Centre for Biodiversity and Environment Research

# Effects of urban growth on bats in Kent, UK

Daisy Jowers

# Intro to me

MSc Ecology and Data Science 2023-24


Work in the sustainable construction sector

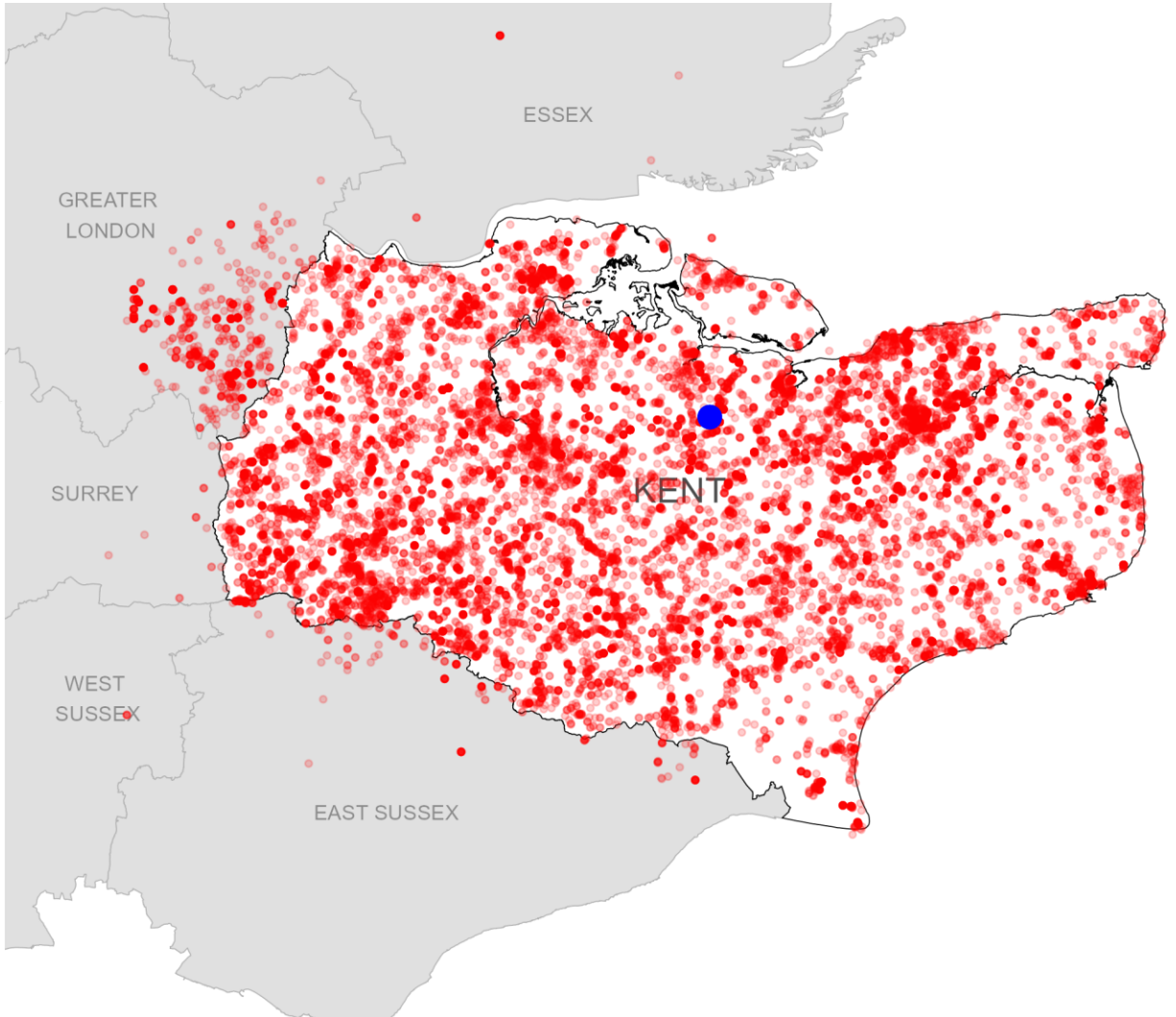
# Outline of talk

1. A look at 40 years of data
2. Investigating the effects of urban growth
3. Questions/Discussion

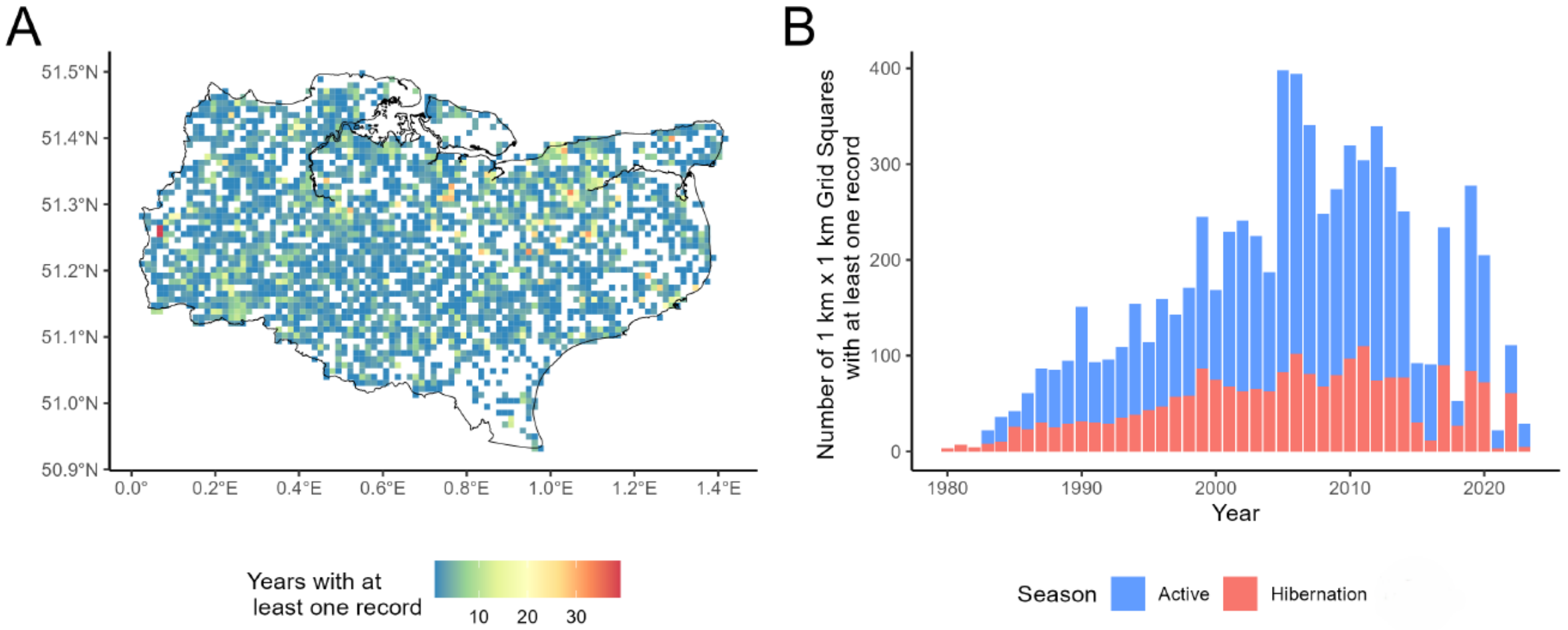
# 43 years of data from citizen scientists


# 43 years of data from citizen scientists

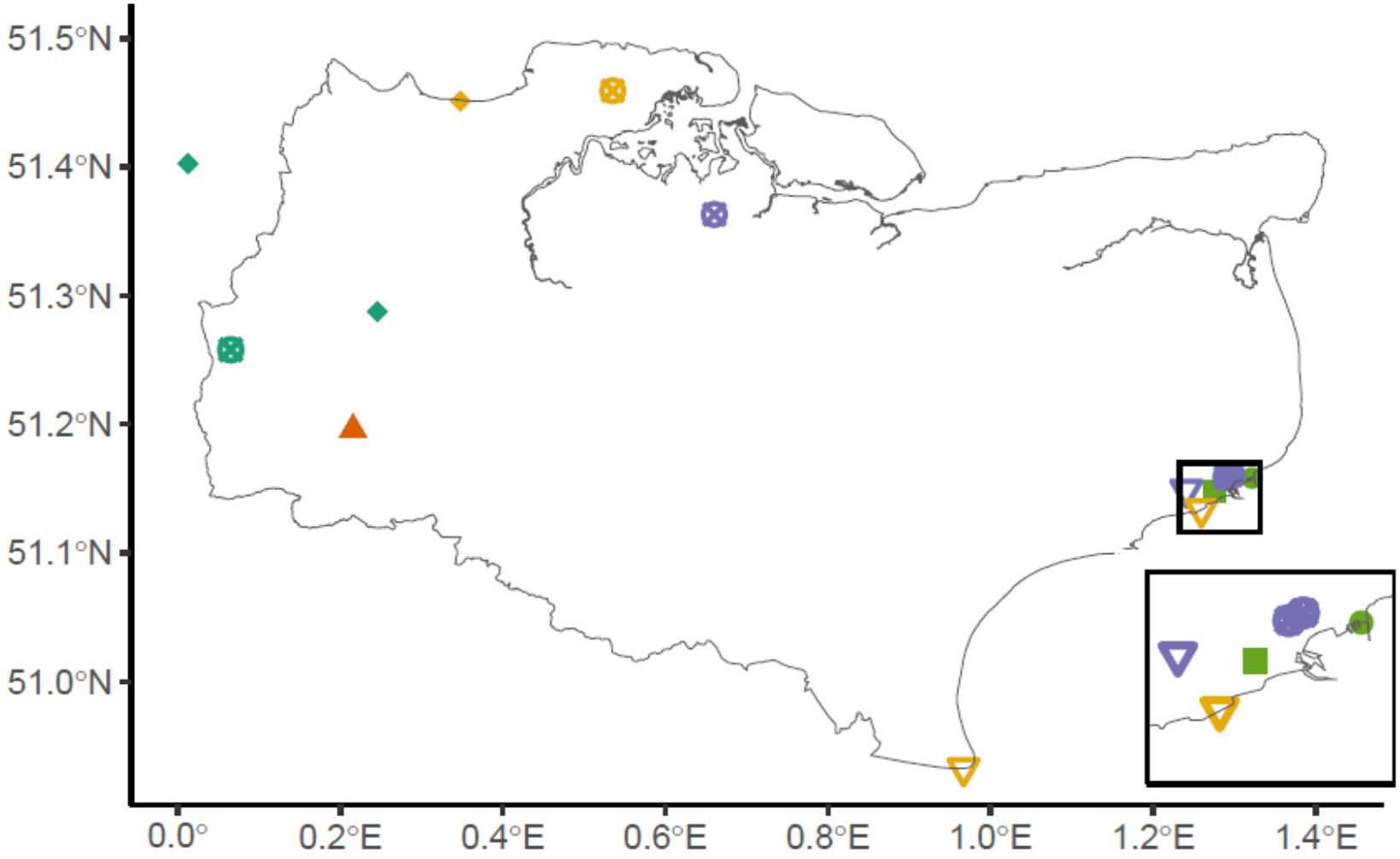
‘subadult. I think coincided with copper underwing emergence.’




