Title: Patch-scale edge effects do not predict landscape-scale fragmentation effects

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Abstract

Negative patch-scale edge effects, where species are more common in habitat interior than edge, are often used as evidence of negative fragmentation effects. This is because, for a given total habitat area, a more fragmented landscape contains less interior habitat. I tested this cross-scale extrapolation by extracting from the literature a sample of species showing negative or positive landscape-scale fragmentation effects, and then for each species I searched for studies from which I could calculated the slope of its patch-scale edge effect. Species showing negative patch-scale edge effects were equally likely to show negative or positive landscape-scale fragmentation effects, and likewise for species showing positive patch-scale edge effects. Thus, a species' patch-scale edge effect does reliably predict its response to habitat fragmentation. Fragmentation effects, and the efficacy of policies related to them, require evidence at a landscape scale, comparing species' responses across landscapes with different levels of fragmentation.

Introduction

The concept of "edge effects" was introduced to ecology by Leopold (1933), in reference to the observation that the diversity and density of many taxa are higher at the edge than in the interior of a forest. For example, Lay (1938) and Johnston (1947) found higher density and diversity of nesting birds along forest edges than forest interiors, the latter author noting that "it is a generally known fact that numbers of birds are greater in forest-edge habitats than in dense woods." Jones & Peterson (1970) demonstrated higher plant species diversity and higher variety of growth forms at the forest edge than in the interior, which may be responsible for the higher density and diversity of herbivorous insects at edges than interiors found in most studies (reviewed in Wirth et al. 2008). Thus, for the first half-century of its usage, the term "edge effect" had a generally positive connotation (e.g. Wiens 1976).

However, this changed during the 1980's, with evidence of higher nest predation on forest birds at forest edges than interiors (Andrén & Angelstam 1988) and on grassland birds at grassland edges than interiors (Johnson & Temple 1990). This led to "conflicts surrounding edge management in high-latitude forests" (Harris 1988), and a caution that "we must not conclude that creation of more edge in landscapes will always have a positive effect on wildlife" (Yahner 1988). Although a subsequent review concluded that most empirical tests had failed to find higher avian nest predation near habitat edges than interiors (Lahti 2001), the term "edge effect" now generally has a negative connotation rather than a positive connotation in ecology. For example, Pfeifer et al. (2017) stated, "Forest edges ... contribute to worldwide declines in biodiversity and ecosystem functions."

With the long history and sustained interest in edge effects, we now have a large body of relevant empirical literature on them. Reviews of edge effects find a wide variety of responses across taxa and across regions. In their qualitative review, Turner (1996) found that edge effects in the tropics are mixed across species. Ries et al. (2004) found mostly neutral effects of forest edges. Where there was an edge effect, they found about twice as many positive as negative effects on densities of birds, plants and mammals. They also found that positive edge effects were more likely when complementary resources were found outside the primary habitat and where edges themselves had elevated resource levels (as observed by Leopold, 1933). Willmer et al. (2022) also found a wide range of edge responses, with a higher likelihood of positive edge effects in temperate than in tropical regions. However, this appears to be taxon-specific, as Stone et al. (2018) and Guimarães et al. (2014) found equally positive edge effects across temperate and tropical systems, for carabid beetles and herbivorous insects, respectively.

An important practical reason for the long-standing interest in edge effects is the assumed link between edge effects and fragmentation effects. For example, Ries et al. (2004) argued that "understanding how ecological patterns change near edges is key to understanding landscape-level dynamics such as the impacts of fragmentation." Haddad et al. (2015) found that " 70% of remaining forest is within 1 km of the forest’s edge, subject to the degrading effects of fragmentation." Betts et al. (2019) repeated this caution, stating that "[f]orest fragmentation is particularly pressing given that 70% of Earth’s remaining forest is within 1 km of the forest edge," and Willmer et al. (2022) stated that "edge effects are an important driver of fragmentation effects."

Inferences about landscape-scale fragmentation effects from patch-scale edge effects are a type of cross-scale extrapolation (**Fig. 1**). Specifically, landscapes with higher habitat fragmentation *per se*, i.e. more patches for a given total amount of habitat (Fahrig 2003; hereafter simply "fragmentation"), have more edge than landscapes with less-fragmented habitat. Therefore, if a species is more (or less) abundant at habitat edges than interiors, its density in the landscape should increase (or decrease) with habitat fragmentation. Although this seems self-evident, it is logically possible that an interior species could show a positive response to fragmentation, and that an edge species could show a negative response to fragmentation (illustrated in **Fig. 2**). Thus, the cross-scale extrapolation from edge effects to fragmentation effects cannot be assumed, but needs to be empirically demonstrated.

It is particularly important to determine whether patch-scale edge effects determine the *direction* of fragmentation effects because landscape-scale management in response to fragmentation effects is specifically about the direction of effect (e.g., Pfeifer et al. 2017). In particular, observed or assumed negative edge effects are used to recommend policies to reduce fragmentation. In addition, while most ecologists might not expect an exact mapping from edge effects to fragmentation effects, there is a general expectation that the direction of fragmentation effects can be predicted from edge effects. For example, Ries et al. (2004) stated, "[e]dge responses are thus likely to manifest at larger scales in a predictable direction, but resulting magnitudes may be dampened depending on the extent to which orientation and landscape structure interact either to weaken edge responses or limit their expression."

This leads to the question, can the direction of a fragmentation effect be reliably predicted from a patch-scale edge effect? Specifically, do species with higher densities at habitat edges than interiors (edge species) show positive fragmentation effects, while species with lower densities at habitat edges than interiors (interior species) show negative fragmentation effects? To address this question, I extracted from the literature a sample of the direction of fragmentation effects on individual species, recording whether the species density/occurrence increased or decreased with habitat fragmentation. Then, for each of these species I conducted a literature search for studies documenting a patch-scale edge effect, i.e. a gradient in density/occurrence from interior to edge habitat for that species. Finally, I tested whether the slope of the edge effect is a reliable predictor of the direction of the fragmentation effect, across species.

Material and methods

Direction of fragmentation effects

I searched for quantitative studies of landscape-scale habitat fragmentation effects on density or occurrence of individual species published within a 6-year period from 1 January 2016 to 2 December 2021. Note that my goal was not to conduct a complete search of the literature but rather to obtain a sufficient sample of species with both quantitative evidence of the direction of fragmentation effects, and quantitative evidence of patch-scale edge effects, to allow evaluation of their relationship. Landscape-scale fragmentation studies typically measure the species response at one or more points in each of multiple landscapes that vary along a gradient of habitat fragmentation (illustrated in **Fig 1B**, right side). As I was interested specifically in effects of fragmentation *per se*, I searched for (i) studies that used landscape-scale measures of fragmentation that are generally uncorrelated with habitat amount across landscapes (e.g. number of patches, edge density), and (ii) studies that used landscape-scale measures of fragmentation that are typically correlated with habitat amount (e.g. mean patch size) but that controlled for habitat amount in their analyses. I searched in Web of Science using the following search string: "fragmentation per se" or "SLOSS" or [("edge density" or "edge length" or "number of patches" or "mean patch size" or "boundary length" or "patch density" or "median patch size" or "clumping index" or "splitting index" or "aggregation index" or "like adjacencies" or "fractal dimension" or "IJI" or "mean circumscribing circle" or "largest patch index" or "shape index" or "mean core area" or "proportion core area" or "mean nearest-neighbor" or "mean perimeter to area" or "mean edge to area") AND ("habitat" or "forest" or "grassland" or "wetland" or "coral" or "landscapes" or "watersheds" or "catchments")], within the research areas "environmental sciences/ecology" and "biodiversity conservation".

I extracted the direction of the fragmentation effect on species density/occurrence from tables, figures or appendices, for each species for which that information was provided. Note I did not extract the actual coefficients of the fragmentation effects, for two reasons. First, my goal was specifically to determine whether edge effects can predict the direction of fragmentation effects, not the magnitude. Second, the number of comparable fragmentation coefficients that I would be able to extract from the literature would be very small due to both variation in methods for measuring fragmentation and wide diversity of statistical model types and co-variates. Note also that I did not include multi-species responses such as species richness, because patch-scale edge effects (below) are considered to be species attributes and are therefore documented on a per-species basis.

