance as measured by splat density was 50% lower in 2019 than in 2004.

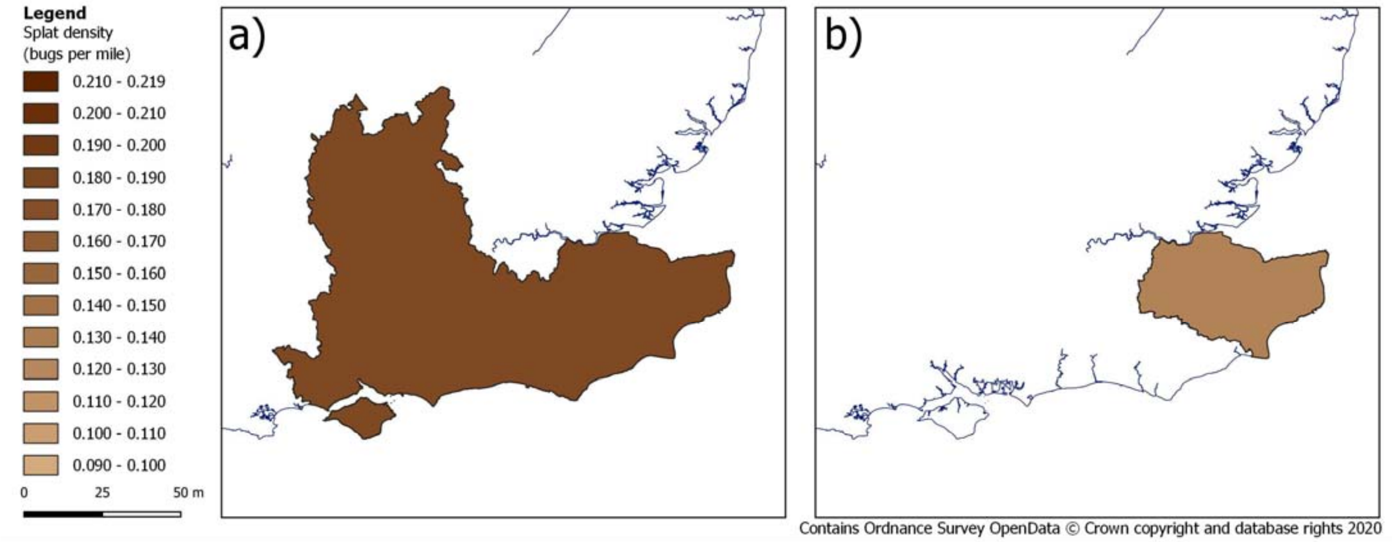

Figure 1 The difference in splat density recorded on vehicle journeys between a) 2004 (in South East England) and b) 2019 (in Kent). Between 2004 and 2019 there was a statistically significant difference in 'splat density' of the order of approximately 50%, from an average of 0.2 splats per mile to 0.1 splats per mile, in 2004 (n=3838) and in 2019 (n=667).

