**Supplementary information: Spatial divergence in ecological responses to typhoons across a subtropical island**

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Table S1. Justification behind multi-stability hypotheses tested in this study. Explanation of *a priori* hypotheses for each tested stability component, in both natural forest sites and developed (urban/agricultural) sites, for our focal acoustic indices (NDSI, NDSIBio, NDSIAnthro; see Methods) and bird species detections (*Corvus macrorhynchos*, *Horornis diphone*, *Otus elegans*). For descriptions of components and their calculation, see Table S3.

|  |  |  |
| --- | --- | --- |
| **Stability component** | **Expectation in forest sites** | **Expectation in Developed sites** |
| ***Acoustic Indices*** | | |
| **Pre-typhoon soundscape** | Forests should support more biodiversity (Itô et al., 2000), and thus should have richer biotic soundscapes (NDSI, NDSIBio; Kasten et al., 2012). | Developed sites should have fewer species (lower biophony) but more prevalent noise pollution (higher NDSIAnthro; Kasten et al., 2012). |
| **Post-typhoon soundscape** | Typhoons should reduce biophony either by direct mortality of vocalising species, or movement of species into other habitats (Wiley & Wunderle, 1993), but damage to canopy structure may produce forest gaps through which higher anthropophony can be heard (Cely, 1991). | Typhoons should also reduce biophony with species losses, but given the lower richness of developed sites, we expect a less extreme change. Similarly NDSIAnthro should not increase as much in developed sites. Overall, post-typhoon soundscapes should be less distinct between land cover types compared to pre-typhoon patterns (soundscape homogenisation). |
| **Temporal stability** | Species rich forests should produce uneven, temporally variable, biotic soundscapes (Bradfer-Lawrence et al., 2020), and NDSIAnthro should be infrequent (*i.e.*, variable). | Developed sites should have more consistent (stable) anthropophony than forests (Derryberry et al., 2020), and vocalising species are more likely to be generalists or disturbance-specialists, so should be less variable through time (Concepción et al., 2015). |
| **Resistance** | Closed canopy forests provide resistance to typhoons, buffering soundscapes in the from the immediate loud geophony (wind, rain, etc.) associated with typhoon impact (Abbas et al., 2020). | The more open habitat structure of developed sites should result in higher geophony (including low frequency sounds recognised as anthropophony) immediately following typhoons, so resistance should be lower than in forests (Raymond et al., 2020). |
| **Recovery speed** | Given the greater potential for structural change to habitat in forests, and higher potential change in species richness as a result of habitat loss, all aspects of forest soundscapes should recover more slowly (Elliott & Nino, 1960). Resistance trades off with recovery, so higher forest resistance should mean slower recovery (Patrick et al., 2022). | Less potential structural change and loss of life means developed sites are more likely to recover quickly; connected urban-ecosystems especially recover quickly after typhoons (Chang et al., 2018). Resistance trades off with recovery, so lower developed site resistance should mean faster recovery (Patrick et al., 2022). |
| **Extent of change** | Given the higher potential structural damage to forest, higher potential species losses, and expected slow recovery, the extent of change (longer-term resistance, Table S3) should be higher in forests (Wiley & Wunderle, 1993). | Given the lower potential structural habitat change, disturbance-adapted species, and expected fast recovery, extent of change should be lower in developed sites (Raymond et al., 2020). |
| **Spatial variability** | Forests should host a greater diversity of species from the regional pool, including disturbance-sensitive forest specialists (Wiley & Wunderle, 1993), so spatial variability should be lower (forest sites should have more similar soundscapes). Typhoons should homogenise forest soundscapes by removing specialists and damaging habitat structure, opening habitats to increase anthropophony; higher expected extent of change in forests should result in higher post-typhoon soundscape spatial homogenisation (Cely, 1991). | Developed sites should be more spatially variable before typhoons, as they include agricultural and urban sites (Olivier et al., 2020). Typhoons should homogenise soundscapes in space through their destructive potential, loss of any specialists etc., though the lower expected extent of change among developed sites (Raymond et al., 2020), means the effect size of the post-typhoon spatial homogenisation should be lower than among forest sites. |