# Distribution of records



# The Very Rare



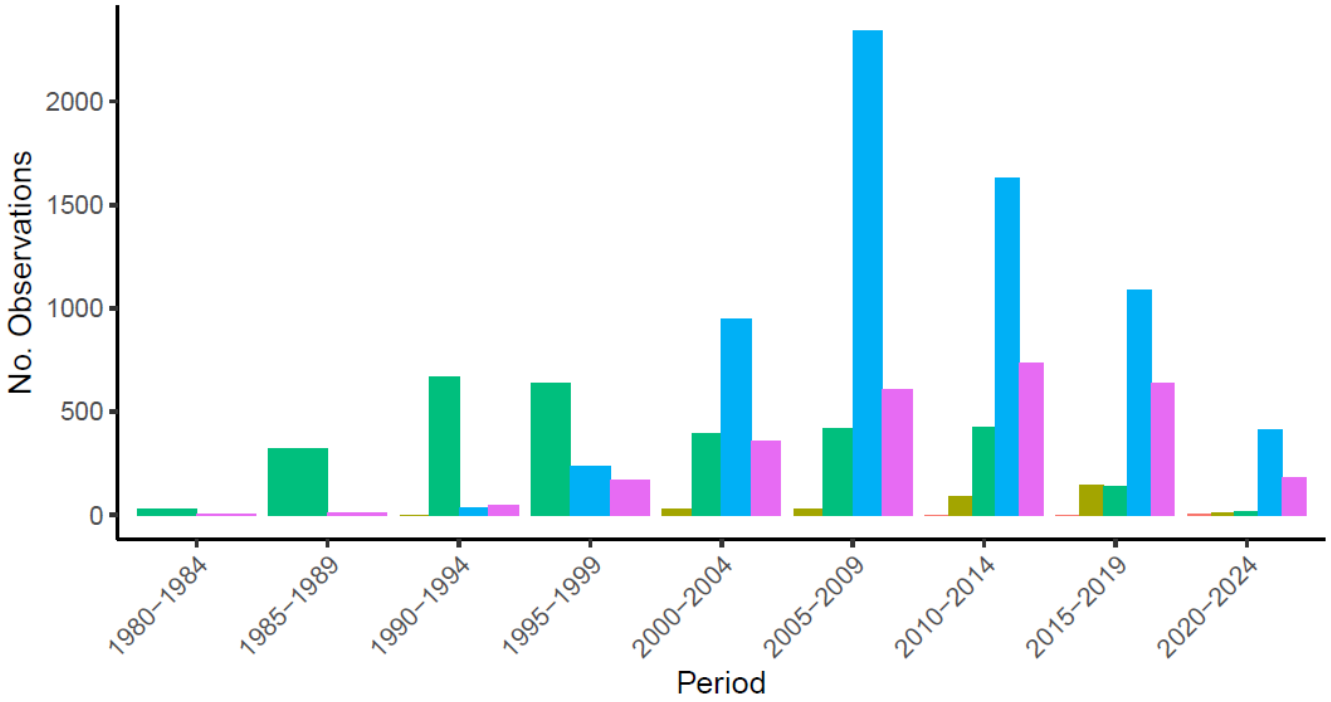

Common Name

- Alcathoe bat
- Barbastelle bat
- Greater horseshoe bat
- Greater mouse−eared bat
- Grey long−eared bat
- Kuhl's pipistrelle

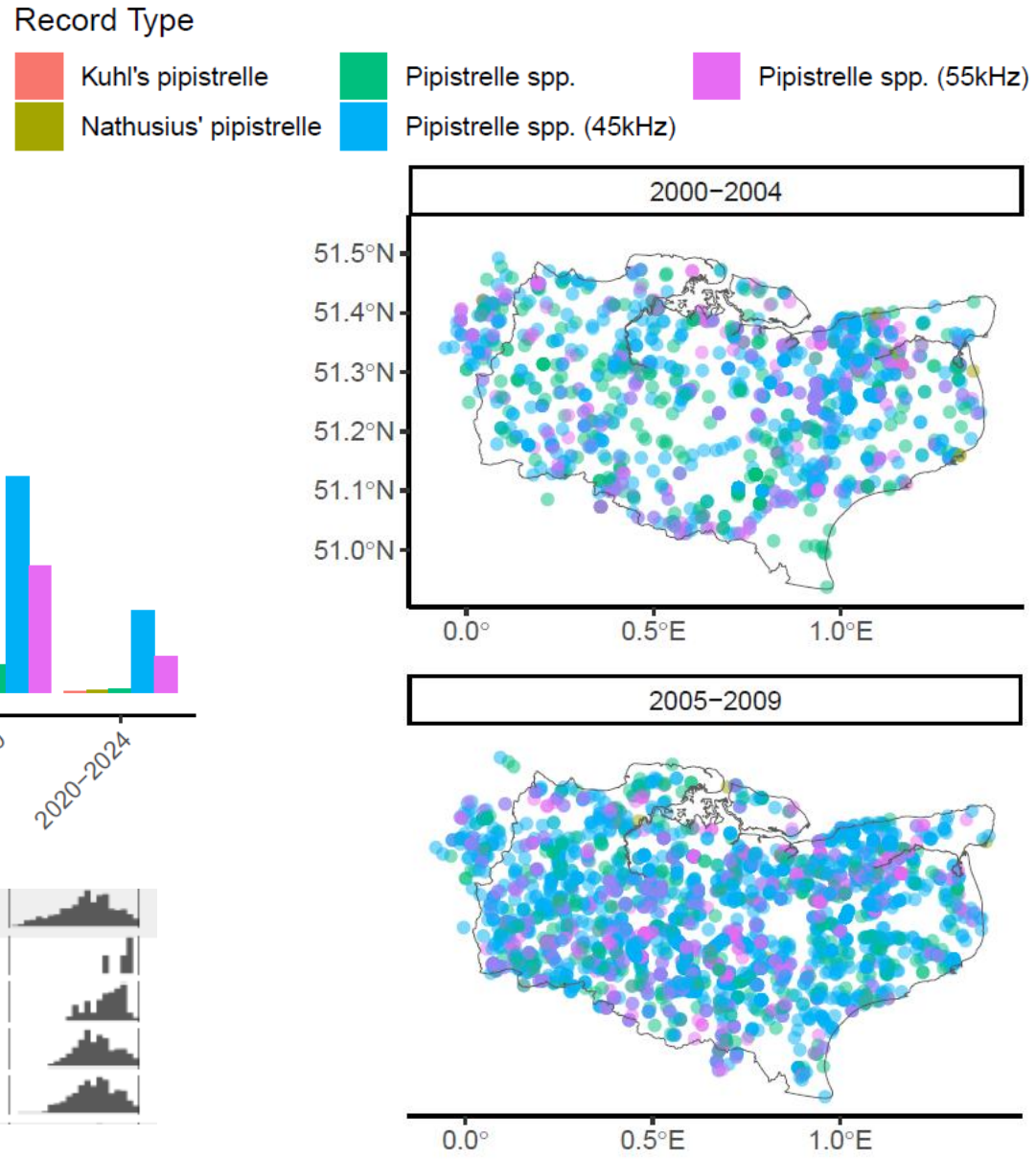
Period

- 1985−1989
- 1995−1999
- 2005−2009
- 2010−2014
- 2015−2019
- 2020−2024

# The Ubiquitous

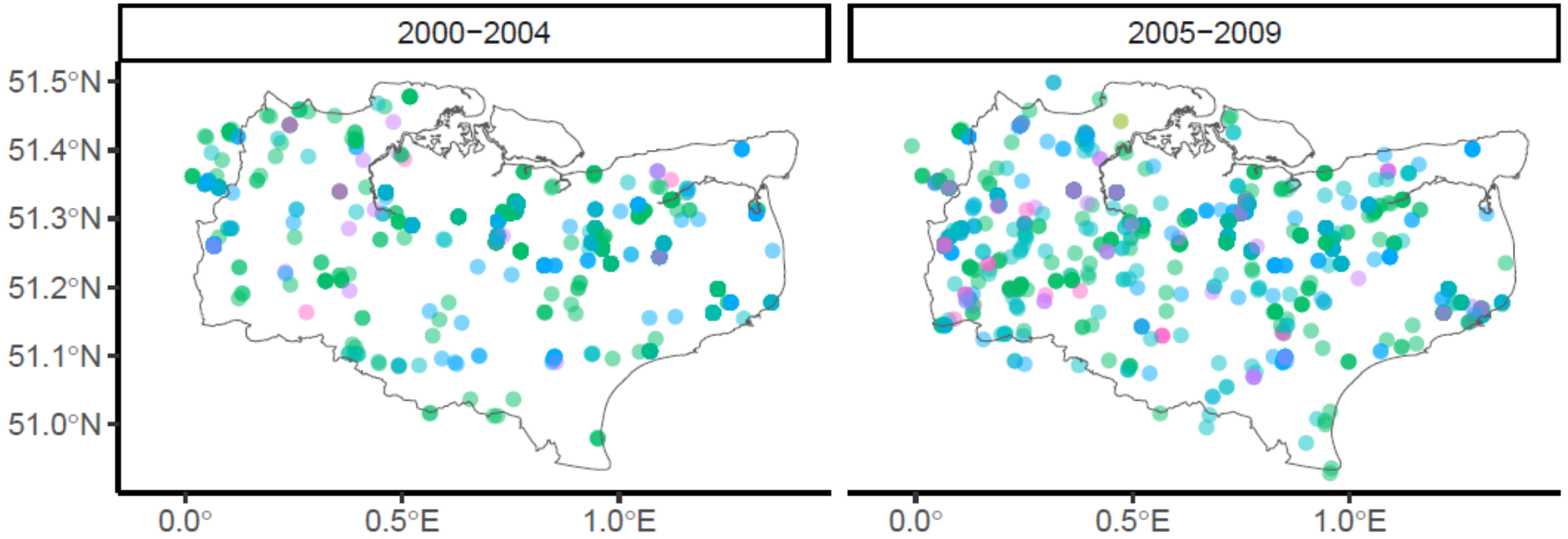



| Pipistrelles | *Pipistrellus gen.* | 12289 | 1981 | 2023 |
|---|---|---|---|---|
| Kuhls pipistrelle | *Pipistrellus kuhlii* | 4 | 2013 | 2020 |
| Nauthusius pipistrelle | *Pipistrellus nathusii* | 299 | 2000 | 2022 |
| Common pipistrelle | *Pipistrellus pipistrellus* | 6395 | 1994 | 2023 |
| Soprano pip | *Pipistrellus pygmaeus* | 2640 | 1984 | 2023 |

