Predicting the effects of urbanisation on biodiversity with the use of soundscape analysis

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Theme: Zero Carbon

Research aim: to assess the effects of newly developed housing estates on biodiversity in Derby, UK based on soundscape analysis.

Objectives:

1) To compare species diversity across new housing estates based on soundscape analysis.
2) To assess the effect of property location and garden type on biodiversity.
3) To propose Nature-based Solutions that will align urbanisation planning and management that minimises biodiversity loss.

Introduction: Due to the ongoing growth in human population, urbanisation is expanding rapidly across the world. The process of urban land expansion often occurs at the expense of natural habitats. This poses the loss of critical resources to many species and consequently drives vulnerable species to population loss with potential exposure to extinction[1].
Additional threats such as the introduction of invasive species, exposure to predators, and noise and light pollution are expected to exacerbate the challenges faced by native and vulnerable species in these areas[2]. Thus, it is critical to understand the dynamics of species diversity across urban areas and identify other disturbances exposed to species in these new building areas.

Figure 1: Two Audio Moth devices deployed in a participants garden, one for bats and one for birds.

Methodology:

- Conducted across two newly developed housing estates; Hackwood Grange and Langley Country Park, in Derby United Kingdom.
- In total, 15 participants volunteered via social media and flyers.
- A questionnaire collected information on house and garden descriptions, see Table 1.

- Audio Moths (Fig.1) were used to assess species richness, bat activity, and acoustic diversity of birds.
- Devices were deployed for four days.
- Several acoustic indices (NDSI, ACI, ADI, and BI) were calculated in Software R[3].
- Bat species identification were performed in Kaleidoscope Pro Analysis Software[4].
- Differences among housing development zones were determined by independent t-tests and were calculated in Software R[3].

Table 1: The questionnaire received 15 responses with houses 1-4 successfully capturing audio. Vegetation descriptions: none (slabbed, gravel, or artificial lawn), some (few pots and planters), fair (lawn, borders, shrubs), mostly (lawn, borders, shrubs, trees).

House	Estate	Vegetation	Habitat within 100 m	Observed species	Bird feeder	Dawn chorus	Hedgerows
1	Hackwood	Fair amount	Semi-urban	0-3	No	Quiet	Some
2	Hackwood	Fair amount	Rural-agricultural	3-6	No	Unaware	Many
3	Langley	Some	Semi-urban	3-6	Yes	Loud	Few
4	Langley	Fair amount	Semi-urban	3-6	No	Quiet	Some
5	Hackwood	Mostly	Semi-urban	6-10	Yes	Quiet	Many
6	Langley	Fair amount	Semi-urban	6-10	Yes	Loud	Few
7	Hackwood	Fair amount	Semi-urban	0-3	No	Quiet	Some
8	Hackwood	Mostly	Semi-urban	3-6	Yes	Loud	Few
9	Hackwood	Some	Semi-urban	3-6	Yes	Loud	Few
10	Langley	None	Urban	3-6	Yes	Unaware	Few
11	Langley	Some	Rural-agricultural	3-6	No	Quiet	Many
12	Langley	Mostly	Semi-urban	3-6	No	Quiet	Few
13	Langley	Some	Semi-urban	3-6	No	Loud	Few
14	Langley	Fair amount	Semi-urban	0-3	Yes	Unaware	Few
15	Hackwood	Fair amount	Semi-urban	0-3	No	Quiet	None

Results:

Of the four houses which captured audio 75% have semi-urban habitat within 100 m of their homes, a variety of hedgerows, have no bird feeders, but still regularly observe 3-6 species in their gardens (Table 1).

There was a significant difference in bird acoustic diversity for all four of the acoustic indices between the two estates (Table 2) which is reflected in Fig.2.

Table 2: Results from the four indices for birds acoustic diversity across both estates. A description of each index is provided along with the statistical result for each.

Index	Description	T result	Df	P-value	Hackwood mean and SD	Langley mean and SD
NDSI	Estimates the level of human disturbance to a soundscape by comparing the ration of human-made sounds to biological sounds	22.37	12188	<0.001	0.09 ± 0.32	-0.04 ± 0.37
ACI	Measures the variability of sound intensity in audio recordings and used to monitor the complexity of the environment	-17.96	13330	<0.001	152.39 ± 3.76	154.04 ± 6.93
ADI	Measures the diversity of sounds in an area by calculating the Shannon entropy of acoustic energy spread across frequency bands	-24.17	7929.1	<0.001	1.49 ± 0.87	1.81 ± 0.57
BI	Measures the abundance of birds by quantifying the acoustic energy between 2 and 8 kHz	-6.10	11376	<0.001	9.16 ± 7.31	9.96 ± 7.69

Results: There was a significance difference in bat activity between the two estates (T = -4.01, df = 183.53, p = <0.001). Langley exhibited a higher amount of bat pulses with a mean of 6.7 whereas Hackwood had a mean of 5.16, which is reflected in Fig.3.
However, Hackwood recorded a far higher diversity in bat species (Table 3). Of the 17 UK species, Hackwood observed nine species.