Slope of patch-scale edge effects

For each species for which I recorded a direction of fragmentation effect, I conducted a search for studies from which I could estimate a patch-scale edge effect slope (as in **Fig. 1B**, left panel). I did not limit the year range of these searches and I found relevant papers dating back to the 1980's. I conducted each species' search in Web of Science using the search string "[species name]" AND "edge". In cases where this led to a large number of clearly irrelevant papers, I added the string AND ("distance" or "gradient" or "near" or "far" or "transect" or "proximity" or "interior").

For each paper where sufficient information was provided, I calculated a scaled slope of density or (probability of) occurrence vs. distance from the edge from data in the paper (see below). Note I did not include other ecological responses to edges such as nest survival. This is because my goal was to test the direct extrapolation from edge effects on density/occurrence to the direction of fragmentation effects on density/occurrence. Including measures such as predation rate or nest survival would have entailed a second extrapolation from those outcomes to density/occurrence.

To estimate the scaled slope of the edge effect, I required values of density, occurrence, or proportion/probability of occurrence with distance from the edge. I extracted these from tables, figures, or appendices. I then converted the value at each distance to a proportion of total observations, and I converted each distance to its proportion from the maximum distance from the edge in that study or from the distance at which the observed density/occurrence values levelled off. I used the proportion of distance from the interior rather than from the edge so that negative slopes would represent negative edge effects and positive slopes would represent positive edge effects, as in **Fig. 1B** (left side). Note I scaled both the species observations and the distances to create comparable slope values so that I could conduct a cross-species evaluation of the relationship between the edge effect slope and the direction of the fragmentation effect (below). In doing so I implicitly assumed that the authors of the edge effect studies selected relevant distances from the edge for the species in their particular studies.

<u>Relationship between edge effect and direction of fragmentation effect</u>

To determined whether edge effects reliably predicted the direction of fragmentation effects, I fit a mixed effects model with a binomial response (positive or negative fragmentation effect) on the scaled slope of the patch-scale edge effect as the fixed effect, and fragmentation study i.d. and species as two random effects. I included fragmentation study i.d. because some fragmentation studies contained the direction of fragmentation effect for multiple species, and I included species because for some species I found more than one fragmentation direction result and/or patch-scale edge effect slope result. I conducted the analysis using the lme4 package (Bates et al. 2015) in R (R Core Team 2020).

Results

The initial literature search for fragmentation studies yielded 839 titles, 62 of which contained a direction of landscape-scale fragmentation effect on density/occurrence of at least one species. These 62 papers yielded 678 values of the direction of fragmentation effect, for 425 different species. Fragmentation was measured using a variety of metrics across studies. Grouped into general categories, these included 299 cases of edge density, 253 of patch density, 177 of aggregation, 35 of principal components combining fragmentation metrics, and 8 of mean patch size. Note these numbers do not add to 678 because in 94 cases the author measured fragmentation using more than one metric; if the direction of fragmentation effect was the same for the two (or more) metrics, I counted these as a single case, i.e. a single positive or negative fragmentation effect.

Of these 425 species, my search for studies from which I could calculate patch-scale edge effect slopes yielded 115 species with at least one edge effect slope, and 254 edge effect slope values altogether. These 115 species included 42 birds, 28 plants, 24 mammals, 18 arthropods, 2 micro-organisms, and 1 amphibian.

There was no relationship between the slope of the edge effect and the direction of the fragmentation effect (**Fig. 3; Appendix Table S1**). Species with stronger negative patch-scale edge effects (interior species) were not more likely to show negative than positive fragmentation effects, and species with stronger positive patch-scale edge effects (edge species) were not more likely to show positive than negative fragmentation effects, irrespective of taxon or biome (**Appendix Fig S1, S2**).

Discussion

The results indicate that patch-scale edge effects do not reliably indicate the direction of landscape-scale fragmentation effects. In other words, if one has information about whether a species is edge-associated or interior-associated, but no information about how it responds to landscape-scale habitat fragmentation, knowing the edge response does not allow one to infer the effect of habitat fragmentation. It is possible that edge effects are responsible for some observed fragmentation effects, i.e., some of the points in the lower left and upper right quadrants of **Fig. 3**. However, the lack of overall relationship invalidates general extrapolation from edge effects to the direction of fragmentation effects. Thus, the results suggest that landscape-scale recommendations for conservation decision-making should not be based on information about patch-scale edge effects. Such recommendations remain a current practice. For example, based on their finding that negative edge effects on species richness are more common in tropical than in temperate regions, Willmer et al. (2022) suggested that the landscape design recommended by Arroyo-Rodriguez et al. (2020) is not suitable in tropical regions. This and other such inferences rely on an extrapolation from patch-scale edge effects to landscape-scale fragmentation effects, which we cannot assume to be correct.

How is it possible for a species to show a negative edge effect while at the same time a positive effect of fragmentation, or vice versa, as illustrated in **Fig. 2**? The answer most likely lies in processes that come into play at a landscape scale. For example, habitat fragmentation can influence species interactions, spread the risk of extinction, and increase habitat connectivity by reducing distances among patches within a landscape (e.g., Roland 1993; Hammill & Clements 2020; Tischendorf & Fahrig 2000, respectively; reviewed in Fahrig 2017; Fahrig et al. 2019). If these processes are strong, this could lead to situations where population density is higher (or lower) across a more fragmented landscape than a less fragmented landscape, despite a negative (or positive) patch-scale edge effect on that species.

The finding that patch-scale edge effects do not reliably predict the direction of landscape-scale fragmentation effects is an example of the general problem that ecological patterns and processes are often documented at spatial extents that are smaller that those relevant to conservation decision-making (Estes et al. 2018). For example, a similar problem occurs when extrapolating from patch size effects on biodiversity to fragmentation effects (Riva & Fahrig 2023). Using the "FragSAD" database of species on multiple patches across multiple studies, Chase et al. (2020) showed a disproportionate patch-scale increase in species richness, with increasing patch size. However, using the same database, Riva & Fahrig (2023) showed declining species richness with increasing mean patch size at a landscape scale, indicating that the patch-scale results could not be extrapolated to a landscape scale, even in the same dataset.

If extrapolation from patch-scale patterns to landscape-scale conservation implications is not valid, then we should base landscape-scale conservation recommendations on studies that compare ecological responses across multiple landscapes. Such studies are challenging to design and implement as they typically must be conducted over very large spatial extents to capture the gradient(s) in landscape structure of interest (e.g., Herse et al. 2020; Morante-Filho et al. 2021). However, there is a growing number of such studies. In some cases, large-scale co-ordinated data-collection efforts may be needed (e.g., Sirami et al. 2019). Recent increases in citizen science databases (e.g. eBird, NatureServe) may alleviate this problem to some extent, but these have limitations due to inherent sampling biases that must be accounted for (Dickinson et al. 2010; e.g. Riva et al. 2023).

It remains possible that the relationship between edge effects and the direction of fragmentation effects might be stronger when both effects are measured at the same time in the same region. In fact, there was high within-species (between-study) variation both in edge effects and in the direction of fragmentation effects (**Appendix Table S2**), which might be due to contextual differences among studies, such as the presence/absence of an interacting species. Where these conditions are controlled for, i.e. where both edge effects and direction of fragmentation effects are measured in the same region at the same time, edge effects might be more predictive of the direction of fragmentation effects. Such studies appear to be rare. In my sample of the literature there was only one study in which the authors measured both patch-scale edge effects and the direction of landscape-scale fragmentation effects (Fischer et al. 2021). In that study, of the 10 species of carabid beetles for which I could obtain both edge effects and direction of fragmentation effects, the fragmentation effect was in the same direction as the edge effect for five species, while for the other five species the direction of the fragmentation effect was opposite to the direction of the edge effect. This does not support the idea that edge effects are a reliable predictor of the direction of fragmentation effects, even when both are measured in the same location. However, more studies are needed that, similar to Fischer et al. (2021), simultaneously estimate both edge effects and fragmentation effects on the same species in the same region.

In conclusion, the results of this study suggest that the direction of fragmentation effects cannot be reliably predicted from patch-scale edge effects. Species with higher densities at habitat edges than interiors may show either positive or negative fragmentation effects, and likewise for species with lower densities at habitat edges. Thus, negative (or positive) edge effects should not be used as evidence of negative (or positive) fragmentation effects. Fragmentation effects, and the efficacy of policies related to them, require evidence at a landscape scale, where the ecological response is measured and compared across landscapes with different levels of fragmentation.