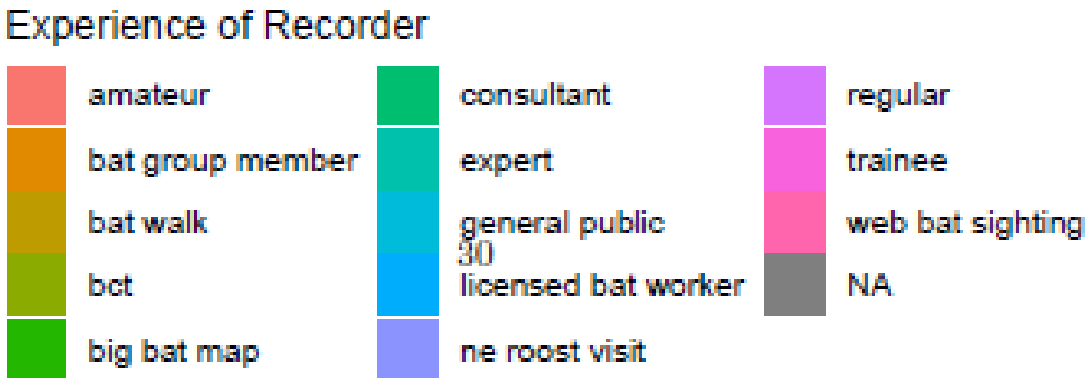


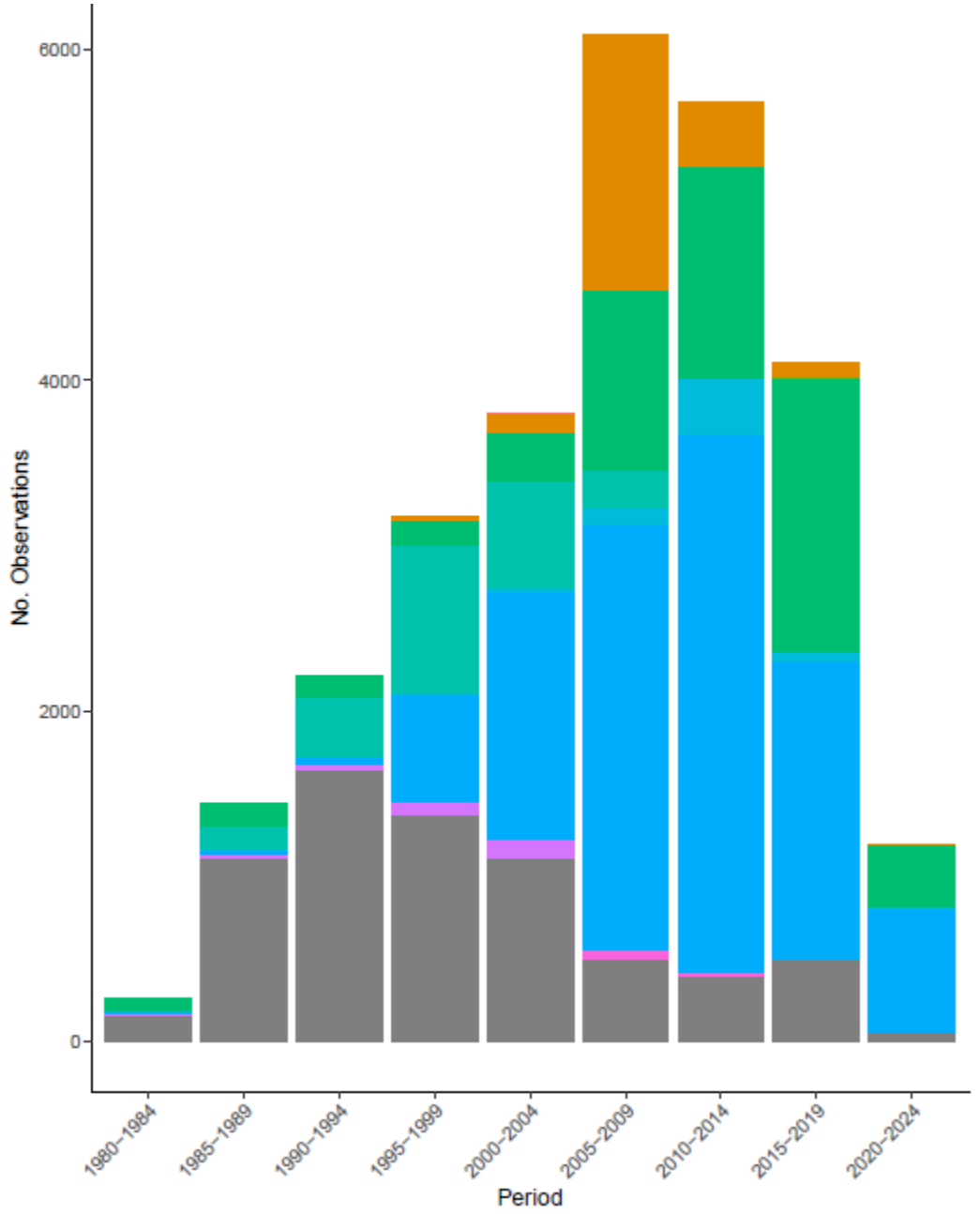
# Myotis

| Mouse-eared bats | *Myotis gen.* | 5685 | 1980 | 2023 |
|---|---|---|---|---|
| Alcathoe | *Myotis alcathoe* | 3 | 2010 | 2017 |
| Bechsteins | *Myotis bechsteinii* | 37 | 2000 | 2019 |
| Brandt's/Whiskered | *Myotis brandtii/mystacinus* | 574 | 1980 | 2022 |
| Daubentons | *Myotis daubentonii* | 2692 | 1980 | 2023 |
| Grey mouse-eared | *Myotis myotis* | 2 | 1985 | 1985 |
| Natterers | *Myotis nattereri* | 1738 | 1980 | 2023 |



# Change in observers over time



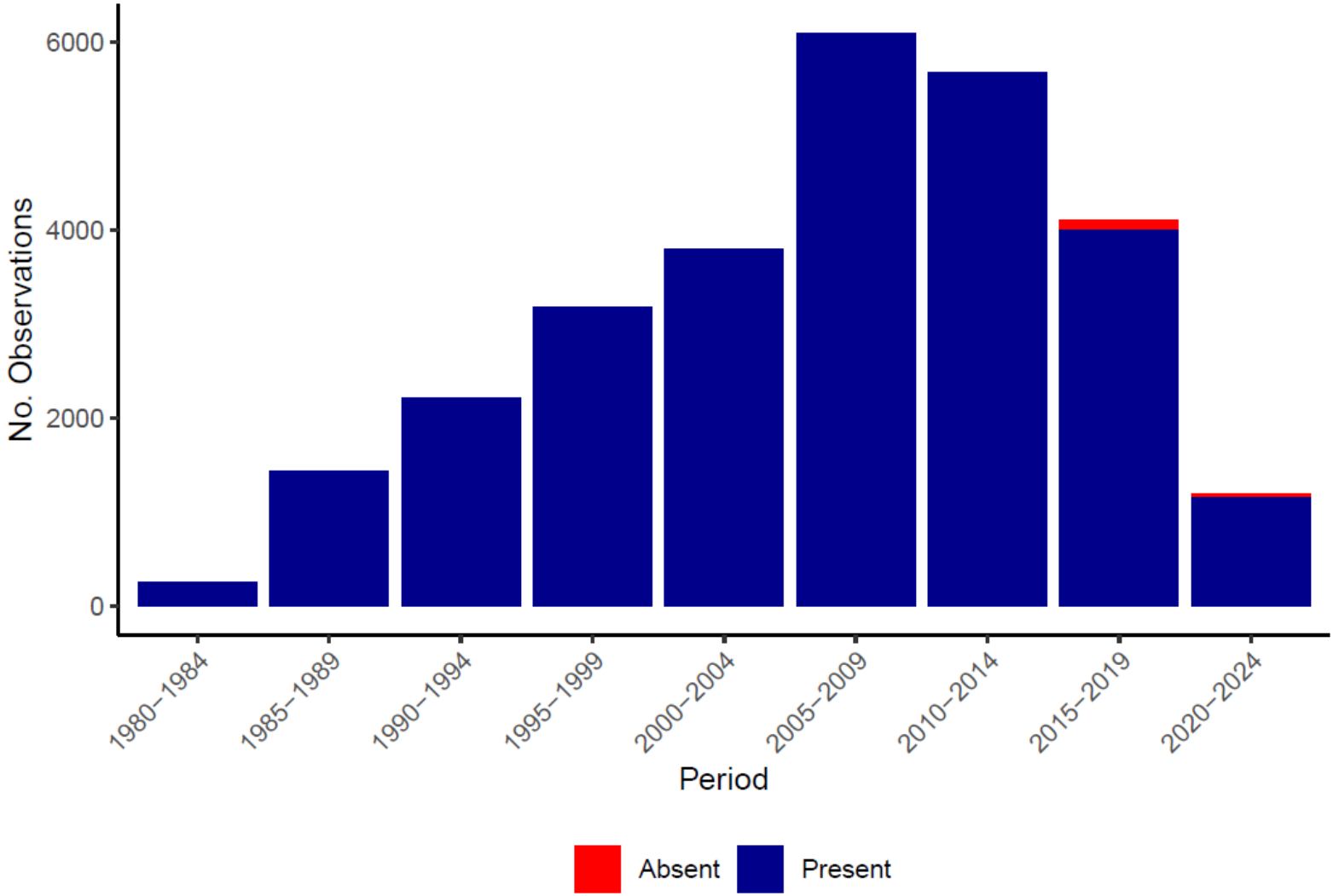
# Recommendations

Record your absences!!

