Supporting Information

Application of the Random Encounter Model in citizen science projects to monitor animal densities

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Supporting Information 1

Table S1. Habitat composition of urban (n=5) and rural (n=4) sites. Brackenhurst, Nottinghamshire, is listed twice as its habitat composition varied in the two years that it was surveyed. Sites are illustrated in Figure 1.

Habitat	Urban					Rural			
Survey	Southwell	Reading	Ipswich West	Ipswich East	Brighton	Hartpury	Brackenhurst 2017	Brackenhurst 2018	Sutton Bonington
Percentage of land cover									
Amenity grassland	11	11.5	6	23	22	25	11	10	22
Arable	0	0	0	0	0	0	0	0	40
Built land	40	47	56	32	34	14	12	11	20
Garden	41	38	34	41	37	0	1	1	3
Pasture	1	0	0	0	0	48	73	75	14
Water	0	0	0	0	0	3	0	0	0
Woodland	7	3.5	4	4	7	10	3	3	1

Table S2. Spatial Capture-Recapture candidate models and specific coefficients values used to estimate densities of hedgehogs in urban and rural landscapes.

Model	K	AIC	dAIC	weight	CumWt
D(~session) p(~1) sig(~sex)	13	2625	0.00	0.46	0.46
D(~session) p(~sex) sig(~sex)	14	2625	0.51	0.36	0.82
D(~session) p(~1) sig(~1)	12	2627	2.57	0.13	0.95
D(~session) p(~sex) sig(~1)	13	2629	4.34	0.05	1.00
D(~1) p(~1) sig(~sex)	5	2648	23.60	0.00	1.00
D(~1) p(~sex) sig(~sex)	6	2649	24.06	0.00	1.00
D(~1) p(~1) sig(~1)	4	2651	26.15	0.00	1.00
D(~1) p(~sex) sig(~1)	5	2653	27.92	0.00	1.00

Supporting Information 2

Citizen science framework for implementing the Random Encounter Model (REM)

The averaged REM parameters (aveREM) approach described in this article is able to detect a 25% change in hedgehog density in both habitats with >90% power. This approach is also a promising solution to the challenge of large-scale and long-term species monitoring. We suggest implementing the Random Encounter Model (REM) as a contributory model (*sensu* Shirk *et al.,* 2012) in a citizen science monitoring study. We propose a 3-stages framework: pilot study, monitoring study, and study output (Figure S1).

1. Pilot study

To apply this framework at a national scale for a specific species, pilot studies across a range of habitats in different locations (study areas) are needed to obtain the survey-specific parameters. Within each study area, random camera trap (CTs) locations are generated and fieldwork is carried out by researchers to measure the survey-specific parameters (angle, distance and speed) and obtain densities using the survey-specific REM (ssREM) approach. Once measurements of the parameters have been collected from a representative sample of habitats, the averages of each of the parameters across surveys are obtained to calculate densities using the averaged parameters REM (aveREM) approach. The pilot study finishes when enough measurements of the parameters have been obtained so that the densities estimated by the ssREM and aveREM are comparable.

2. Monitoring study

The monitoring study requires the participation of a starting pool of citizen scientists in community engagement activities (i.e., recruiting further participants) and camera trapping surveys (i.e., placement and collection of camera traps, and data reporting). At this stage, researchers need to provide camera trap training to all the participants. For the long-term implementation of the project, the same areas will be surveyed along the years. For successive surveys, assuming participants are still engaged with the project, only camera trapping surveys would be needed as the same CTs locations will be re-used. If any participant decides to discontinue their involment in the study, a small community engagement activity will be required to find new participants and relocate the camera trap location(s).

3.Study output

Study output is the final stage and involves data analysis and dissemination of results to the local and research community. Researchers will receive raw data (i.e., videos) from the citizen scientists and, using the aveREM parameters estimated in the pilot study, estimate the densities.

By including diverse habitat types into the study areas, a national population estimation can be obtained using camera traps and the averaged REM approach. In this study, we have carried out the pilot study needed to survey hedgehogs, so that future studies use the parameters obtained here to estimate densities of hedgehogs at other sites. Therefore, a citizen science project to monitor hedgehogs in the United Kingdom will require only the last two stages. Any other monitoring programs focused on a different species to be included in this framework would require to follow all three stages described.