| ***Species detections*** | | |
| **Pre-typhoon detections** | Total species detections should be higher in forests, driven by the forest specialist *Otus elegans* (Inoue et al., 2019). | Total species detections should be lower in developed sites than in forests, and individual species (*Horornis diphone*, *O. elegans*) should be detected less frequently, but *Corvus macrorhynchos* is a generalist well adapted to developed sites, so should not differ with land cover (Devictor et al., 2008). |
| **Post-typhoon detections** | Total species detections should decline following the typhoons, driven by the habitat specialist *O. elegans* and sensitive, small-bodied *H. diphone*, while *C. macrorhynchos* is largely unaffected (Cohen et al., 2021). The greater potential habitat loss in forests should result in a greater change in vocalisation rates in the forest than developed sites (Wiley & Wunderle, 1993). | Total species detections should decline following the typhoons, driven by the vulnerable small-bodied *H. diphone* in agricultural sites (Cohen et al., 2021). *C. macrorhynchos*, a disturbance-adapted omnivore, should be unaffected by the typhoon (Seki, 2005). The lesser expected structural habitat change should produce less severe drops in detection rates in developed sites (Wiley & Wunderle, 1993), and the change in forested sites should serve to bring detection rates closer together among habitat types (no expected post-typhoon difference in detections). |
| **Temporal stability** | Bird detections should mirror acoustic indices (Kasten et al., 2012); natural forest soundscapes should have more variable bird detections of each species, owing to high competition for acoustic space with non-focal vocalising species (Krause, 1993). | Variability of bird detections should be lower in developed sites than in forests; open habitat structure provides less attenuation of sound, and species are more likely to be generalists, with less extreme competition for acoustic space due to lower species richness (Krause, 1993). |
| **Extent of change** | Greater potential structural habitat change should produce higher extent of change values in forest for bird detections, particularly for the sensitive/specialist species *H. diphone* and *O. elegans*, which should both decline post-typhoon (Chevalier et al., 2019). *C. macrorhynchos*, a generalist, should be largely unaffected, or in some cases benefit by the creation of forest gaps increasing access to insect, small mammal, and reptilian prey (Zhang et al., 2016). | Less potential structural habitat change should result in lower extents of change for bird detections in developed sites (Wiley & Wunderle, 1993). *C. macrorhynchos*, a generalist, should be largely unaffected, while *H. diphone* should decline where present due to its reliance of bush and understorey vegetation (Chevalier et al., 2019). |
| **Spatial variability** | As with acoustic indices, typhoons should homogenise bird detections across forest sites due to changes in habitat structure, and mortality or behavioural changes of birds following typhoons (Wiley & Wunderle, 1993). The specialists, *H. diphone* and *O. elegans* should be more homogenised than *C. macrorhynchos* (Seki, 2005). The higher potential extent of change in forests should result in a greater post-typhoon spatial homogenisation among forest sites than among developed sites (Elliott & Nino, 1960). | Typhoons should homogenise bird detections across developed sites, as agricultural and urban sites become more similar following changes to habitat specialists in agricultural sites such as *H. diphone* (Olivier et al., 2020). The lower richness and lower potential extent of change (due to less structural habitat change) should result in less severe spatial homogenisation among developed sites (Elliott & Nino, 1960). The disturbance-adapted generalist, *C. macrorhynchos* should not suffer spatial homogenisation as much as the other species among developed sites (Seki, 2005). |