Fill in everything you know

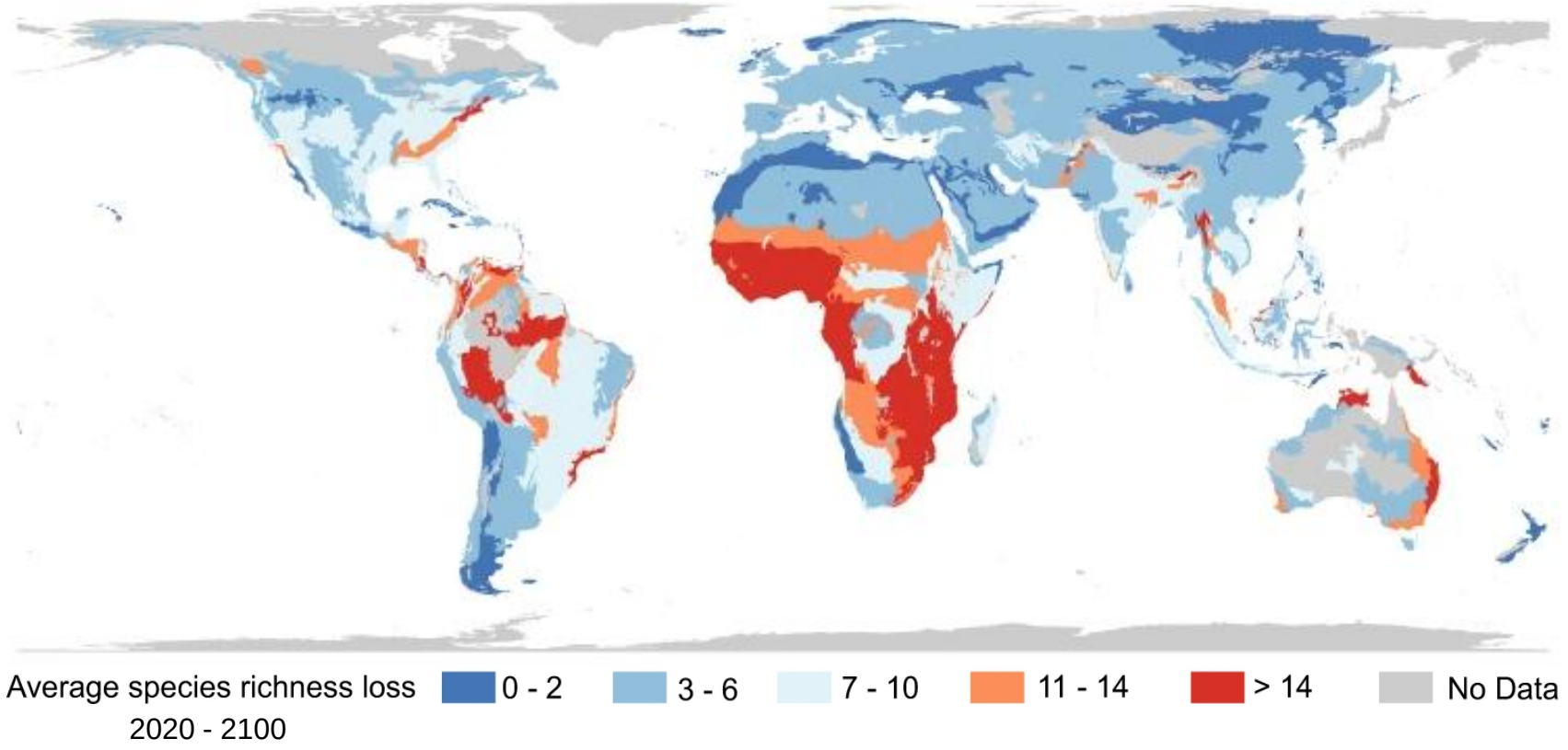
1 entry per species!

Keep personal data separate



# Questions on Part 1?

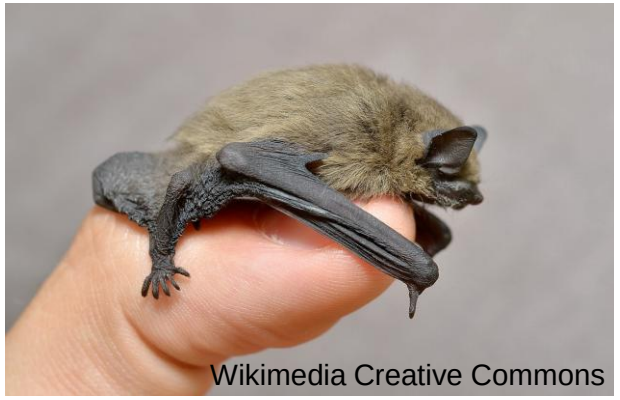
# Biodiversity is globally threatened by urban growth

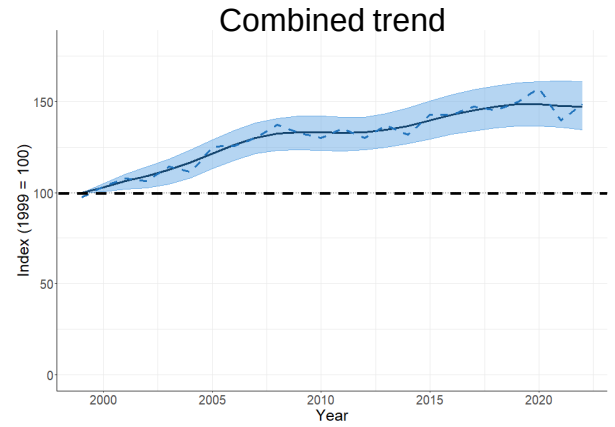



Li et al. (2022) *Global impacts of future urban expansion on terrestrial vertebrate diversity*

# A brief overview of British bats

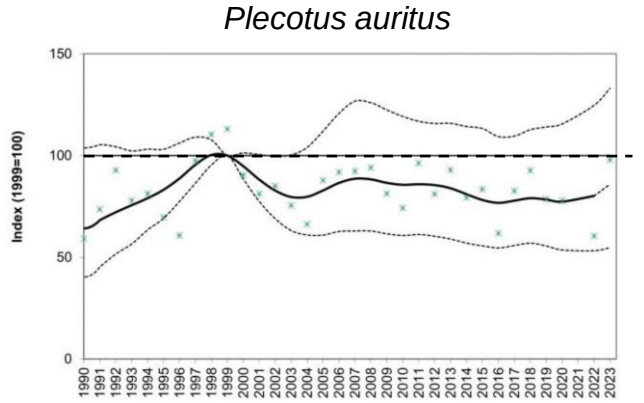
- 18 species (17 breeding).
- Overall UK population trend is positive.
- Variation across species.
- Limited knowledge of some species.


Wikimedia Creative Commons





Northumberland Bat Group



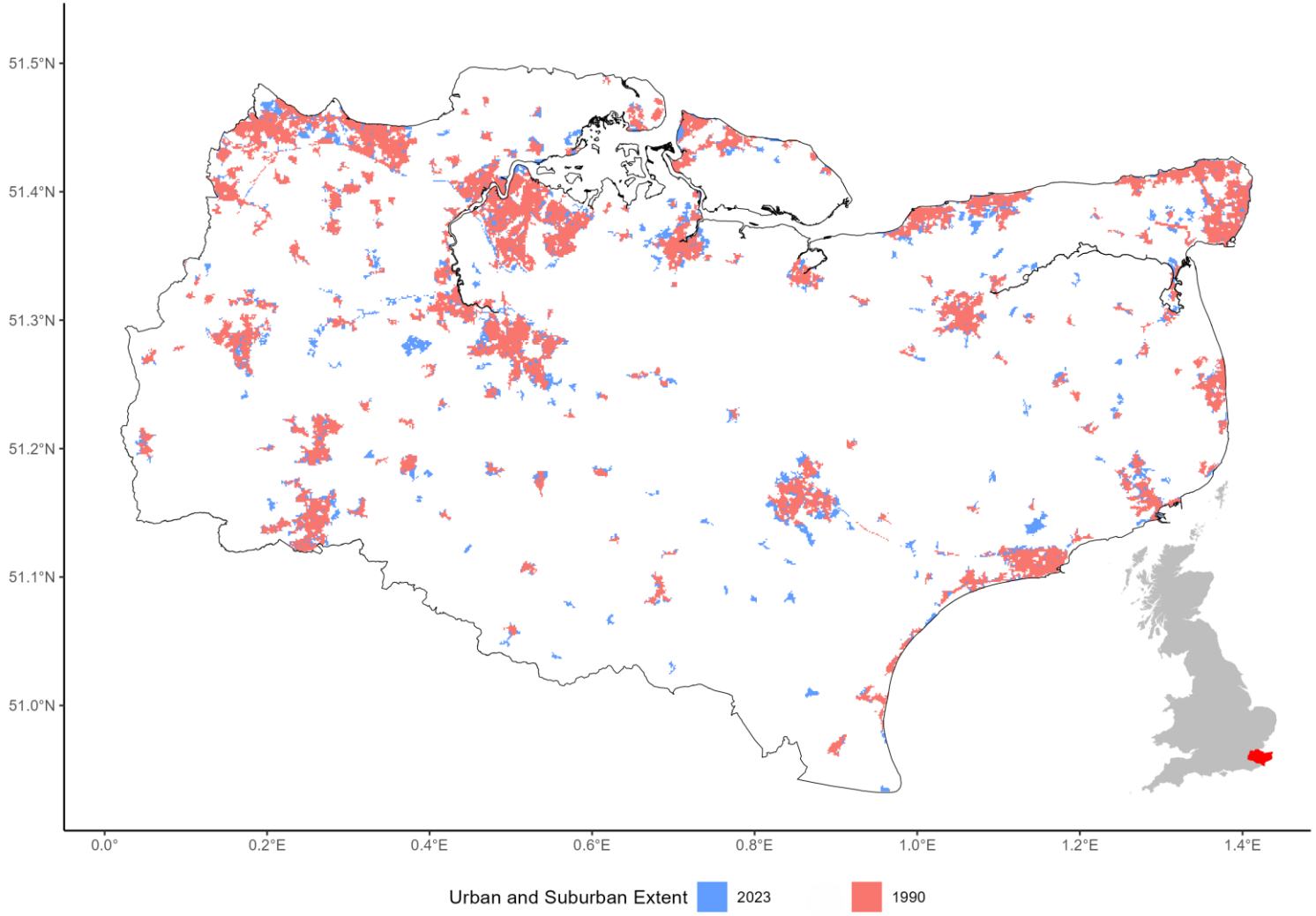

Bat Conservation Trust (2024) *The National Bat Monitoring Programme Annual Report 2023.*
Joint Nature Conservation Committee (2023) *UK Biodiversity Indicators 2023* (Indicator C8i).

# Bats can act as indicators of wider population trends

- Increasingly easy to monitor.
- Successfully used for other ecological changes.
- Monitored across the UK and the EU.
- More knowledge required in urban landscapes.