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Figure legends

Figure 1. Inferring landscape-scale fragmentation effects from patch-scale edge effects is a cross-scale extrapolation. A. Illustration of patch-scale edge effects. Dots represent individuals of two species: the edge species is more likely to occur and has higher densities near the edge than in the interior of the patch, while the interior species is less likely to occur and has lower densities near the edge than in the interior of the patch. B. Illustration of cross-scale extrapolation from patch- scale edge effects to the direction of landscape-scale fragmentation effects. For the same total amount of habitat, a landscape containing more-fragmented habitat has more edge and less interior than a landscape containing less-fragmented habitat. If patch-scale edge effects determine landscape-scale fragmentation effects, then species with negative edge effects (interior species) should be less likely to occur and have lower densities at sites in more fragmented landscapes, and species with negative edge effects (interior species) should be more likely to occur and have higher densities at sites in more fragmented landscapes. Green rectangles are habitat patches and red x's are sample sites.

Figure 2. Illustration of how a species could simultaneously show a negative patch-scale edge effect and a positive landscape-scale fragmentation effect (A) or a positive patch-scale edge effect and a negative landscape-scale fragmentation effect (B). Large squares are landscapes, green rectangles are patches, rectangle outlines within patches indicate the approximate distance dividing edge from interior habitat for these species, and circles are individuals. All four landscapes contain the same amount of habitat.

Figure 3. Relationship between the scaled slope of the patch-scale edge effect and the direction of the landscape-scale fragmentation effect. Each point represents the direction of a fragmentation effect on a given species taken from a single fragmentation study, matched to a patch-scale edge effect from an edge-effect study on that same species. Negative edge-effect slopes indicate the species density/occurrence is lower at the edge than in the interior of habitat (as in Fig. 1). If edge effects reliably predict the direction of fragmentation effects then the points should be clustered in the bottom left and top right quadrants of the figure. Points are vertically jittered to allow distinguishing individual points.

Figure 1

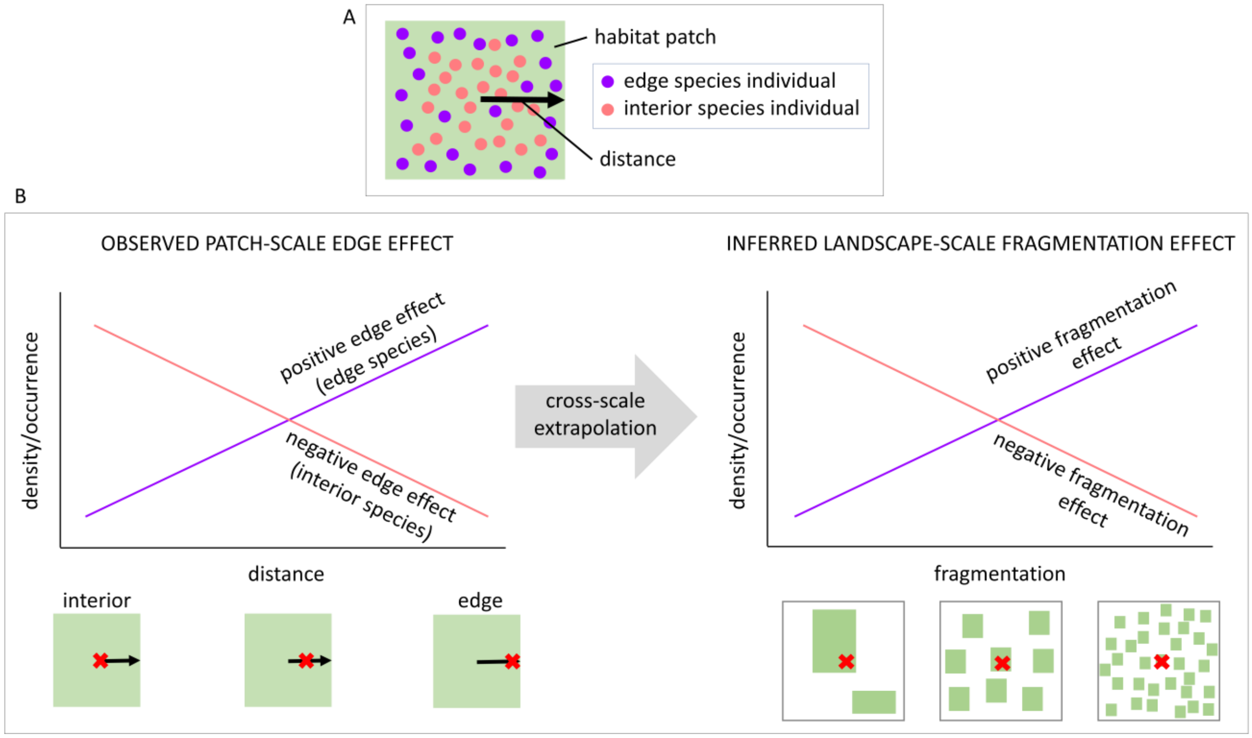

A
habitat patch
edge species individual
interior species individual
distance
B
OBSERVED PATCH-SCALE EDGE EFFECT
density/occurrence
positive edge effect
(edge species)
negative edge effect
(interior species)
distance
interior
edge
cross-scale
extrapolation
INFERRED LANDSCAPE-SCALE FRAGMENTATION EFFECT
density/occurrence
positive fragmentation
effect
negative fragmentation
effect
fragmentation

Figure 2

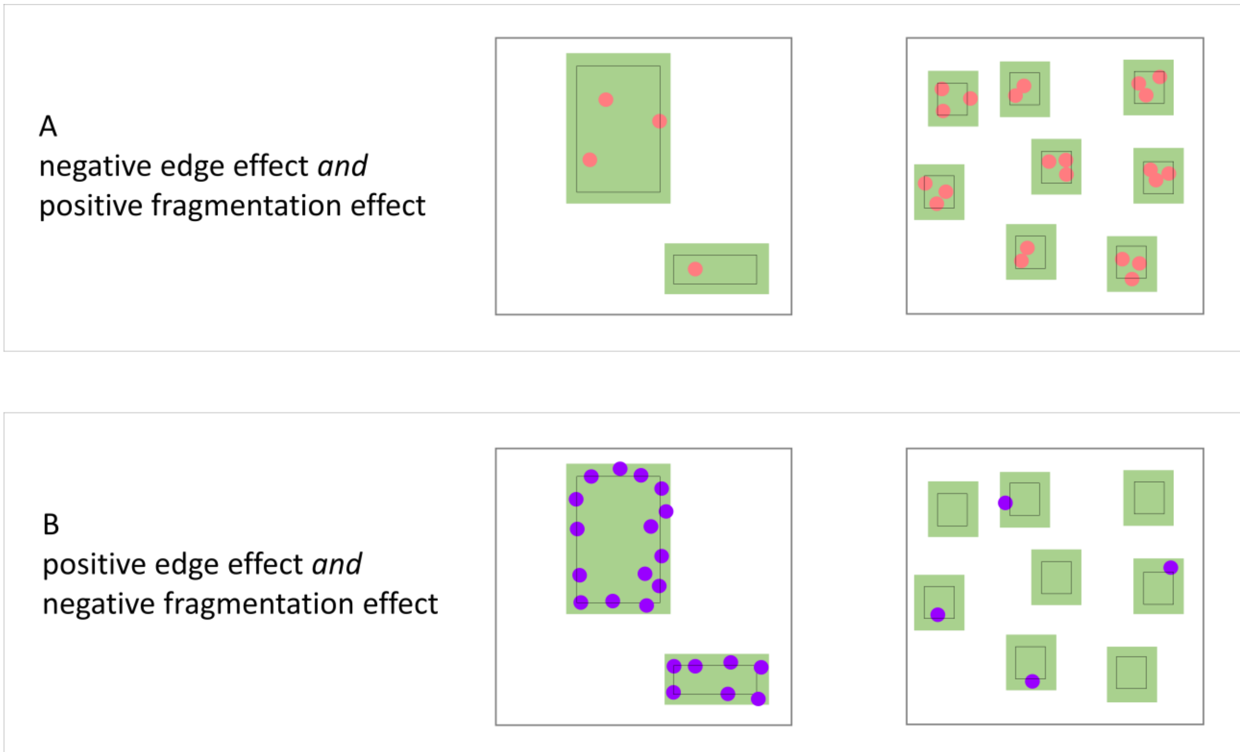
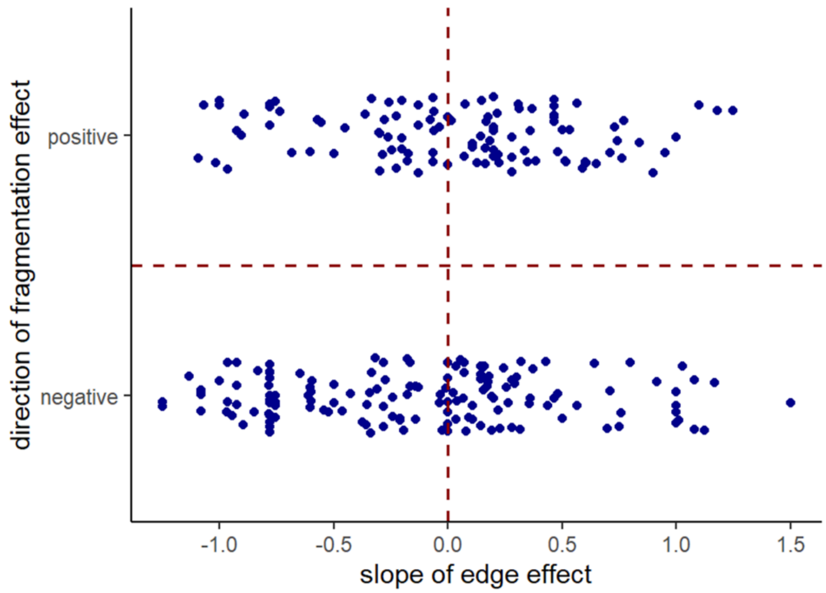