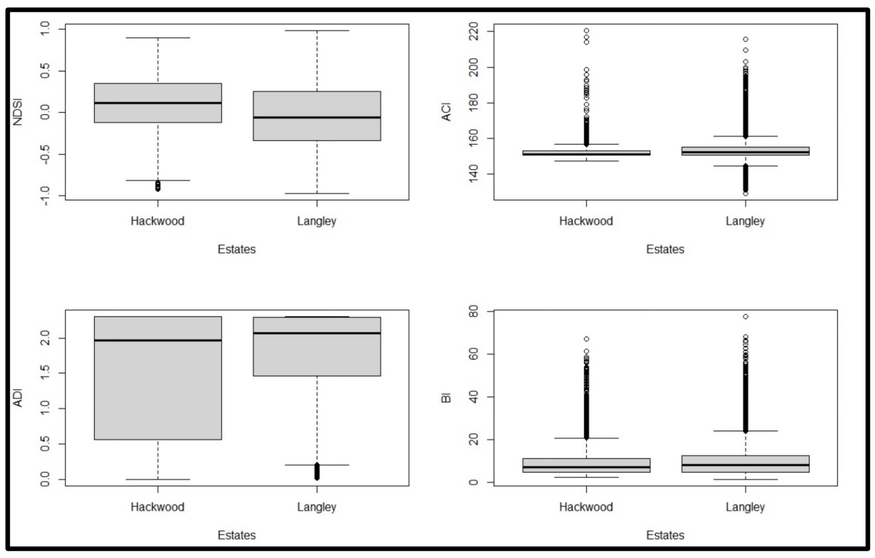

Figure 2: boxplots comparing the four acoustic indices across both housing estates for bird diversity.

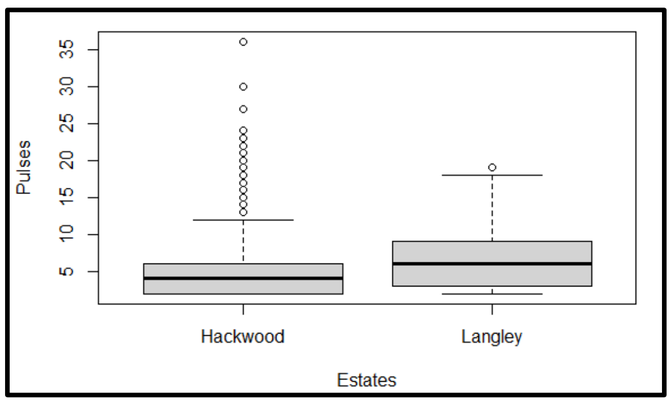

Figure 3: boxplot comparing the bat activity across both housing estates.

Discussion: Langley performed higher in bird acoustic diversity (Table 2, Fig.2). Of the four houses, only one at Langley possessed a bird feeder (Table 1). It is possible this contributed to the species visiting this garden.
Additionally, Langley also exhibited more bat activity (Fig.3).
Interestingly, Hackwood observed more than twice the amount of bat species when compared to Langley.

Conclusion: Hedgerows are important for birds and should remain a permanent fixture in housing estates to promote bird diversity.

Table 3: The UK has 17 bat species, the presence or absence of these species was recorded for both estates.

Species code	Scientific name	Common name	Hackwood	Langley
BARBAR	*Barbastella barbastellus*	Western barbastelle	0	1
EPSTER	*Eptesicus serotinus*	Common serotine	0	0
MYOALC	*Myotis alcathoe*	Alcathoe myotis	0	0
MYOBEC	*Myotis bechsteinii*	Bechstein's myotis	0	0
MYOBRA	*Myotis brandtii*	Brandt's myotis	1	0
MYODAU	*Myotis daubentonii*	Daubenton's myotis	1	1
MYOMAS	*Myotis mystacinus*	Whiskered myotis	1	0
MYONAT	*Myotis natterei*	Natterer's myotis	0	0
NYCLEI	*Nyctalus leisleri*	Leisler's	1	1
NYCNOC	*Nyctalus noctula*	Noctule	1	1
PIPNAT	*Pipistrellus nathusii*	Nathusius' pipestrelle	0	0
PIPPIP	*Pipistrellus pipistrellus*	Common pipestrelle	1	0
PIPPYG	*Pipistrellus pygmaeus*	Soprano pipistrelle	1	0
PLEAUR	*Plecotus auritus*	Brown long-eared bat	1	0
PLEAUS	*Plecotus austriacus*	Grey long-eared bat	0	0
RHIFER	*Rhinolophus ferrumequinum*	Great horseshoe bat	1	0
RHIHIP	*Rhinolophus murinus*	Lesser horseshoe bat	0	0
		Total species:	9	4
		Mean:	0.53	0.24

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