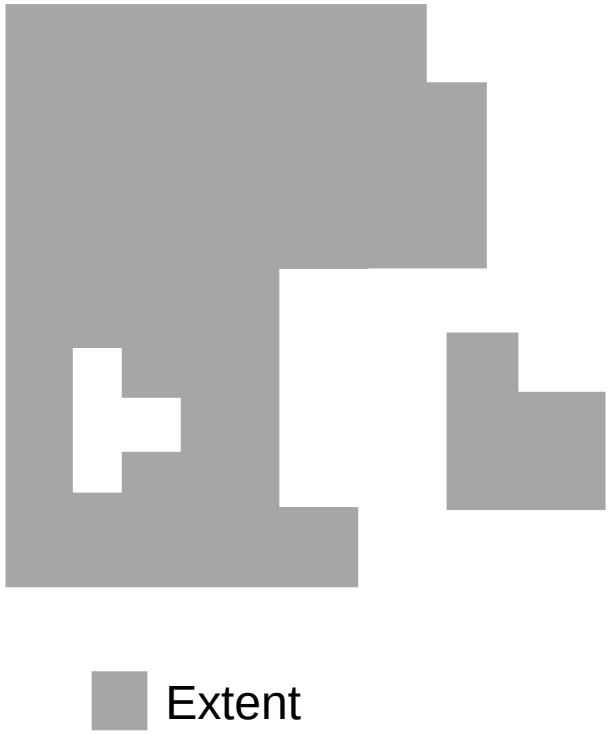

Russo et al. (2021) *Do We Need to Use Bats as Bioindicators?* (Review)
Hill et al. (2018) *AudioMoth: Evaluation of a smart open acoustic device for monitoring biodiversity and the environment.*
Gibb et al. (2019) *Emerging opportunities and challenges for passive acoustics in ecological assessment and monitoring.*

# Urban growth in Kent



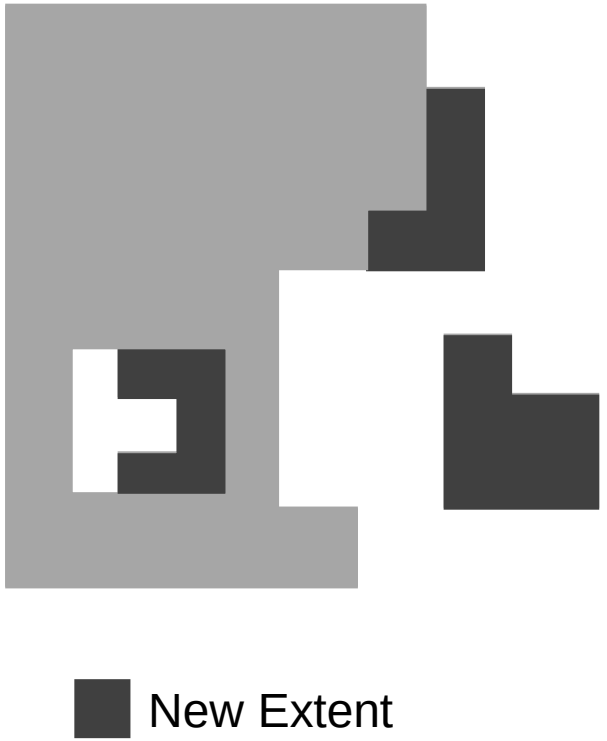
# Three hypotheses about urban growth effects

**H1:** Urban Extent



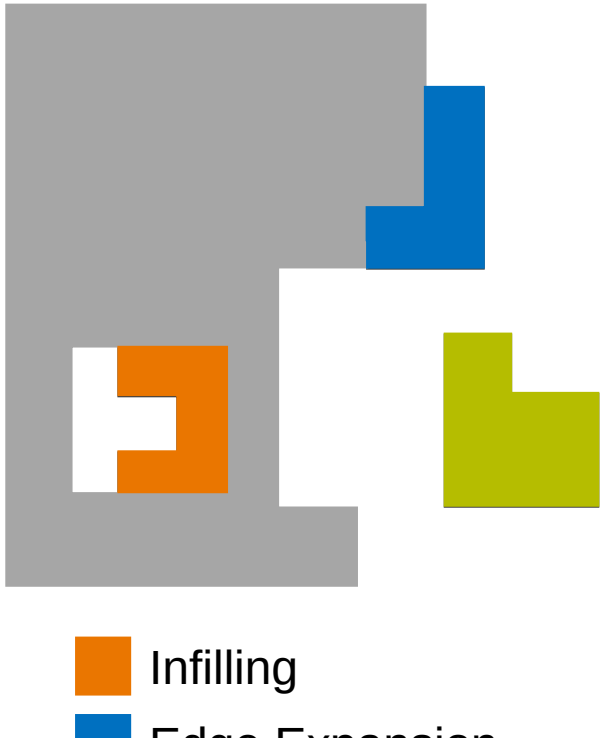
Extent

**H2:** Urban Growth



New Extent

**H3:** Pattern of Urban Growth



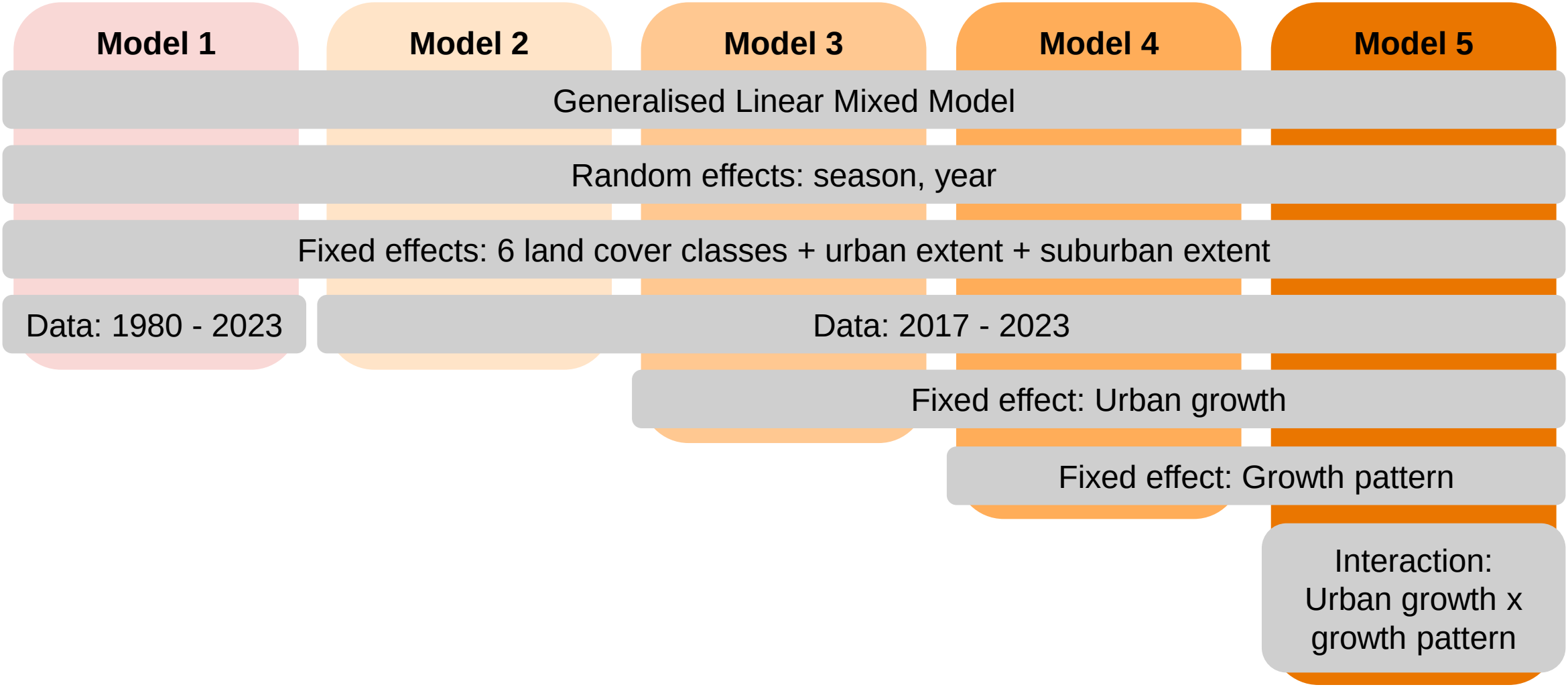
Infilling

Edge Expansion

Outlying

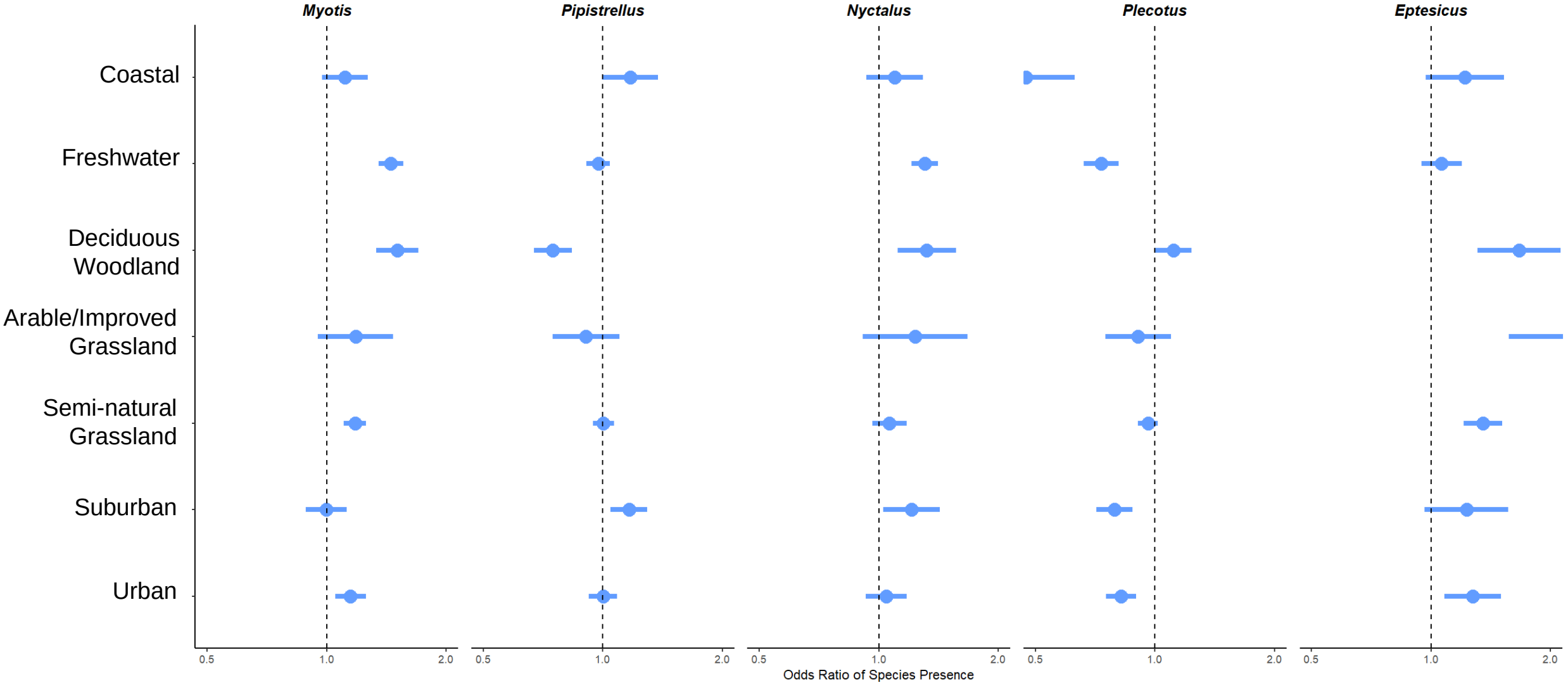
Liu et al. (2010) *A new landscape index for quantifying urban expansion using multi-temporal remotely sensed data.*