A
negative edge effect *and*
positive fragmentation effect
B
positive edge effect *and*
negative fragmentation effect

Figure 3


direction of fragmentation effect
positive
negative
-1.0
-0.5
0.0
0.5
1.0
1.5
slope of edge effect

Appendix

Table S1. Model results for a mixed effects model with a binomial response (positive or negative fragmentation effect) on the scaled slope of the patch-scale edge effect (fixed effect), and fragmentation study i.d. and species (random effects). Total number of observations is 254.

Random effects				
Variable name	Variance	Standard deviation	Number of groups	
Species	25.90	5.089	115	
Citation for fragmentation effect	23.57	4.854	27	
Fixed effects				
	Parameter estimate	Standard error	z value	p value
Intercept	-1.6031	1.6991	-0.943	0.345
Edge effect	0.2889	0.9376	0.308	0.758

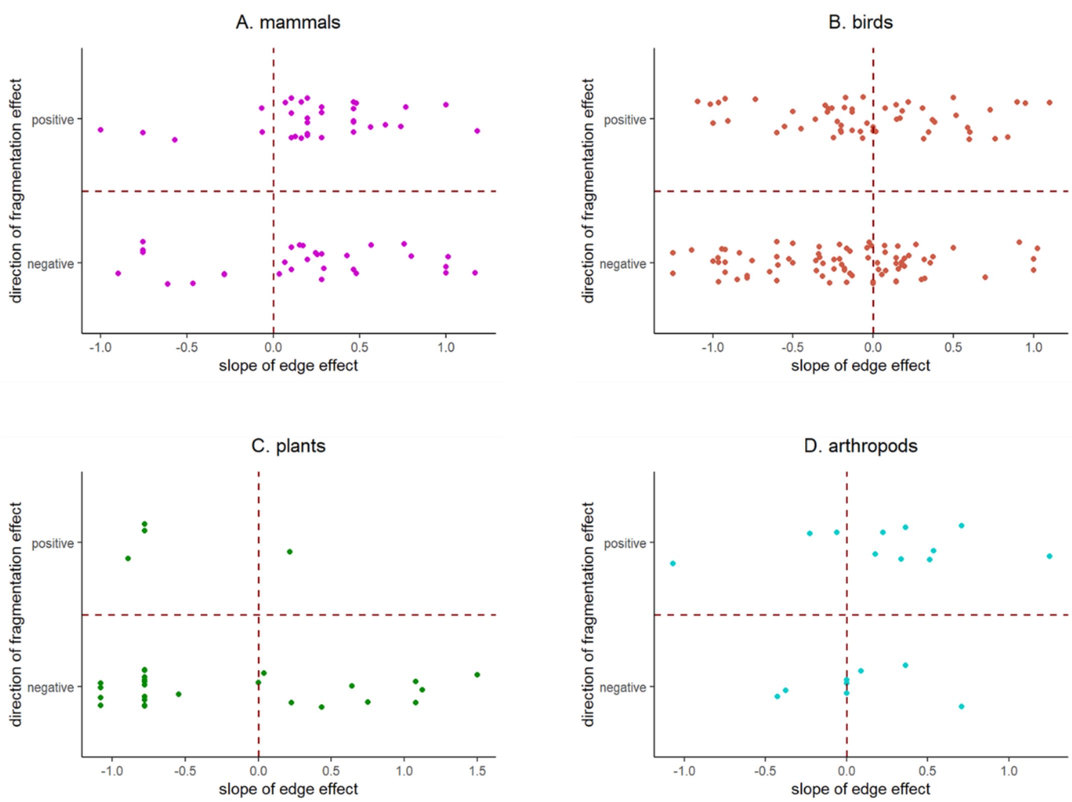


Figure S1. Relationship between the slope of the patch-scale edge effect and the direction of the fragmentation effect, separately for major taxonomic groups. A negative edge effect slope indicates the species density/occurrence is lower at the edge than in the interior of habitat (as in **Fig. 1**). If edge effects reliably predict the direction of fragmentation effects then the points should be clustered in the bottom left and top right quadrants of the figures. Points are vertically jittered to allow distinguishing individual points.

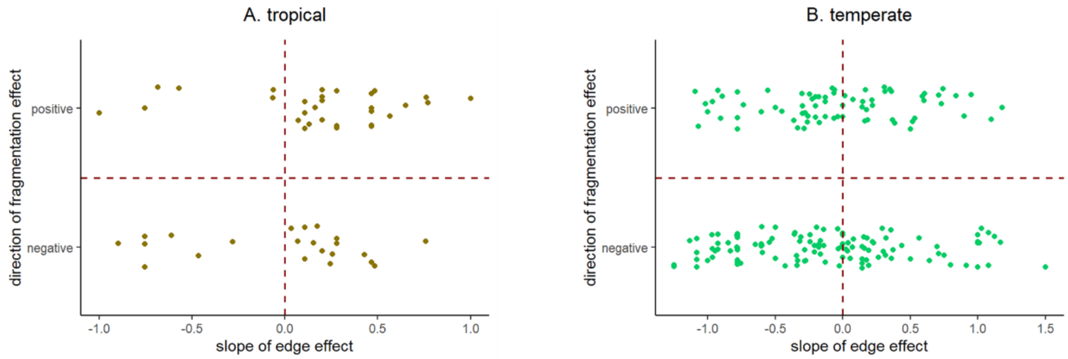


Figure S2. Relationship between the slope of the patch-scale edge effect and the direction of the fragmentation effect, separately for tropical and temperate species. A negative edge effect slope indicates the species density/occurrence is lower at the edge than in the interior of habitat (as in **Fig. 1**). If edge effects reliably predict the direction of fragmentation effects then the points should be clustered in the bottom left and top right quadrants of the figures. Points are vertically jittered to allow distinguishing individual points.

Table S2. Data and data sources, sorted first by taxon and then by species within taxon. Letters in italics from *a* to *ii* refer to notes at the bottom of the table.