2. Invertebrate abundance varied considerably within Kent.

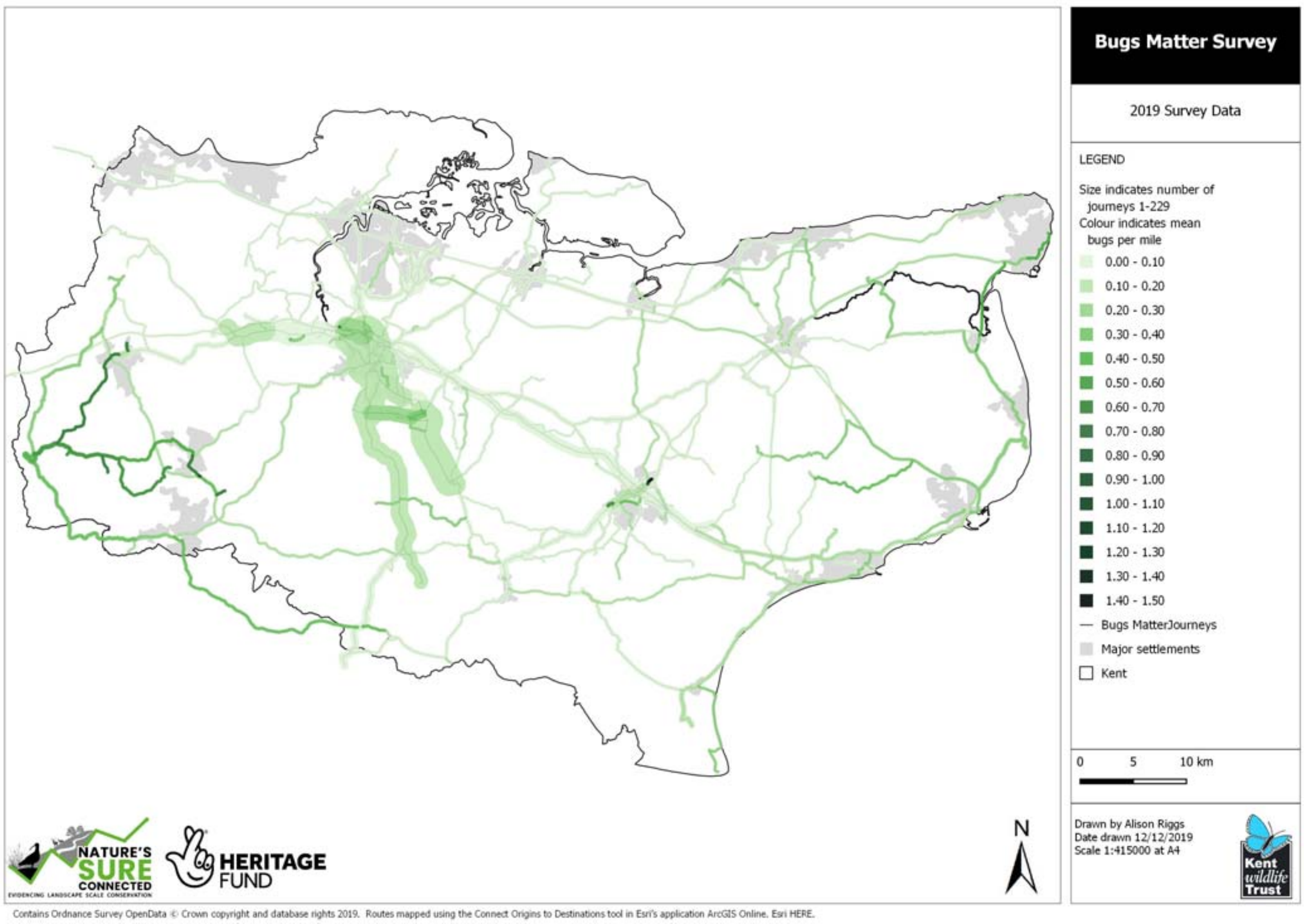

Figure 2 Spatially referenced heat map of the variation in splat density recorded from vehicle journeys in Kent in 2019. Wider tracks indicate more samples (journeys), and darker tracks indicate higher average density of invertebrates, so that the pattern of variation in abundance is independent of sampling effort.

3a. The difference in splat density between 2004 and 2019 there was statistically significant, and of the order of approximately 50%, from an average of 0.2 splats per mile to 0.1 splats per mile.

3b. Newer vehicles had a positive, rather than the anticipated negative effect, on splat density. More invertebrate were squashed by newer cars.

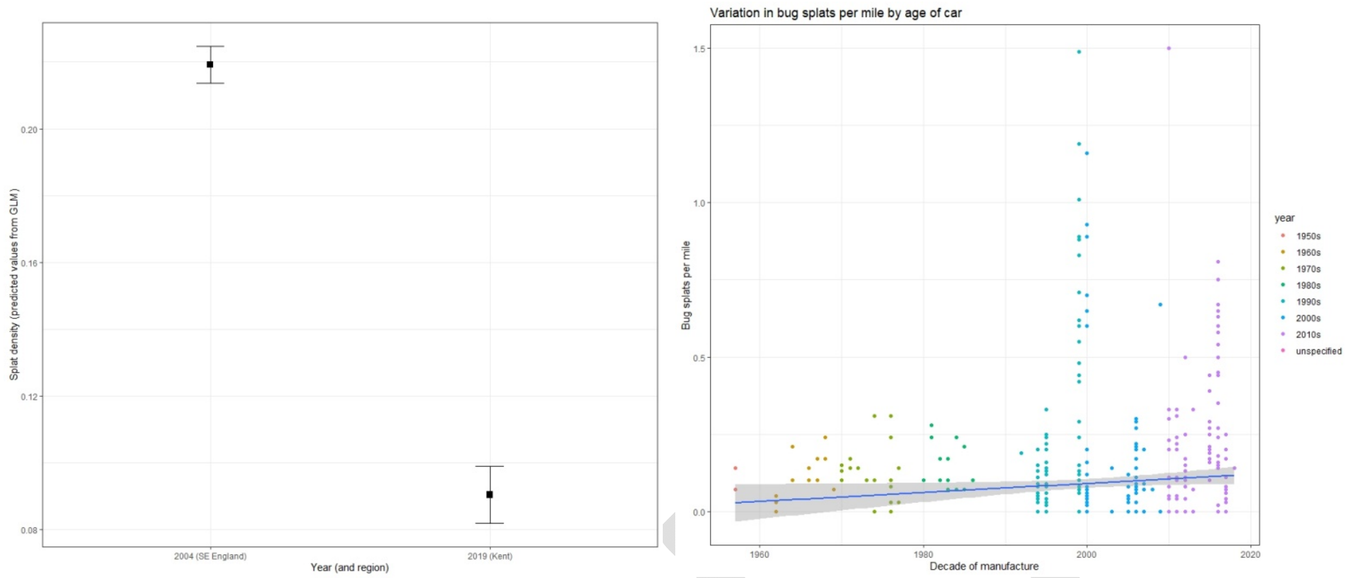

Figure 3 a) Model estimates and confidence limits of the difference in splat density recorded on vehicle journeys in 2004 (in SE England) and 2019 (in Kent). b) The relationship with confidence intervals, between splat density and age of vehicle predicted by a Generalised Linear Model.