# Five model specifications

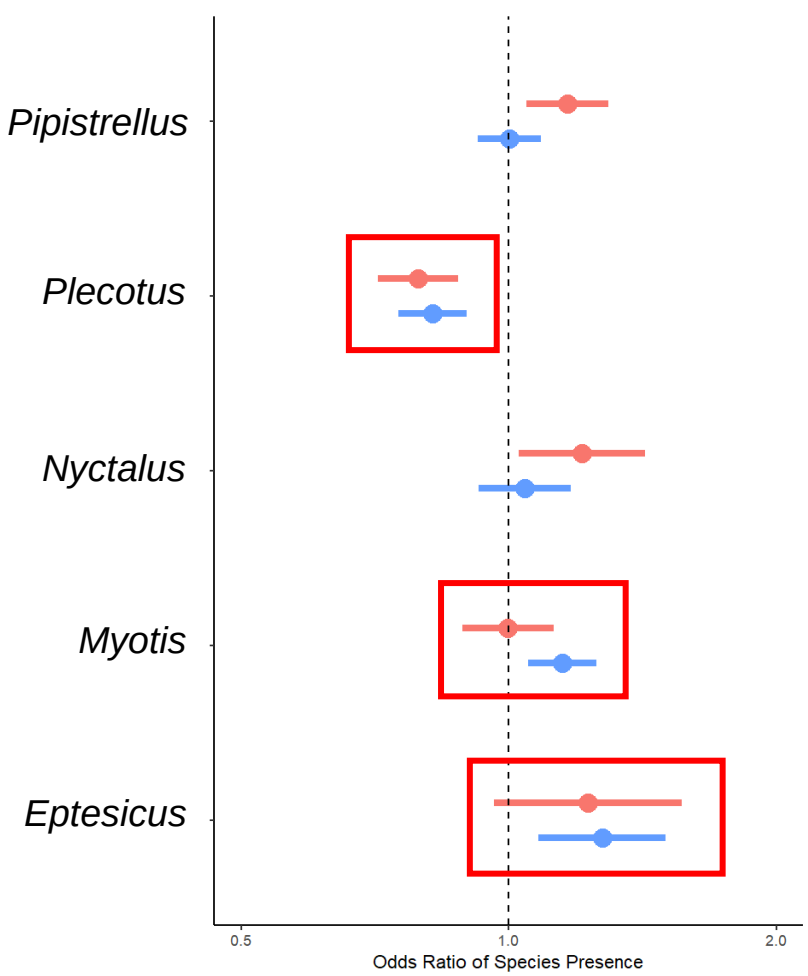


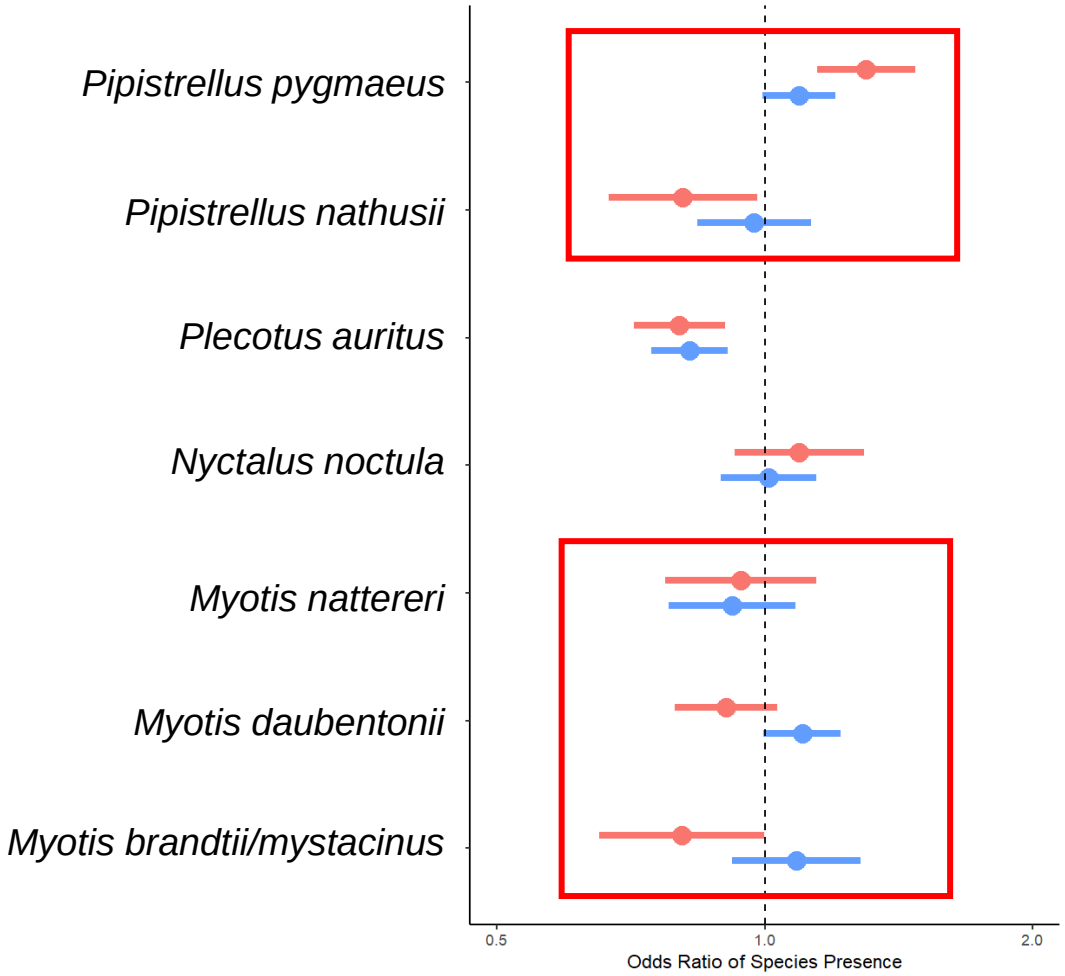

Bates et al. (2015) *Fitting Linear Mixed-Effects Models Using* `lme4`.

# Results of non-urban land cover types



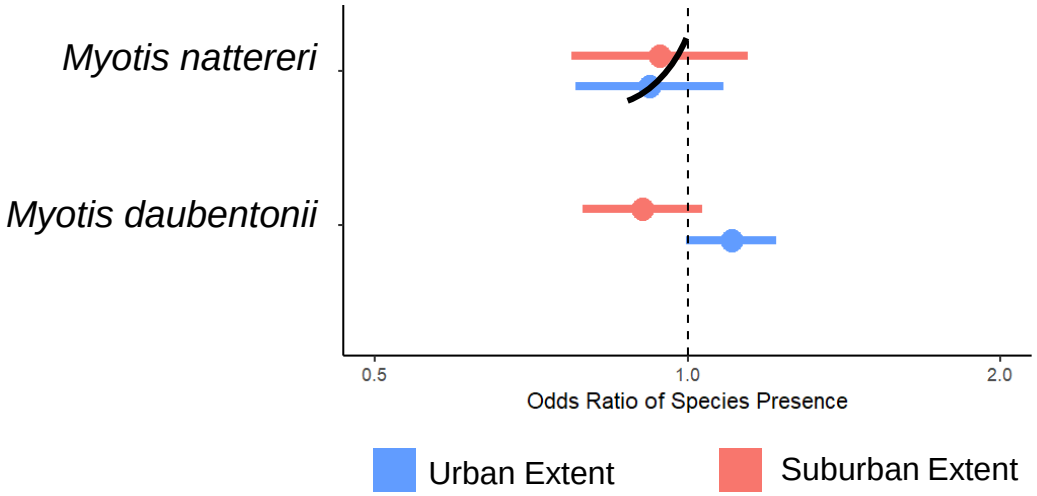
# More species utilise urban land than expected