Species	**Taxon**	**Citation for fragmentation study**	**Biome**	**Fragmentation response taken from**	**Direction of fragmentation effect**	**Citation for patch scale edge effect**	**Edge effect taken from**	**Scaled edge effect**
Bufo gargarizans	amphibian	Li et al. 2018	tropical	Table 3; *bb*	positive	Yu and Guo 2012	Fig 1 gray bar vs. white bar; *a*	-0.684210526
Aglais milberti	arthropod	Riva et al. 2018	boreal	supp mat 4; *cc*	negative	Pocewicz et al. 2009	data from author: excel file 4th tab; *a*	0
Amara convexior	arthropod	Fischer et al. 2021	temperate	Fig A1 sup mat 3, lower panel; *dd*	positive	Fischer et al. 2021	Sup mat 2	0.177135427
Amara similata	arthropod	Fischer et al. 2021	temperate	Fig A1 sup mat 3, lower panel; *dd*	negative	Fischer et al. 2021	Sup mat 2	-0.426793692
Carterocephalus palaemon	arthropod	Riva et al. 2018	boreal	supp mat 4; *cc*	positive	Ravenscroft 1994	Fig 2 (a); *b*	0.512977099
Carterocephalus palaemon	arthropod	Riva et al. 2018	boreal	supp mat 4; *cc*	positive	Pocewicz et al. 2009	data from author: excel file 4th tab	1.25
Celastrina ladon	arthropod	Riva et al. 2018	boreal	supp mat 4; *cc*	negative	Pocewicz et al. 2009	data from author: excel file 4th tab	1.40513E-17
Colias philodice	arthropod	Riva et al. 2018	boreal	supp mat 4; *cc*	negative	Pocewicz et al. 2009	data from author: excel file 4th tab	0.09
Diachromus germanus	arthropod	Fischer et al. 2021	temperate	Fig A1 sup mat 3, lower panel; *dd*	positive	Fischer et al. 2021	Sup mat 2	0.361972394
Glaucopsyche lygdamus	arthropod	Riva et al. 2018	boreal	supp mat 4; *cc*	positive	Pocewicz et al. 2009	data from author: excel file 4th tab	-0.225
Harpalus affinis	arthropod	Fischer et al. 2021	temperate	Fig A1 sup mat 3, lower panel; *dd*	positive	Fischer et al. 2021	Sup mat 2	-0.061130976
Harpalus latus	arthropod	Fischer et al. 2021	temperate	Fig A1 sup mat 3, lower panel; *dd*	positive	Fischer et al. 2021	Sup mat 2	0.535257051
Harpalus zabroides	arthropod	Fischer et al. 2021	temperate	Fig A1 sup mat 3, lower panel; *dd*	negative	Fischer et al. 2021	Sup mat 2	0.361972394
Ophonus ardosiacus	arthropod	Fischer et al. 2021	temperate	Fig A1 sup mat 3, lower panel; *dd*	negative	Fischer et al. 2021	Sup mat 2	0.708541708
Ophonus azureus	arthropod	Fischer et al. 2021	temperate	Fig A1 sup mat 3, lower panel; *dd*	positive	Fischer et al. 2021	Sup mat 2	0.708541708
Pieris rapae	arthropod	Riva et al. 2018	boreal	supp mat 4; *cc*	negative	Pocewicz et al. 2009	data from author: excel file 4th tab	-0.375
Plebejus saepiolus	arthropod	Riva et al. 2018	boreal	supp mat 4; *cc*	positive	Pocewicz et al. 2009	data from author: excel file 4th tab	0.3375
Polygonia satyrus	arthropod	Riva et al. 2018	boreal	supp mat 4; *cc*	positive	Pocewicz et al. 2009	data from author: excel file 4th tab	0.225

Pseudoophonus rufipes	arthropod	Fischer et al. 2021	temperate	Fig A1 sup mat 3, lower panel; *dd*	negative	Fischer et al. 2021	Sup mat 2	0.001129731
Zabrus tenebrioides	arthropod	Fischer et al. 2021	temperate	Fig A1 sup mat 3, lower panel; *dd*	positive	Fischer et al. 2021	Sup mat 2	-1.070514103
Agelaius phoeniceus (Red-winged Blackbird)	bird	Lockhart and Koper 2018	temperate	Figure 5, Table 2	positive	Patten et al. 2006	Table 1; *c*	0.730504271
Agelaius phoeniceus (Red-winged Blackbird)	bird	Lockhart and Koper 2018	temperate	Figure 5, Table 2	positive	Bock et al. 1999	Fig 2	-0.038461538
Alauda arvensis (Skylark)	bird	Ekroos et al. 2019	temperate	Table 3, text p. 399; *ee*	positive	Fonderflick et al. 2013	Fig 1, supp mat Table 3	-0.278220141
Ammodramus henslowii (Henslow's Sparrow)	bird	Herse et al. 2020	temperate	Table 1	negative	Winter et al. 2000	Table 3; *d*	-1.25
Ammodramus henslowii (Henslow's Sparrow)	bird	Herse et al. 2020	temperate	Table 1	negative	Winter et al. 2000	Table 3; *d*	-0.357142857
Ammodramus henslowii (Henslow's Sparrow)	bird	Herse et al. 2020	temperate	Table 1	negative	Winter et al. 2000	Table 3; *d*	-0.833333333
Ammodramus henslowii (Henslow's Sparrow)	bird	Herse et al. 2020	temperate	Table 1	negative	Winter et al. 2000	Table 3; *d*	-0.243055556
Ammodramus henslowii (Henslow's Sparrow)	bird	Herse et al. 2020	temperate	Table 1	negative	Patten et al. 2006	Table 1; *c*	-1
Ammodramus henslowii (Henslow's Sparrow)	bird	Herse et al. 2020	temperate	Table 1	negative	Ellison et al. 2013	Table 2; *e*	-1.25
Ammodramus savannarum (Grasshopper Sparrow)	bird	Herse et al. 2020	temperate	Table 1	negative	Renfrew et al. 2005	Fig 2	-0.602384868
Ammodramus savannarum (Grasshopper Sparrow)	bird	Herse et al. 2020	temperate	Table 1	negative	Delaney et al. 2013	Fig 2B	-0.178571429
Ammodramus savannarum	bird	Herse et al. 2020	temperate	Table 1	negative	Patten et al. 2006	Table 1; *c*	-0.96453202

(Grasshopper Sparrow)								
Ammodramus savannarum (Grasshopper Sparrow)	bird	Herse et al. 2020	temperate	Table 1	negative	Bock et al. 1999	Fig 2	-0.5
Ammodramus savannarum (Grasshopper Sparrow)	bird	Lockhart and Koper 2018	temperate	Figure 5, Table 2	negative	Renfrew et al. 2005	Fig 2	-0.602384868
Ammodramus savannarum (Grasshopper Sparrow)	bird	Lockhart and Koper 2018	temperate	Figure 5, Table 2	negative	Delaney et al. 2013	Fig 2B	-0.178571429
Ammodramus savannarum (Grasshopper Sparrow)	bird	Lockhart and Koper 2018	temperate	Figure 5, Table 2	negative	Patten et al. 2006	Table 1; *c*	-0.96453202
Ammodramus savannarum (Grasshopper Sparrow)	bird	Lockhart and Koper 2018	temperate	Figure 5, Table 2	negative	Bock et al. 1999	Fig 2	-0.5
Ammodramus savannarum (Grasshopper Sparrow)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Renfrew et al. 2005	Fig 2	-0.602384868
Ammodramus savannarum (Grasshopper Sparrow)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Delaney et al. 2013	Fig 2B	-0.178571429
Ammodramus savannarum (Grasshopper Sparrow)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Patten et al. 2006	Table 1; *c*	-0.96453202
Ammodramus savannarum (Grasshopper Sparrow)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Bock et al. 1999	Fig 2	-0.5
Caprimulgus vociferus (Whip-poor-will)	bird	Vala et al. 2020	temperate	Table 2, Fig 3	negative	Wilson and Watts 2008	text p. 780	0.5
Caprimulgus vociferus (Whip-poor-will)	bird	De Camargo et al. 2018	temperate	Supp Mat Table S1-10	positive	Wilson and Watts 2008	text p. 780	0.5
Carduelis pinus (Pine Siskin)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Keller and Anderson 1992	Table 4	0.025641026

Carduelis tristis (American Goldfinch)	bird	Shahan et al. 2017	temperate	Fig 3	negative	Boutin et al. 1999	Table 5	0.357894737
Carpodacus mexicanus (House Finch)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Bock et al. 1999	Fig 4	0.6
Carpodacus mexicanus (House Finch)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Knight et al. 2016	Table 1	1.1
Catharus guttatus (Hermit Thrush)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Thomas et al. 2014	Appendix A	0
Catharus guttatus (Hermit Thrush)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Flaspohler et al. 2001	Fig 3	0.07802982
Catharus guttatus (Hermit Thrush)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	King et al. 1997	Table 1; *f*	-0.341603053
Catharus guttatus (Hermit Thrush)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Dellinger et al. 2007	Table 3	0.19392793
Catharus guttatus (Hermit Thrush)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Keller and Anderson 1992	Table 4	-0.242966752
Catharus guttatus (Hermit Thrush)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Bayne et al. 2008	Table 2	0.177897574
Certhia americana (Brown Creeper)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Thomas et al. 2014	Appendix A	-0.130434783
Certhia americana (Brown Creeper)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Brand and George 2001	Table 1	-0.2
Certhia americana (Brown Creeper)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Rodewald and Brittingham 2002	Table 1; shrubby edge	-0.552628816
Certhia americana (Brown Creeper)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Rodewald and Brittingham 2002	Table 1; abrupt edge	-1.016123952
Certhia americana (Brown Creeper)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Keller and Anderson 1992	Table 4	-1
Cistothorus platensis (Sedge Wren)	bird	Shahan et al. 2017	temperate	Fig 3	positive	Tack et al. 2017	Fig 3 open symbols	-0.129066667
Cistothorus platensis (Sedge Wren)	bird	Shahan et al. 2017	temperate	Fig 3	positive	Tack et al. 2017	Fig 3 open symbols	-0.129066667
Dendroica coronata (Yellow-rumped Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Rodewald and Brittingham 2002	Table 1; shrubby edge	-0.449150297
Dendroica coronata (Yellow-rumped Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Rodewald and Brittingham 2002	Table 1; abrupt edge	-1.093979493
Dendroica coronata (Yellow-rumped Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Keller and Anderson 1992	Table 4	-0.063205418