**Figure S1.** Ordination biplot for the land cover variables used in this study. We used unsupervised k-means clustering (optimal *k* value = 2 clusters) of a Principal Component Analysis (PCA) of land cover variables (see Methods) to automatically identify clusters of sites with similar land cover. We found a clear distinction between two clusters (red versus blue points and ellipsoids). When examining the variable loadings (land cover classes marked on PCA ordination with names and arrow length showing relative variable weights), we found that the clusters represented a clear distinction along PCA axis 1 (variance explained = 81.2%), where the 10 blue sites were primarily forest sites, while the 14 red sites with either primarily agricultural, urban, or managed grassland sites, herein collectively termed ‘developed’ sites.

**Table S1.** Automatic supervised learning bird species detection classifiers across field sites. We produced automated (supervised machine learning) species vocalisation classifiers in Kaleidoscope Pro (version 5.3.0; Wildlife Acoustics Inc., Concord, MA, USA), using training data from across a variety of sites and dates, and applying trained classifiers to the full dataset of recordings (30 Aug-04 Nov 2018) to automatically identify species detections. We assessed classifier accuracy at each site (Site name, with land use marked in brackets: FOR = forest, DEV = developed site) via visual inspection with a threshold of 15% false positives. We applied the same species-specific classifiers to each site, to prevent site-specific differences in base classifier performance (though given the challenge of applying a single classifier across 24 sites, there were several cases where classifiers did not meet our accuracy threshold (0s in columns 2-4). We achieved accurate classifiers at a range of sites for three species: the large-billed crow (*Corvus macrorhynchos*, 嘴太烏 in Japanese); the Japanese bush warbler (*Horornis diphone*, 鶯); and the Ryukyu scops-owl (*Otus elegans*, 琉球木の葉木菟). Accurate classifiers are marked with 1, indicating that we used data from that site-by-species combination for analysis (see *Analyses on automated species detections*). Note that *O. elegans* is a forest specialist, so is not expected to be found at the developed sites (we did not produce an accurate classifier at any developed sites for this species, in accordance with expectation). Classifiers were produced by S.R.P-J.R. and R.M. and accuracy was visually checked by a single observer (S.R.P-J.R.) for consistency.

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| --- | --- | --- | --- |
| Site name (Land use) | *Corvus macrorhynchos* | *Horornis diphone* | *Otus elegans* |
| Genka (FOR) | 1 | 0 | 0 |
| Hentona (FOR) | 1 | 1 | 1 |
| Katsuudake (FOR) | 1 | 1 | 1 |
| Kemin (FOR) | 1 | 1 | 1 |
| Manabi (FOR) | 1 | 1 | 0 |
| OIST forest (FOR) | 1 | 1 | 1 |
| OIST campus (FOR) | 1 | 1 | 0 |
| Oku (FOR) | 1 | 1 | 1 |
| Takeyanbaru (FOR) | 1 | 1 | 1 |
| Yona (FOR) | 1 | 1 | 1 |
| Chatan (DEV) | 0 | 0 | - |
| Gesashi (DEV) | 1 | 0 | - |
| Heiwa (DEV) | 0 | 1 | - |
| Kurashiki (DEV) | 1 | 1 | - |
| Nago (DEV) | 1 | 0 | - |
| Nakagusuku (DEV) | 1 | 1 | - |
| Oyama (DEV) | 0 | 0 | - |
| Sefa-utaki (DEV) | 1 | 1 | - |
| Senbaru (DEV) | 1 | 1 | - |
| Sueyoshi (DEV) | 1 | 0 | - |
| Tamagusuku (DEV) | 1 | 1 | - |
| Tounan (DEV) | 1 | 1 | - |
| Uehara (DEV) | 1 | 0 | - |
| Yacho (DEV) | 1 | 1 | - |
| Total | 21 | 17 | 7 |



**Figure S2.** **Difference in mean detections of *Horornis diphone* and *Corvus macrorhynchos* under different detection confidence thresholds**. Posterior distributions represent 90,000 post-convergence MCMC draws of the comparison between *Horornis diphone* and *Corvus macrorhynchos* mean daily detections, where values below zero (grey) indicate lower number of detections, and values above zero (blue) a more detections of *H. diphone* relative to *C. macrorhynchos*. Non-zero-spanning credible intervals are marked with \*, while circles indicate zero-spanning credible intervals (no change based on the posterior distribution). Draws are shown per site, ordered from most forested (top) to most developed (bottom) based on principle component axis 1 of the land use dimensionality reduction (Fig. S1). Panels represent results for under three automated detection probability thresholds: 0.5 (a), 0.75 (b), and 0.9 (c). Note that 0.5, which we use throughout, is a conservative filter, as credible intervals more often span zero.



**Figure S3.** Comparison of Biophony (NDSIBio) time series at the Manabi (FOR) field site after detrending using moving average window sizes of **a**) 3 days, **b**) 5 days, and **c**) 7 days. Red dashed lines represent the pre-disturbance baseline value (mean). Grey windows indicate the periods of typhoons Trami (29-30 Sep 2018) and Kong-Rey (04-05 Oct 2018).