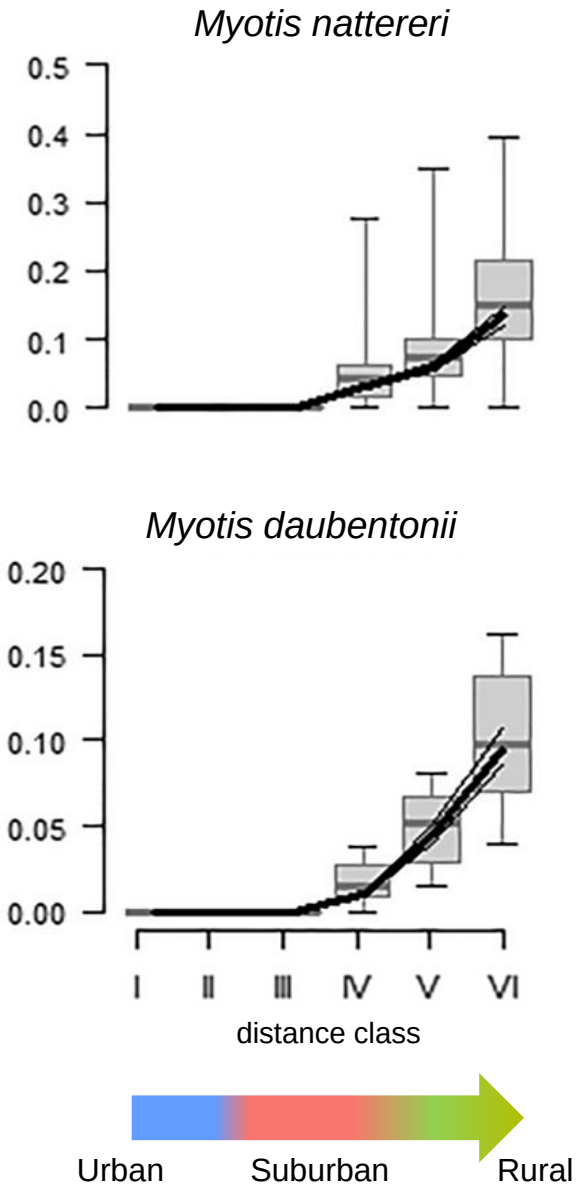



Urban Extent  Suburban

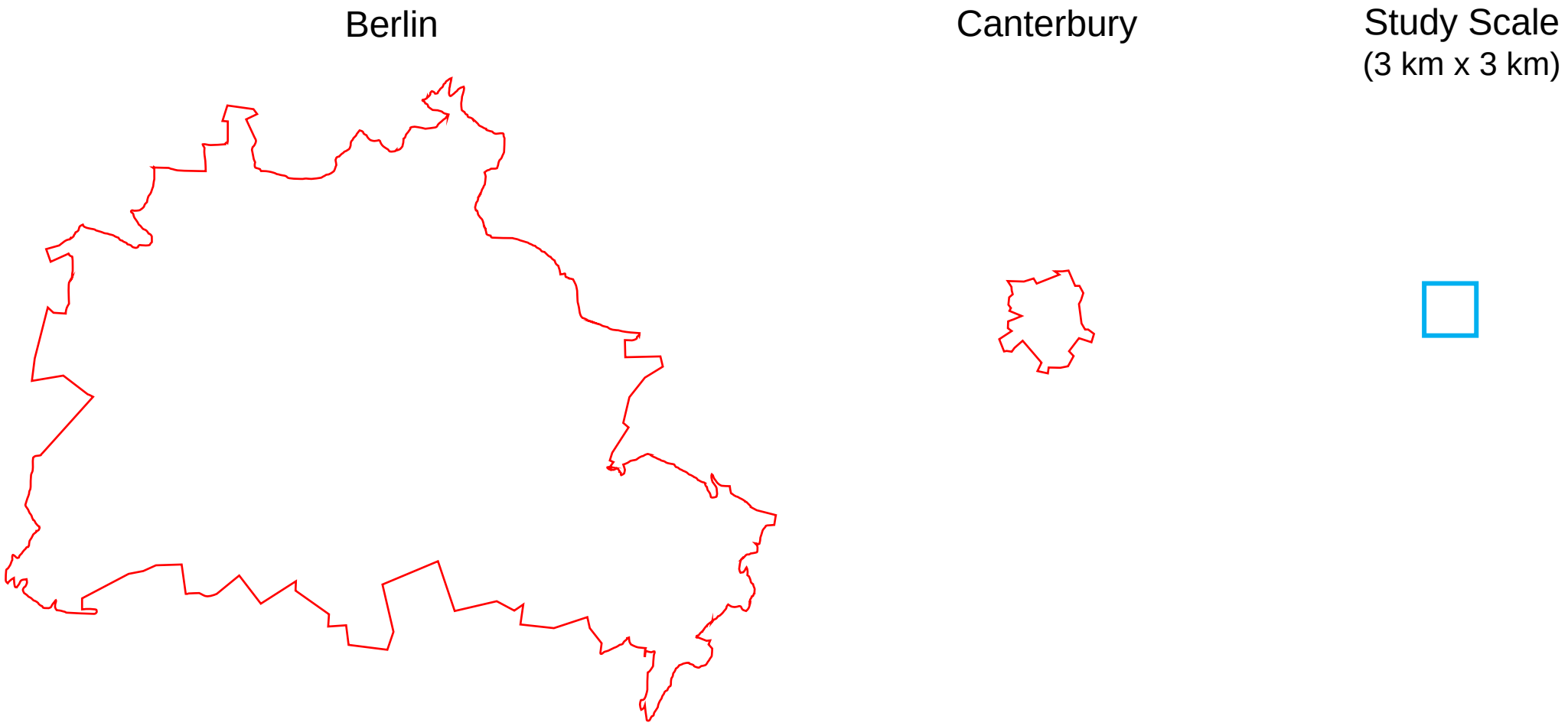
# Findings contrast with previous studies for *Myotis* species




Starik et al. (2024) *Unexpected bat community changes along an urban-rural gradient in the Berlin-Brandenburg metropolitan area.*

# Scale of urban extent may explain difference in findings



# Where urban growth is important, its pattern matters

Infilling

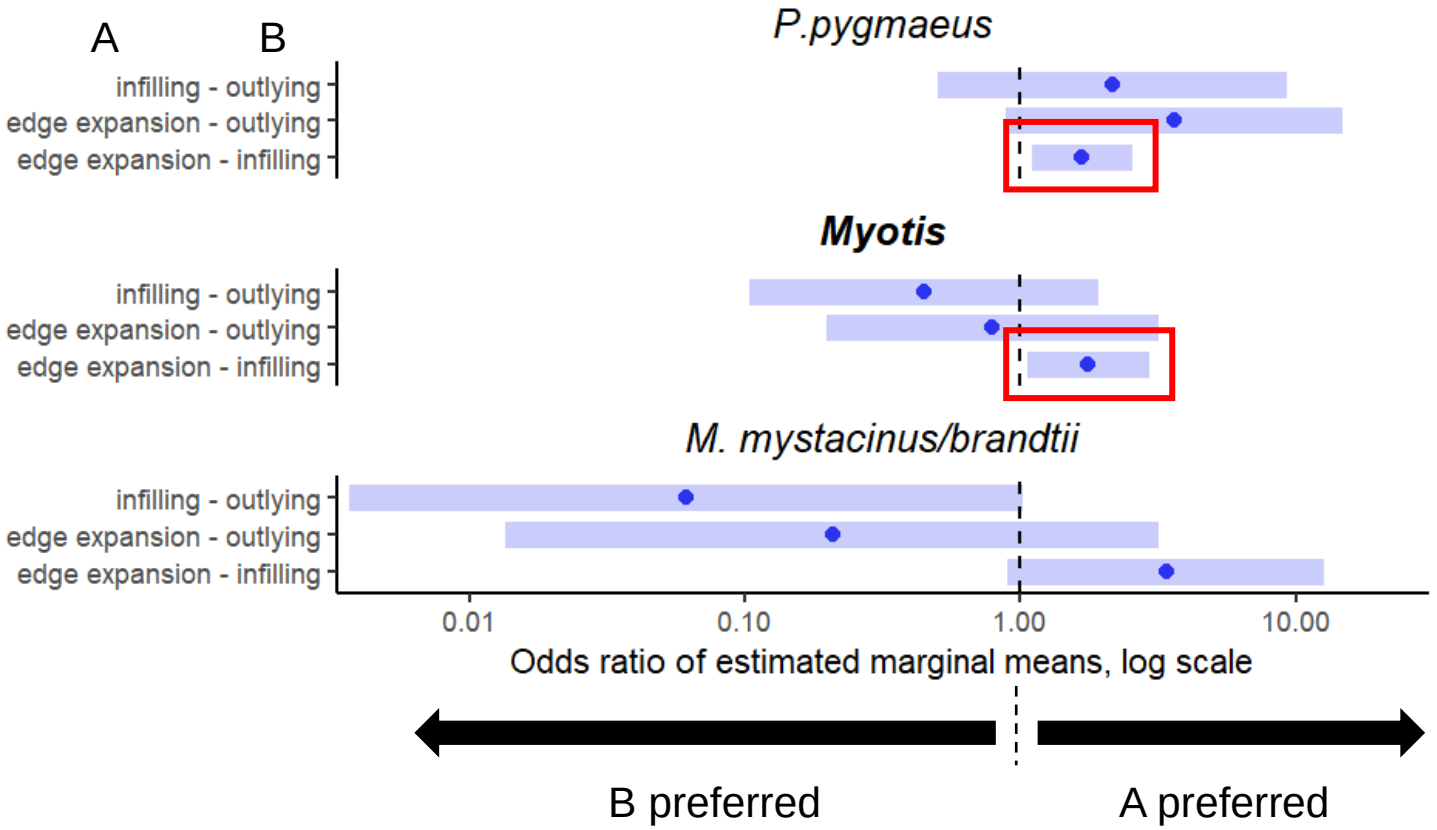
Edge Expansion

Outlying

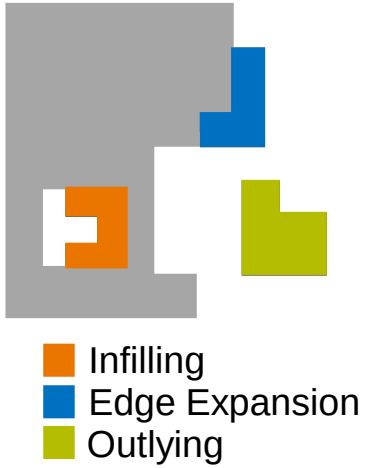
# Where urban growth is important, its pattern matters

Improved model fit in:

- 2 of 7 species
- 1 of 5 genera

# Where urban growth is important, its pattern matters




**Mechanism 1:** ↑ Edge expansion → ↑ Suburban extent → ↑ Populations of regular suburban exploiters

**Mechanism 2:** ↑ Infilling → ↓ Urban fragmentation → ↓ Populations of opportunistic urban exploiters

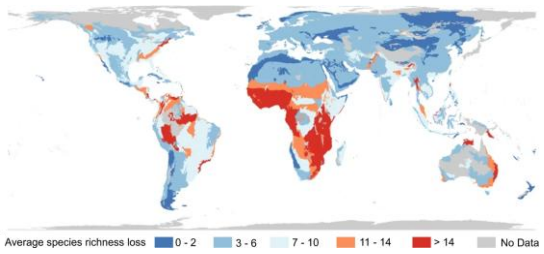
Starik et al. (2024) *Unexpected bat community changes along an urban-rural gradient in the Berlin-Brandenburg metropolitan area.*
Lintott et al. (2015) *Opportunities for improving the foraging potential of urban waterways for bats.*

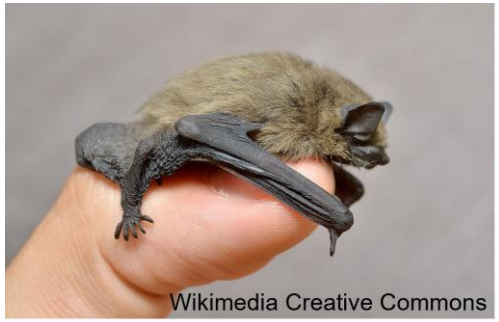
# Conclusions

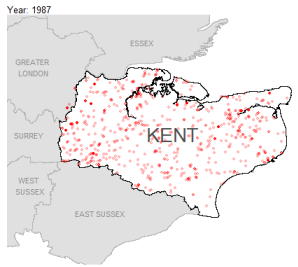
- Valuable historic information is hidden in poorly-standardised databases.
- Scale matters when considering effects of urban extent.
- In smaller cities and large towns, more species may be able to exploit urban resources – as long as sufficient fragmentation is maintained.
- Future research: rarer species, activity levels, greater temporal coverage.