Dendroica coronata (Yellow-rumped Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Battin & Siskin 2011	Fig 2b right panel; *g*	0.01544651
Dendroica coronata (Yellow-rumped Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Bayne et al. 2008	Table 1; bird density	0.314285714
Dendroica coronata (Yellow-rumped Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Bayne et al. 2008	Table 2; bird occupancy	-0.224489796
Dendroica fusca (Blackburnian Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Thomas et al. 2014	Appendix A	-0.202531646
Dendroica fusca (Blackburnian Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Rodewald and Brittingham 2002	Table 1; shrubby edge	0.34799826
Dendroica fusca (Blackburnian Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Rodewald and Brittingham 2002	Table 1; abrupt edge	-0.25609628
Dendroica pensylvanica (Chestnut-sided Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Rodewald and Brittingham 2002	Table 1; shrubby edge	0.94999525
Dendroica pensylvanica (Chestnut-sided Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Rodewald and Brittingham 2002	Table 1; abrupt edge	0.30722738
Dendroica pensylvanica (Chestnut-sided Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Thomas et al. 2014	Appendix A	0.384615385
Dendroica pinus (Pine Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Rodewald and Brittingham 2002	Table 1; shrubby edge	0.605260132
Dendroica pinus (Pine Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Rodewald and Brittingham 2002	Table 1; abrupt edge	-0.199999
Dendroica pinus (Pine Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Moorman and Guynn 2001	Table 3; *h*	-0.361111111
Dendroica tigrina (Cape May Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Meikeljohn and Hughes 1999	Table 3; *i*	-0.756583173
Dendroica tigrina (Cape May Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Rodewald and Brittingham 2002	Table 1; shrubby edge	0.221310369
Dendroica tigrina (Cape May Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Rodewald and Brittingham 2002	Table 1; abrupt edge	0.2999985

Dendroica virens (Black-throated Green Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Flaspohler et al. 2001	Fig 3	0.076176219
Dendroica virens (Black-throated Green Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	King et al. 1997	Table 1; *f*	0.21986166
Dendroica virens (Black-throated Green Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Rodewald and Brittingham 2002	Table 1; shrubby edge	0.370687802
Dendroica virens (Black-throated Green Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Rodewald and Brittingham 2002	Table 1; abrupt edge	-0.286362205
Dumetella carolinensis (Gray Catbird)	bird	Gilbert et al. 2019	temperate	Table 4; *ff*	negative	Yahner 1991	p. 157, Table 3	-0.273003033
Dumetella carolinensis (Gray Catbird)	bird	Gilbert et al. 2019	temperate	Table 4; *ff*	negative	Thomas et al. 2014	Appendix A	1
Dumetella carolinensis (Gray Catbird)	bird	Gilbert et al. 2019	temperate	Table 4; *ff*	negative	Zegers et al. 2000	Table 1	1.025641026
Empidonax alnorum (Alder Flycatcher)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Bayne et al. 2008	Table 2	0
Eremophila alpestris (Horned Lark)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Sliwinski and Koper 2012	Table 2	-0.194626474
Eremophila alpestris (Horned Lark)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Sliwinski and Koper 2012	Table 4	-0.966386555
Eremophila alpestris (Horned Lark)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Bock et al. 1999	Fig 2	-0.846153846
Eremophila alpestris (Horned Lark)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Ingelfinger and Anderson 2004	text p. 391-392	0.178571429
Eremophila alpestris (Horned Lark)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Duchardt et al. 2019	Fig 4	0.158823529
Hirundo rustica (Barn Swallow)	bird	De Camargo et al. 2018	temperate	Supp Mat Table S1-10	negative	Shi et al. 2014	Table 2	-0.924
Hirundo rustica (Barn Swallow)	bird	Shahan et al. 2017	temperate	Fig 3; median patch size	positive	Shi et al. 2014	Table 2	-0.924
Hirundo rustica (Barn Swallow)	bird	Shahan et al. 2017	temperate	Fig 3	negative	Shi et al. 2014	Table 2	-0.924
Hirundo rustica (Barn Swallow)	bird	Shahan et al. 2017	temperate	Fig 3	negative	Shi et al. 2014	Table 2	-0.924

Icterus spurius (Orchard Oriole)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Patten et al. 2006	Table 1; *c*	0.91349412
Junco hyemalis (Dark-eyed Junco)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Thomas et al. 2014	Appendix A	-0.333333333
Junco hyemalis (Dark-eyed Junco)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Keller and Anderson 1992	Table 4	-0.031390135
Junco hyemalis (Dark-eyed Junco)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Battin & Sisk 2011	Fig 2c left panel; *j*	0.073774528
Mimus polyglottos (Northern Mockingbird)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Patten et al. 2006	Table 1; *c*	0.83908046
Molothrus ater (Brown-headed Cowbird)	bird	Lockhart and Koper 2018	temperate	Figure 5, Table 2	negative	Sliwinski and Koper 2012	Table 3	0.142857143
Molothrus ater (Brown-headed Cowbird)	bird	Lockhart and Koper 2018	temperate	Figure 5, Table 2	negative	Sliwinski and Koper 2012	Table 4	0.142857143
Molothrus ater (Brown-headed Cowbird)	bird	Lockhart and Koper 2018	temperate	Figure 5, Table 2	negative	Bernath-Plaisted et al. 2017	Fig 1; *k*	0.265853659
Parula americana (Northern Parula)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Moorman and Guynn 2001	Table 3; *h*	0.318394024
Passerculus sandwichensis (Savannah Sparrow)	bird	Lockhart and Koper 2018	temperate	Figure 5, Table 2	negative	Perkins et al. 2013	text p. 514	-0.78473949
Passerculus sandwichensis (Savannah Sparrow)	bird	Lockhart and Koper 2018	temperate	Figure 5, Table 2	negative	Tack et al. 2017	Fig 3 open symbols	-0.210833333
Passerculus sandwichensis (Savannah Sparrow)	bird	Lockhart and Koper 2018	temperate	Figure 5, Table 2	negative	Renfrew et al. 2005	Fig 2	-0.163761468
Passerculus sandwichensis (Savannah Sparrow)	bird	Lockhart and Koper 2018	temperate	Figure 5, Table 2	negative	Sliwinski and Koper 2012	Table 2	-0.142857143
Passerculus sandwichensis (Savannah Sparrow)	bird	Lockhart and Koper 2018	temperate	Figure 5, Table 2	negative	Sliwinski and Koper 2012	Table 4	0.142857143
Passerculus sandwichensis (Savannah Sparrow)	bird	Lockhart and Koper 2018	temperate	Figure 5, Table 2	negative	Bock et al. 1999	Fig 2	-0.6