Table 1 Effect sizes, standard errors and exponents of a Generalised Linear Model of the temporal difference in splat density observed in overlapping regions of south-east England between 2004 and 2019.

Year and region	Estimate	Exponent (mean)	Std. Error	t value	P
2004 South East	-1.51786	0.2191804	0.02501	-60.683	<0.001***
2019 Kent	-0.88471	0.09048511	0.09688	-9.132	<0.001***

Notes: Estimate: estimate of the model intercept indicating the change in response per unit increase in the explanatory variable. Std. Error: standard error of the model estimate. t-value model t-statistic. P: model p-value. Asterisks indicate the level of significance: P < 0.05 = *, P < 0.01 = **, P < 0.001 = ***. P values for significant effects are taken from the model output of the minimum adequate model.

Table 2 Effect sizes and standard errors of a Generalise Linear Model of the effect of vehicle age on splat density of insects squashed on number plates.

Year and region	Estimate	Std. Error	t value	P
Intercept	-37.654614	16.402368	-2.296	0.0220*
Decade of manufacture	0.017615	0.008192	2.150	0.0319*

Notes: Estimate: estimate of the model intercept indicating the change in response per unit increase in the explanatory variable. Std. Error: standard error of the model estimate. t-value model t-statistic. P: model p-value. Asterisks indicate the level of significance: P < 0.05 = *, P < 0.01 = **, P < 0.001 = ***. P values for significant effects are taken from the model output of the minimum adequate model.

Further work

More data is required to a) build up a trend over time and confirm that the difference is a decline rather than simply an inter-annual effect caused by factors such as weather; b) increase confidence in the observed pattern of the effect of vehicle age and design (more older cars need to be included in the survey); c) expand spatial coverage to other counties to provide wider geographic coverage.

Next steps

More data requires greater participation by the public. Experience shows surveys must be as easy as possible, and present a few barriers as possible, to maximise numbers taking part. We ran our pilot survey in 2019 using paper forms and spread sheets, which are not conducive to mass participation. To address this we have drawn up a specification for a mobile app to encourage wider participation and are seeking funding for its development.

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Appendix

Spatial analysis

Route mapping used GIS software. Each journey was first assigned a unique ID number. The start, via and end postcodes for each of these were converted into spatially referenced GIS points. Esri's ArcGIS Online Connect Origins to Destinations tool[5] was used to map the routes between them along the road network[6]. All the route lines were merged and points calculated at 100m intervals along the simplified line layer. These points were buffered into polygons large enough to overlap all the route lines along different carriageways of a single road. A spatial join was used to calculate the count of journeys and mean splat density from the all the original route lines corresponding with each buffered point and put these into the attributes for each buffer polygon. These buffer polygons were then saved as centroid points, retaining the attributes. To visualise sample size spatially, the points were buffered once more, in proportion to the count of journeys each one represents. To visualise splat density, the symbology for the points was assigned using a graduated colour ramp.

Statistical analysis

Statistical analyses were performed using the software R 2.10.1 for Windows[7] following established techniques[8,9]. A Generalised Linear Model (GLM) was used to test the null hypotheses a) that there was no difference between years in the rate of bug splatter and b) that there was no effect of vehicle age on the rate of bug splatter. Examination of histograms of the data revealed a strong negative skew in each response, as is typical of count-derived data, and examination of dispersion in the response variables revealed over-dispersion. To comply with model assumptions, analyses were therefore performed using GLM's with a quasi-Poisson error structure, appropriate for over-dispersed count-derived data. As only one explanatory variable was modelled, these models were the Minimum Adequate Models (MAMs). All MAM's were checked for goodness of fit by plotting the residuals against the fitted values to look for evidence of heteroscedasticity, and the ordered residuals against the normal scores to look for evidence of non-normality of errors. To plot graphical representations of each model, the function allEffects from library(effects) was used to extract the model estimates and parameters, and the estimated mean and standard error (splat density) and 95% confidence intervals (vehicle age) plotted against the explanatory variables. Refinement of the statistical approach is anticipated.

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[5] ESRI 2019. ArcGIS Online. Redlands, CA: Environmental Systems Research Institute. www.esri.com/en-us/arcgis/products/arcgis-online/overview
[6] Routes mapped using Esri ArcGIS Online Connect Origins to Destinations tool. Esri HERE.
[7] R Development Core Team (2010) R: A Language and Environment for Statistical Computing. Vienna, Austria.
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[9] Crawley, M.J. (2007) The R Book. John Wiley and Sons Ltd, Chichester.