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**Figure S4.** Comparison of recovery time values for different recovery window sizes. A change in window size represents a change in the amount of time for which consecutive data points must remain within the pre-typhoon baseline mean ± 1 standard deviation. Relationships between the 24 hr window size used in our analyses (x-axis) and the 12 (top panels) or 48 hr window sizes (bottom panels) are shown for three acoustic indices: NDSI (left), NDSIBio, and NDSIAnthro (right). Note the number of data points differs particularly for the 48 hr window size, since normalised acoustic index values were found not to recover within 30 days of the typhoon when using the 48 hr window size. Results generally show a positive correlation between the chosen 24 hr window size and other window sizes, excepting NDSIAnthro with a 12 hr window size, which recovered quickly in most cases, resulting in a flat relationship.

**Table S2**. Response variables measured in this study, methods of their measurement and interpretation. Stability components (see also Figure 2) were calculated separately for time series of acoustic indices and bird species detections, based largely on methods adapted from Hillebrand *et al.* (2018) and White *et al.* (2020). Following calculation, all stability measures were normalised to 0-1 (see Methods) and then temporal variability was converted to temporal stability as 1 values, and recovery time to recovery speed in the same way. This was done so that all stability measures have high values which represent higher stability (except for extent of change which retains a sign positive/negative element to express the direction of change).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Response variable** | **Time window of measurement** | **Method of measurement:**  ***acoustic indices*** | **Method of measurement:**  ***species detections*** | **Interpretation** |
| **Mean state** | 30 days pre- and post-typhoon | Mean acoustic index value across the 30-day detrended time series before or after the typhoons. | Mean number of daily species detections across the 30-day time series before or after the typoons. | Higher values correspond to higher acoustic index values (a proxy for biodiversity for NDSI and NDSIBio or higher abiotic/anthropogenic noise for NDSIAnthro) or more species detections. |
| **Temporal stability** | 30 days pre- and post-typhoon | 1 coefficient of variation (that is, standard deviation/mean) among acoustic index values across the 30-day detrended time series from the pre-typhoon period. | 1 coefficient of variation (that is, standard deviation / mean) among daily species detections across the 30-day time series from the pre-typhoon period. | Higher values correspond to lower variability through time (higher stability). |
| **Resistance** | 2 days post- typhoon | Maximum absolute difference in acoustic index values from pre-typhoon mean in the 48 hours following the 2nd typhoon. | - | Values represent log response ratios, where zero equates to complete resistance (no change), and more extreme positive or negative values represent lower resistance through over- or underperformance, respectively (Hillebrand et al., 2018). |
| **Recovery time** | 30 days post- typhoon | 1 *recovery time*, calculated as the time taken (in hours) for acoustic index values to return to baseline (that is, mean ± 95% confidence interval of 30-day pre-typhoon detrended time series) and stay within this range for 24 consecutive hours, starting from the point of maximum displacement (the resistance point; (Garnier et al., 2017; White et al., 2020). | - | Higher values indicate shorter recovery time (higher stability). |
| **Spatial variability** | One value per day (full time series) | Coefficient of variation (standard deviation/mean) among field sites in daily mean acoustic index values on each date (Donohue et al., 2013). | Coefficient of variation among field sites in daily species detections on each date. | Higher values represent higher variability in space, which is stabilising as spatial variability represents asynchronous biomass fluxes within or among species, in turn providing spatial insurance through patch dynamics (Leibold et al., 2004; Loreau et al., 2003). |

**Table S3**. Summary of typhoon, land cover, and species identity effects on each response variable. We tested the effects of time period (Pre-typhoon = the 30-day period before typhoon Trami, Post-typhoon = the 30-day period after typhoon Kong-Rey), land cover (Forest = 10 forest sites, Developed = 14 developed sites described by k-means clustering; Fig. S1), and their interaction (For/Pre = forest sites pre-typhoon, For/Post = forest sites post-typhoon, Dev/Pre = developed sites pre-typhoon, Dev/Post = developed sites post-typhoon) on three acoustic indices (NDSI, Biophony [NDSIBio] and Anthropophony [NDSIAnthro]), and the summed bird detections of three species, as well as their individual detections (Corvus = *Corvus macrorhynchos*, Horornis = *Horornis diphone*, Otus = *Otus elegans*). We also tested for interactions between species and land use (Corv/For = *C. macrorhynchos* in forest, Corv/Dev = *C. macrorhynchos* in developed sites, Horo/For = *H. diphone* in forest, Horo/Dev = *H. diphone* in developed sites, Otus/For = *O. elegans* in forest) and species and time period (Corv/Pre = *C. macrorhynchos* pre-typhoon, Corv/Post = *C. macrorhynchos* post-typhoon, Horo/Pre = *H. diphone* pre-typhoon, Horo/Post = *H. diphone* post-typhoon, Otus/Pre = *O. elegans* pre-typhoon, Otus/Post = *O. elegans* post-typhoon).