Passerculus sandwichensis (Savannah Sparrow)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Perkins et al. 2013	text p. 514	-0.78473949
Passerculus sandwichensis (Savannah Sparrow)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Tack et al. 2017	Fig 3 open symbols	-0.210833333
Passerculus sandwichensis (Savannah Sparrow)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Renfrew et al. 2005	Fig 2	-0.163761468
Passerculus sandwichensis (Savannah Sparrow)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Sliwinski and Koper 2012	Table 2	-0.142857143
Passerculus sandwichensis (Savannah Sparrow)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Sliwinski and Koper 2012	Table 4	0.142857143
Passerculus sandwichensis (Savannah Sparrow)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Bock et al. 1999	Fig 2	-0.6
Perisoreus canadensis (Gray Jay)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Ibarzabal and Desrochers 2004	Fig 3; *l*	0.19392793
Perisoreus canadensis (Gray Jay)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Keller and Anderson 1992	Table 4	0.372340426
Perisoreus canadensis (Gray Jay)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Bayne et al. 2008	Table 2	-0.523809524
Pipilo erythrophthalmus (Eastern Towhee also Rufous-sided Towhee)	bird	Gilbert et al. 2019	temperate	Table 4; *ff*	negative	Kroodsma 1984	Fig 2, p. 432	0.7
Pipilo erythrophthalmus (Eastern Towhee also Rufous-sided Towhee)	bird	Gilbert et al. 2019	temperate	Table 4; *ff*	negative	Yahner 1991	text p. 155 (Abstract)	0.15503876
Pipilo erythrophthalmus (Eastern Towhee	bird	Gilbert et al. 2019	temperate	Table 4; *ff*	negative	Rodewald and Vitz 2005	Table 1	-0.129032258

also Rufous-sided Towhee)								
Pipilo erythrophthalmus (Eastern Towhee also Rufous-sided Towhee)	bird	Gilbert et al. 2019	temperate	Table 4; *ff*	negative	Thomas et al. 2014	Appendix A	0.320754717
Pooecetes gramineus (Vesper Sparrow)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Sliwinski and Koper 2012	Table 3	0.147083686
Pooecetes gramineus (Vesper Sparrow)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Bock et al. 1999	Fig 2	-0.733333333
Pooecetes gramineus (Vesper Sparrow)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Knight et al. 2016	Table 1	-0.905882353
Regulus calendula (Ruby-crowned Kinglet)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Rodewald and Brittingham 2002	Table 1; shrubby edge	-0.315787895
Regulus calendula (Ruby-crowned Kinglet)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Rodewald and Brittingham 2002	Table 1; abrupt edge	-1.133582118
Regulus calendula (Ruby-crowned Kinglet)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Keller and Anderson 1992	Table 4	0.054945055
Regulus calendula (Ruby-crowned Kinglet)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Bayne et al. 2008	Table 2; *m*	0
Saxicola rubetra (Whinchat)	bird	Ekroos et al. 2019	temperate	Table 3, text p. 399; *ee*	positive	Besnard et al. 2016	Fig 3; *n*	-0.065971661
Sitta canadensis (Red-breasted Nuthatch)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Thomas et al. 2014	Appendix A; *h*	1
Sitta canadensis (Red-breasted Nuthatch)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Brand and George 2001	Table 1	-0.311195446
Sitta canadensis (Red-breasted Nuthatch)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Keller and Anderson 1992	Table 4	-0.647058824
Sitta canadensis (Red-breasted Nuthatch)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Bayne et al. 2008	Table 2	-0.942857143
Sturnella magna (Eastern Meadowlark)	bird	De Camargo et al. 2018	temperate	Supp Mat Table S1-10	negative	Walk et al. 2010	Table 3	-0.009231905

Sturnella magna (Eastern Meadowlark)	bird	De Camargo et al. 2018	temperate	Supp Mat Table S1-10	negative	Walk et al. 2010	Table 3	-0.594152361
Sturnella magna (Eastern Meadowlark)	bird	De Camargo et al. 2018	temperate	Supp Mat Table S1-10	negative	Patten et al. 2006	Table 1; *c*	-0.335740072
Sturnella magna (Eastern Meadowlark)	bird	De Camargo et al. 2018	temperate	Supp Mat Table S1-10	negative	Ellison et al. 2013	Table 2; male density; *o*	-0.038032454
Sylvia communis (Common Whitethroat)	bird	Ekroos et al. 2019	temperate	Table 3, text p. 399; *ee*	positive	Fonderflick et al. 2013	Fig 1, supp mat Table3	-0.171428571
Turdus leucomelas	bird	Morante-Filho et al. 2021	tropical	Fig 2	positive	Da Silveira et al. 2016	Sup mat 2; *p*	0.76173913
Vermivora chrysoptera (Golden-winged Warbler)	bird	De Camargo et al. 2018	temperate	Supp Mat Table S1-10	positive	Martin et al. 2007	Table 1, Fig2	-0.246808511
Vermivora peregrina (Tennessee Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Rodewald and Brittingham 2002	Table 1; shrubby edge	0.034883547
Vermivora peregrina (Tennessee Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Rodewald and Brittingham 2002	Table 1; abrupt edge	-0.352939412
Vermivora peregrina (Tennessee Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Bayne et al. 2008	Table 1; bird density	-0.023454158
Vermivora peregrina (Tennessee Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	negative	Bayne et al. 2008	Table 2; bird occupancy	0.070063694
Vermivora ruficapilla (Nashville Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Rodewald and Brittingham 2002	Table 1; shrubby edge	0.519228173
Vermivora ruficapilla (Nashville Warbler)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Rodewald and Brittingham 2002	Table 1; abrupt edge	0.589282768
Vireo philadelphicus (Philadelphia Vireo)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Rodewald and Brittingham 2002	Table 1; shrubby edge	0.166665833

Vireo philadelphicus (Philadelphia Vireo)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Rodewald and Brittingham 2002	Table 1; abrupt edge	-0.2999985
Wilsonia canadensis (Canada Warbler)	bird	De Camargo et al. 2018	temperate	Supp Mat Table S1-10	positive	Rodewald and Brittingham 2002	Table 1; shrubby edge	0.9
Wilsonia canadensis (Canada Warbler)	bird	De Camargo et al. 2018	temperate	Supp Mat Table S1-10	positive	Rodewald and Brittingham 2002	Table 1; abrupt edge	0
Zonotrichia albicollis (White-throated Sparrow)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Hannah et al. 2008	Fig 3	0.182509506
Zonotrichia albicollis (White-throated Sparrow)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Bayne et al. 2008	Table 1; bird density	0.142857143
Zonotrichia albicollis (White-throated Sparrow)	bird	De Camargo et al. 2018	temperate	Appendix S3-1; *cc*	positive	Bayne et al. 2008	Table 2; bird occupancy	-0.078571429
Akodon cursor	mammal	Palmeirim et al. 2019	tropical	Table S1.10	positive	Pires et al. 2005	Fig 1	0.565233645
Alouatta palliata mexicana (mantled howler monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 3; Uxpanapa region	positive	Bolt et al. 2020	Fig 4	0.2
Alouatta palliata mexicana (mantled howler monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 3; Uxpanapa region	positive	Bolt et al. 2020	Fig 4	0.466666667
Alouatta palliata mexicana (mantled howler monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 3; Los Tuxtlas region	positive	Bolt et al. 2020	Fig 4	0.2
Alouatta palliata mexicana (mantled howler monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 3; Los Tuxtlas region	positive	Bolt et al. 2020	Fig 4	0.466666667
Alouatta palliata mexicana (mantled howler monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 3; 8th North region	positive	Bolt et al. 2020	Fig 4	0.2
Alouatta palliata mexicana (mantled howler monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 3; 8th North region	positive	Bolt et al. 2020	Fig 4	0.466666667
Alouatta palliata mexicana	mammal	Galán-Acedo et al. 2018	tropical	Figure 3; Uxpanapa region	positive	Bolt et al. 2020	Fig 4	0.2

(mantled howler monkey)								
Alouatta palliata mexicana (mantled howler monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 3; Uxpanapa region	positive	Bolt et al. 2020	Fig 4	0.466666667
Alouatta palliata mexicana (mantled howler monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 3; Los Tuxtlas region	positive	Bolt et al. 2020	Fig 4	0.2
Alouatta palliata mexicana (mantled howler monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 3; Los Tuxtlas region	positive	Bolt et al. 2020	Fig 4	0.466666667
Alouatta palliata mexicana (mantled howler monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 3; 8th North region	negative	Bolt et al. 2020	Fig 4	0.2
Alouatta palliata mexicana (mantled howler monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 3; 8th North region	negative	Bolt et al. 2020	Fig 4	0.466666667
Alouatta pigra (black howler monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 3; Marques de Comillas region	negative	Gavazzi et al. 2008	text p. 1109-1111; *q*	-0.754098361
Alouatta pigra (black howler monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 3; Marques de Comillas region	negative	Gavazzi et al. 2008	text p. 1109-1111; *q*	-0.754098361
Alouatta pigra (black howler monkey)	mammal	Arce-Peña et al. 2019	tropical	Figure 2	positive	Gavazzi et al. 2008	text p. 1109-1111; *q*	-0.754098361
Alouatta pigra (black howler monkey)	mammal	Arce-Peña et al. 2019	tropical	Figure 2	negative	Gavazzi et al. 2008	text p. 1109-1111; *q*	-0.754098361
Artibeus cinereus (Gervais' fruit-eating bat)	mammal	Mendes et al. 2017	tropical	coefficient provided by author	negative	Delaval and Charles-Dominique 2006	Table 1	0.256100291
Artibeus lituratus (Great fruit-eating bat)	mammal	Mendes et al. 2017	tropical	coefficient provided by author	negative	Delaval and Charles-Dominique 2006	Table 1	0.245354824
Artibeus lituratus (Great fruit-eating bat)	mammal	Mendes et al. 2017	tropical	coefficient provided by author	negative	da Silva et al. 2013	Table 2	-0.612244898
Ateles geoffroyi (spider monkey)	mammal	Galán-Acedo et al. 2019	tropical	Table 1	negative	Bolt et al. 2020	Fig 4	0.107692308
Ateles geoffroyi (spider monkey)	mammal	Galán-Acedo et al. 2019	tropical	Table 1	negative	Bolt et al. 2020	Fig 4	0.28