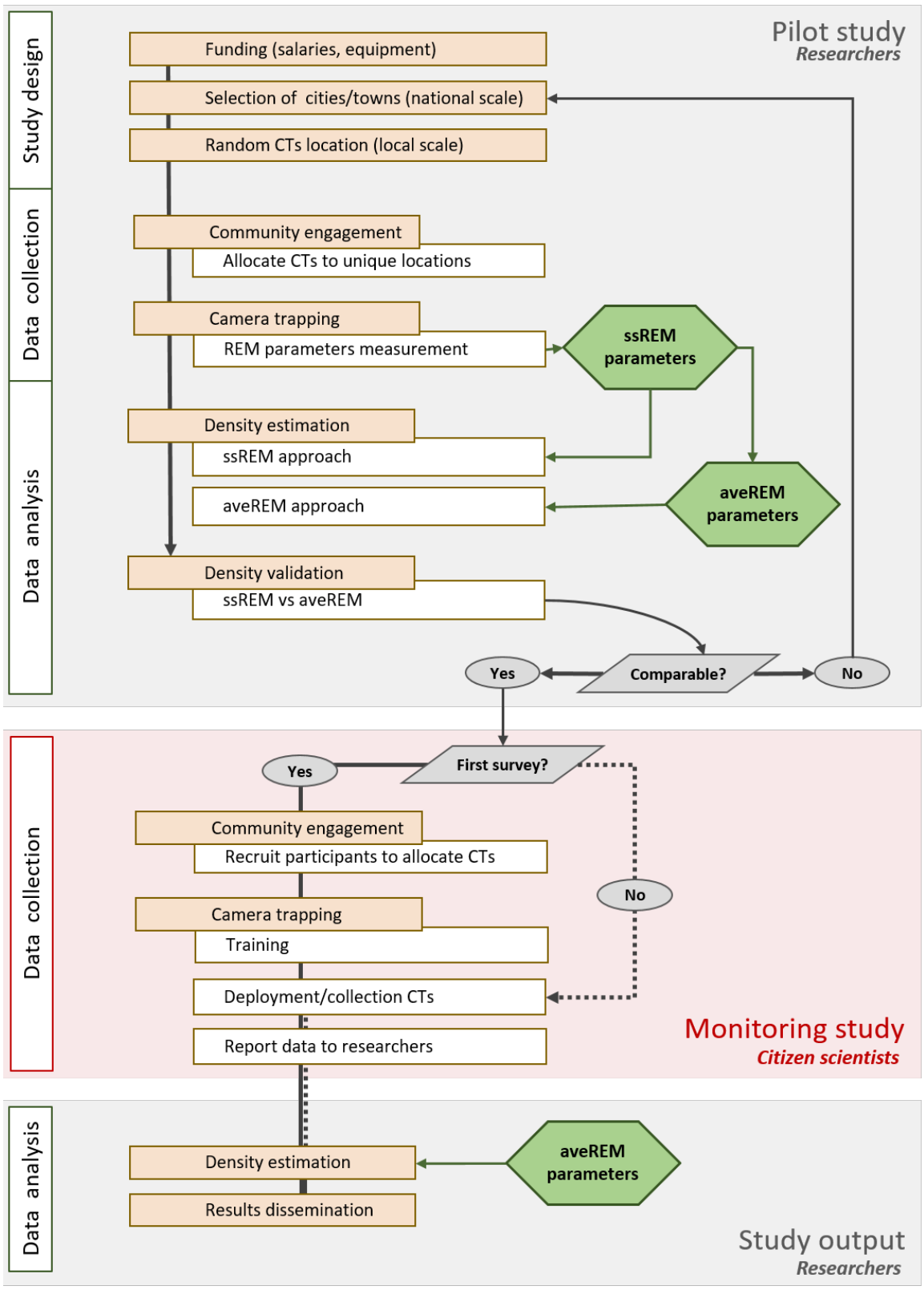

Figure S1. Citizen science monitoring framework based on the use of the Random Encounter Model. Flowchart to implement the Random Encounter Model (REM) in a contributory model of citizen

science monitoring study. We propose a 3-stages framework: pilot study, monitoring study, and study output. CTs =camera traps ; ssREEM= survey-specific REM; aveREM= averaged REM.