**Table S3**. **XXX**. Mean, standard deviation (S.D.), and 95% credible intervals of the posterior distribution for parameters included in each best-fitting model. Error distribution represents the best performing model error distribution for each variable, and the R function within the brms package used to assign family = XXX (models were compared using LooIC etc etc)

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **Data** | **Response variable** | **Error distribution** | **Model Parameter** | **Mean** | **S.D.** | **2.5% C.I.** | **97.5% C.I.** |
| **Acoustic Indices** |  |  |  |  |  |  |
| NDSI | **Mean** | Beta | **Intercept** | **1.45** | **0.23** | **0.99** | **1.92** |
|  |  |  | LandDev | 0.37 | 0.36 | -0.35 | 1.09 |
|  |  |  | **TyphoonPost** | **-0.52** | **0.13** | **-0.78** | **-0.26** |
|  |  |  | LandDev:TyphoonPost | 0.06 | 0.21 | -0.36 | 0.48 |
|  | Temporal Variability | Beta | Intercept | -0.16 | 0.39 | -0.93 | 0.62 |
|  |  | LandDev | 0.36 | 0.59 | -0.80 | 1.53 |
|  |  | TyphoonPost | -0.10 | 0.40 | -0.91 | 0.69 |
|  |  | LandDev:TyphoonPost | -0.22 | 0.80 | -1.82 | 1.38 |
|  | Resistance | Beta | Intercept | 0.66 | 0.48 | -0.29 | 1.63 |
|  |  |  | LandDev | 0.04 | 0.77 | -1.51 | 1.55 |
|  | Recovery Time | Beta | Intercept | 0.94 | 0.52 | -0.08 | 1.97 |
|  |  |  | LandDev | 0.66 | 0.89 | -1.10 | 2.43 |
| NDSIBio | Mean | Beta | Intercept | -0.12 | 0.14 | -0.39 | 0.16 |
|  |  |  | LandDev | 0.16 | 0.22 | -0.26 | 0.59 |
|  |  |  | TyphoonPost | -0.06 | 0.13 | -0.31 | 0.19 |
|  |  |  | LandDev:TyphoonPost | -0.02 | 0.20 | -0.41 | 0.37 |
|  | Temporal Variability | Beta | Intercept | -0.33 | 0.41 | -1.15 | 0.49 |
|  |  | LandDev | 0.26 | 0.61 | -0.96 | 1.46 |
|  |  | TyphoonPost | 0.40 | 0.54 | -0.67 | 1.48 |
|  |  | LandDev:TyphoonPost | -0.10 | 1.00 | -2.09 | 1.89 |
|  | Resistance | Beta | Intercept | 0.10 | 0.55 | -0.98 | 1.20 |
|  |  |  | LandDev | 0.57 | 0.89 | -1.17 | 2.34 |
|  | Recovery Time | Beta | Intercept | 0.91 | 0.59 | -0.26 | 2.08 |
|  |  |  | LandDev | 1.62 | 0.96 | -0.25 | 3.54 |
| NDSIAnthro | **Mean** | Beta | Intercept | -0.51 | 0.26 | -1.01 | 0.00 |
|  |  |  | LandDev | -0.44 | 0.40 | -1.23 | 0.34 |
|  |  |  | **TyphoonPost** | **0.68** | **0.17** | **0.34** | **1.00** |
|  |  |  | LandDev:TyphoonPost | -0.12 | 0.26 | -0.62 | 0.40 |
|  | Temporal Variability | Beta | Intercept | 0.48 | 0.28 | -0.07 | 1.04 |
|  |  | LandDev | -0.98 | 0.72 | -2.42 | 0.46 |
|  |  | TyphoonPost | -0.73 | 0.45 | -1.62 | 0.16 |
|  |  | LandDev:TyphoonPost | 0.34 | 0.95 | -1.55 | 2.24 |
|  | Resistance | Beta | Intercept | 0.20 | 0.48 | -0.73 | 1.15 |
|  |  |  | LandDev | 0.30 | 0.77 | -1.21 | 1.84 |
|  | Recovery Time | Beta | Intercept | 0.04 | 0.53 | -1.01 | 1.07 |
|  |  |  | LandDev | 1.11 | 0.64 | -0.15 | 2.40 |
| **Species detections** |  |  |  |  |  |  |  |
|  | **Mean Daily Detections** | lognormal | **Intercept** | **3.57** | **0.32** | **2.94** | **4.2** |
|  |  |  | LandDev | 0.25 | 0.44 | -0.62 | 1.12 |
|  |  |  | TyphoonPost | -0.18 | 0.32 | -0.81 | 0.45 |
|  |  |  | **SpeciesHoro** | **-1.06** | **0.35** | **-1.76** | **-0.36** |
|  |  |  | SpeciesOtus | -0.46 | 1.43 | -3.25 | 2.34 |
|  |  |  | LandDev:TyphoonPost | -0.41 | 0.38 | -1.17 | 0.35 |
|  |  |  | LandDev:SpeciesHoro | -0.32 | 0.41 | -1.12 | 0.49 |
|  |  |  | LandDev:SpeciesOtus | -0.47 | 1.43 | -3.26 | 2.31 |
|  |  |  | **TyphoonPost:SpeciesHoro** | **-1.25** | **0.39** | **-2.01** | **-0.49** |
|  |  |  | TyphoonPost:SpeciesOtus | -0.13 | 0.55 | -1.2 | 0.95 |
|  | **Temporal Variability** | lognormal | **Intercept** | **0.3** | **0.08** | **0.15** | **0.45** |
|  |  |  | LandDev | 0.06 | 0.11 | -0.15 | 0.27 |
|  |  |  | **TyphoonPost** | **0.4** | **0.09** | **0.22** | **0.58** |
|  |  |  | SpeciesHoro | 0.15 | 0.1 | -0.05 | 0.35 |
|  |  |  | SpeciesOtus | -0.19 | 1.42 | -2.96 | 2.6 |
|  |  |  | LandDev:TyphoonPost | -0.21 | 0.11 | -0.43 | 0.01 |
|  |  |  | LandDev:SpeciesHoro | 0.08 | 0.12 | -0.15 | 0.31 |
|  |  |  | LandDev:SpeciesOtus | -0.19 | 1.42 | -2.98 | 2.58 |
|  |  |  | TyphoonPost:SpeciesHoro | -0.16 | 0.11 | -0.38 | 0.06 |
|  |  |  | TyphoonPost:SpeciesOtus | -0.09 | 0.16 | -0.4 | 0.22 |