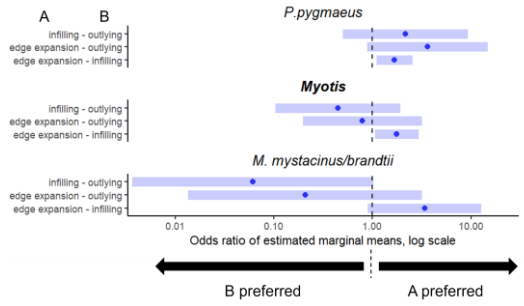
# Summary

- Global biodiversity is threatened by urban growth.
- Bats are a promising indicator group.
- A large citizen science dataset was used to investigate effects of urban growth on populations.
- Edge expansion is better for *Myotis* and *P. pygmaeus* than infilling.
- More research is needed to investigate effects in other genera/species.



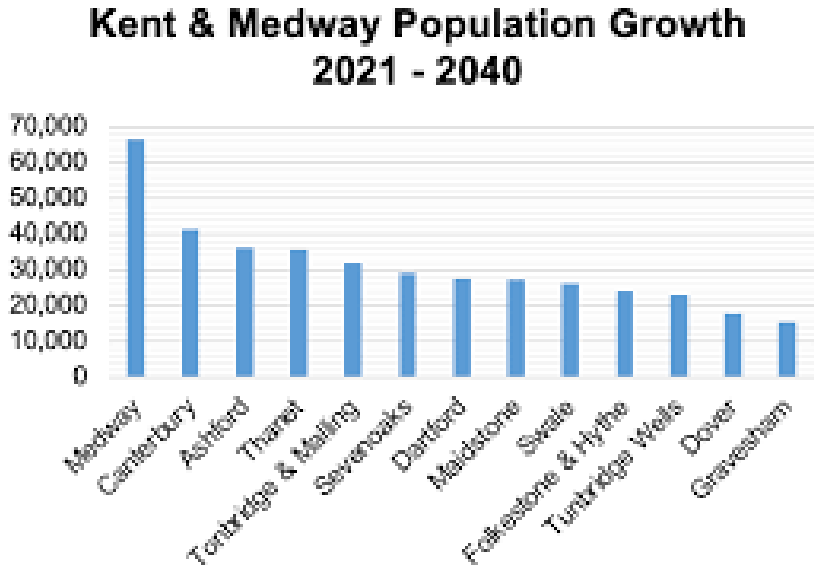




# Future Directions

- Better detection modelling
- Other regional bat groups and other fauna/flora groups
- More understanding of outlying developments
- Projecting into the future



# References


Li, G., Fang, C., Li, Y., Wang, Z., Sun, S., He, S., Qi, W., Bao, C., Ma, H., Fan, Y., Feng, Y., & Liu, X. (2022). Global impacts of future urban expansion on terrestrial vertebrate diversity [Publisher: Nature Publishing Group]. *Nature Communications*, 13(1), 1628. https://doi.org/10.1038/s41467-022-29324-2

Gibb, R., Browning, E., Glover-Kapfer, P., & Jones, K. E. (2019). Emerging opportunities and challenges for passive acoustics in ecological assessment and monitoring [Num Pages: 17 Place: Hoboken Publisher: Wiley Web of Science ID: WOS:000459020800002]. *Methods in Ecology and Evolution*, 10(2), 169–185. https://doi.org/10.1111/2041-210X.13101

Hill, A., Prince, P., Piña Covarrubias, E., Doncaster, C., Snaddon, J., Rogers, A. (2018). AudioMoth: Evaluation of a smart open acoustic device for monitoring biodiversity and the environment. *Methods in Ecology and Evolution.* 2018; 9: 1199-1211. https://doi/10.1111/2041-210X.12955

Russo, D., Salinas-Ramos, V. B., Cistrone, L., Smeraldo, S., Bosso, L., & Ancillotto, L. (2021). Do We Need to Use Bats as Bioindicators? *Biology*, 10(8), 693. https://doi.org/10.3390/biology10080693

Joint Nature Conservation Committee. (2023). *UK Biodiversity Indicators 2023* (Indicator C8i). Available at: https://jncc.gov.uk/our-work/ukbi-c8-mammals-of-the-wider-countryside/ Accessed: 2024-09-03.

Bat Conservation Trust. (2024). *The National Bat Monitoring Programme Annual Report 2023.* [Publisher: Bat Conservation Trust, London]. Available at: https://www.bats.org.uk/our-work/national-bat-monitoring-programme/reports/nbmp-annual-report Accessed: 2024-09-03.

Liu, X., Li, X., Chen, Y., Tan, Z., Li, S., & Ai, B. (2010). A new landscape index for quantifying urban expansion using multi-temporal remotely sensed data [Num Pages: 12 Place: Dordrecht Publisher: Springer Web of Science ID: WOS:000276609800002]. *Landscape Ecology*, 25(5), 671–682. https://doi.org/10.1007/s10980-010-9454-5

Bates, D., Machler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. *Journal of Statistical Software*, 67, 1–48. https://doi.org/10.18637/jss.v067.i01

Starik, N., Gygax, L., & Gottert, T. (2024). Unexpected bat community changes along an urban–rural gradient in the Berlin–Brandenburg metropolitan area [Publisher: Nature Publishing Group]. *Scientific Reports*, 14(1), 10552. https://doi.org/10.1038/s41598-024-61317-7

Lintott, P. R., Bunnefeld, N., & Park, K. J. (2015). Opportunities for improving the foraging potential of urban waterways for bats. *Biological Conservation*, 191, 224–233. https://doi.org/10.1016/j.biocon.2015.06.036

# Questions and Discussion

# Model Equation

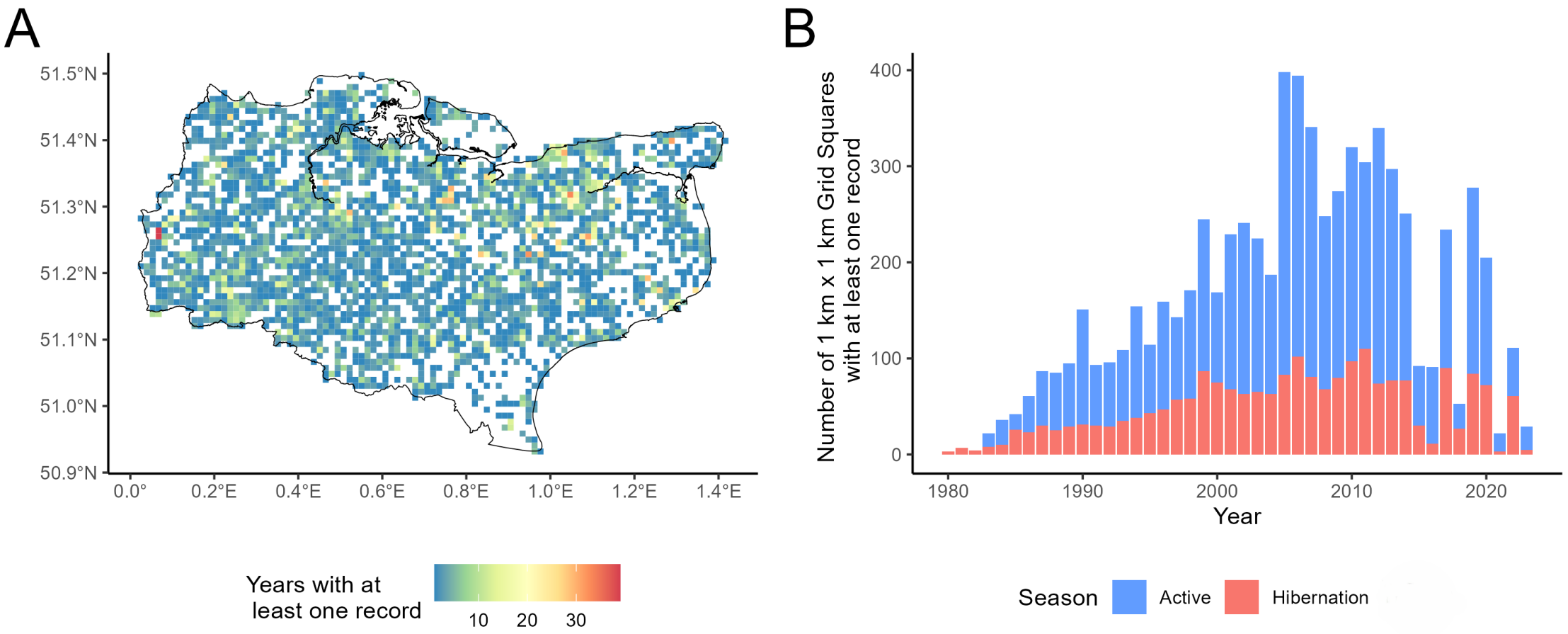
```
glmer(presence ~ fixedeffect1 + fixedeffect2 + … + (1|season) + (1|year), family = "binomial")
```

$$Y_i \sim \text{Binomial}(1, \pi_i)$$

$$\log\left(\frac{\pi_i}{1-\pi_i}\right) = \beta_j Z_{j,i} + b_k W_{k,i}$$

| | | |
|---|---|---|
| $Y_i$ | Response in observation $i$. | $Y_i \in \{0, 1\}$ |
| $\pi_i$ | Probability of observation $i$ being 1. | $0 \leq \pi_i \leq 1$ |
| $\beta_j$ | Coefficient (slope) of fixed effect $j$. | $j \in \{\text{deciduous woodland}, \ldots, \text{growth pattern}\}$ |
| $Z_{j,i}$ | Value of fixed effect $j$ in observation $i$. | $Z_{j,i} = \frac{X_i - \mu_j}{\sigma_j}$ |
| $b_k$ | Coefficient (slope) of random effect $k$. | $k \in \{\text{season}, \text{year}\}$ |
| $W_{k,i}$ | Value (level) of random effect $k$ in observation $i$. | $W_k \in \begin{Bmatrix}\text{hibernation}, \text{active} \\ 1980, \ldots, 2023\end{Bmatrix}$ |

# Spatial and temporal distribution of records



# The Kent Bat Group

https://www.kentbatgroup.org.uk

- Formed in 1983.
- Monitor populations.
- Run the ‘bat ambulance’.
- Educate local residents.