**Figure S5. Spatial variability in biophony across sites through time.** Left panels show time series of NDSIBio spatial variability across all sites (a), and across forest (green) and developed (purple) sites separately (b). Dashed lines delineate the pre- and post-typhoon periods. Right panels show the 95% confidence intervals of NDSIBio spatial variability across all sites (a) or separated by land use (b) for the pre-typhoon (circles) and post-typhoon (triangles) periods. Significant pairwise contrasts are denoted with subscript/superscript letters.



**Figure S6. Spatial variability in anthropophony across sites through time.** Left panels show time series of NDSIAnthro spatial variability across all sites (a), and across forest (green) and developed (purple) sites separately (b). Dashed lines delineate the pre- and post-typhoon periods. Right panels show the 95% confidence intervals of NDSIAnthro spatial variability across all sites (a) or separated by land use (b) for the pre-typhoon (circles) and post-typhoon (triangles) periods. Significant pairwise contrasts are denoted with subscript/superscript letters.



**Figure S7.** **Difference from *Corvus macrorhynchos* in mean automated species detections**. Posterior distributions represent 90,000 post-convergence MCMC draws of the comparison between *Horornis diphone* (a) or *Otus elegans* (b) and *Corvus macrorhynchos* mean daily detections, where values below zero (grey) indicate lower number of detections, and values above zero (blue) a more detections of *H. diphone* or *O. elegans* relative to *C. macrorhynchos*. Non-zero-spanning credible intervals are marked with \*, while circles indicate zero-spanning credible intervals (no change based on the posterior distribution). Draws are shown per site, ordered from most forested (top) to most developed (bottom) based on principle component axis 1 of the land use dimensionality reduction (Fig. S1).

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