Ateles geoffroyi (spider monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 2; Marques de Comillas region	negative	Bolt et al. 2020	Fig 4	0.107692308
Ateles geoffroyi (spider monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 2; Marques de Comillas region	negative	Bolt et al. 2020	Fig 4	0.28
Ateles geoffroyi (spider monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 2; Uxpanapa region	positive	Bolt et al. 2020	Fig 4	0.107692308
Ateles geoffroyi (spider monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 2; Uxpanapa region	positive	Bolt et al. 2020	Fig 4	0.28
Ateles geoffroyi (spider monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 2; Marques de Comillas region	positive	Bolt et al. 2020	Fig 4	0.107692308
Ateles geoffroyi (spider monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 2; Marques de Comillas region	positive	Bolt et al. 2020	Fig 4	0.28
Ateles geoffroyi (spider monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 2; Uxpanapa region	positive	Bolt et al. 2020	Fig 4	0.107692308
Ateles geoffroyi (spider monkey)	mammal	Galán-Acedo et al. 2018	tropical	Figure 2; Uxpanapa region	positive	Bolt et al. 2020	Fig 4	0.28
Callithrix penicillata	mammal	Grande et al. 2020	tropical	Table 3	positive	Secco et al. 2018	Table 3, text p. 139	0.130033782
Castor canadensis (American beaver)	mammal	Francis et al. 2017	temperate	Fig 2 - woody wetland edge density	positive	Deardorff and Gorchov 2021	Fig 3	0.16431063
Castor canadensis (American beaver)	mammal	Francis et al. 2017	temperate	Fig 2 - woody wetland edge density	positive	Barnes and Mallik 2001	Fig 3	1.182017544
Castor canadensis (American beaver)	mammal	Francis et al. 2017	temperate	Fig 2 - woody wetland edge density	positive	King et al. 1998	Fig 2	0.741758242
Desmodus rotundus (Vampire bat)	mammal	Bolívar-Cimé et al. 2019	tropical	text p. 267	negative	Ávila-Flores et al. 2019	Fig 1	0.483438194
Desmodus rotundus (Vampire bat)	mammal	Mendes et al. 2017	tropical	coefficient provided by author	positive	Ávila-Flores et al. 2019	Fig 1	0.483438194
Didelphis aurita	mammal	Palmeirim et al. 2019	tropical	Table S1.10	positive	Ribeiro et al. 2016	Fig 2	0.072368421
Eulemur rubriventer	mammal	Eppley et al. 2020	tropical	Table S5 supp mat	negative	Lehman et al. 2006a	Table 3, Table 4	0.153920284
Eulemur rufus (formlerly E fulvus rufus)	mammal	Eppley et al. 2020	tropical	Table S5 supp mat	negative	Lehman 2007	Table 2	-0.463768116
Glossophaga soricina (Pallas' long-tongued bat)	mammal	Mendes et al. 2017	tropical	coefficient provided by author	negative	Delaval and Charles-Dominique 2006	Table 1	0.03546004
Lasiurus cinereus (hoary bat)	mammal	Neece et al. 2018	temperate	Figure 3, Table S4	negative	Jantzen and Fenton 2013	Fig 1b; *r*	0.566666667

Lasiurus cinereus (hoary bat)	mammal	Neece et al. 2018	temperate	Figure 3, Table S4	negative	Caldwell et al. 2019	Fig 3	1.168831169
Lasiurus cinereus (hoary bat)	mammal	Neece et al. 2018	temperate	Figure 3, Table S4	negative	McGowan and Hogue 2016	Table 1; *s*	1
Lasiurus cinereus (hoary bat)	mammal	Neece et al. 2018	temperate	Figure 3, Table S4	negative	Morris et al. 2010	Fig 4; t	1.013333333
Leopardus pardalis (ocelot)	mammal	Lombardi et al. 2020	temperate	Table 1, Fig 2	negative	Wolff et al. 2019	Figure 2C	-0.28125
Leopardus pardalis (ocelot)	mammal	Lombardi et al. 2020	temperate	Table 1, Fig 2	negative	Wolff et al. 2019	Figure 2C	-0.28125
Leopardus pardalis (ocelot)	mammal	García-R et al. 2019	tropical	Figure 3	negative	Wolff et al. 2019	Figure 2C	-0.28125
Metachirus nudicaudatus	mammal	Palmeirim et al. 2019	tropical	Table S1.10	positive	Pires et al. 2005	Fig 1	0.163126593
Metachirus nudicaudatus	mammal	Palmeirim et al. 2019	tropical	Table S1.10	positive	Mendes-Oliveira et al. 2012	text p. 61; u	-1
Myotis nigricans (Black myotis)	mammal	Mendes et al. 2017	tropical	Table 2, coefficient provided by author	negative	da Silva et al. 2013	Fig 4	0.428571429
Nycticeius humeralis (evening bat)	mammal	Neece et al. 2018	temperate	Table S4	negative	McGowan and Hogue 2016	Table 1; *s*	1
Nycticeius humeralis (evening bat)	mammal	Neece et al. 2018	temperate	Table S4	negative	Morris et al. 2010	Fig 4; *t*	0.293333333
Nycticeius humeralis (evening bat)	mammal	Neece et al. 2018	temperate	Table S4	negative	Hein et al. 2009	Table 4, text p. 1203	0.8
Philander frenata	mammal	Palmeirim et al. 2019	tropical	Table S1.10	positive	Pires et al. 2005	Fig 1	-0.569374551
Philander frenata	mammal	Palmeirim et al. 2019	tropical	Table S1.10	positive	Ribeiro et al. 2016	Fig 2	-0.06547619
Philander frenata	mammal	Palmeirim et al. 2019	tropical	Table S1.10	positive	Lira et al. 2007	text p. 430, Fig 2; *v*	0.649665552
Propithecus coquereli	mammal	Eppley et al. 2020	tropical	Table S5 supp mat	negative	Ramilison et al. 2021	Figure 2, p. 354	0.173246419
Propithecus diadema	mammal	Eppley et al. 2020	tropical	Table S5 supp mat	negative	Irwin 2008	Fig 4; *w*	-0.896341463
Propithecus edwardsi AKA Propithecus diadema edwardsi	mammal	Eppley et al. 2020	tropical	Table S5 supp mat	negative	Lehman et al. 2006b	Table 1	0.759856631
Propithecus tattersalli	mammal	Eppley et al. 2020	tropical	Table S5 supp mat	negative	Quemere et al. 2010	Figure 2	0.068161784

Sturnira lilium (Little yellow-shouldered bat)	mammal	Mendes et al. 2017	tropical	coefficient provided by author	positive	Delaval and Charles-Dominique 2006	Table 1	0.769230769
Sturnira lilium (Little yellow-shouldered bat)	mammal	Mendes et al. 2017	tropical	coefficient provided by author	positive	da Silva et al. 2013	Table 2	-0.0625
Sturnira lilium (Little yellow-shouldered bat)	mammal	Mendes et al. 2017	tropical	coefficient provided by author	positive	Lomascola 2016	Table 1	1
Borrelia burgdorferi (Lyme disease)	micro-organism	Moon et al. 2019	temperate	Figure 2; *gg*	positive	Horobik et al. 2006	Fig 4	-0.296296296
Borrelia burgdorferi (Lyme disease)	micro-organism	Ehrmann et al. 2018	temperate	text p. 1, p. 8; *hh*	positive	Horobik et al. 2006	Fig 4	-0.296296296
Central European tick-borne encephalitis (for local edge search for the tick host, Ixodes ricinus)	micro-organism	Stefanoff et al. 2018	temperate	Table 2, Fig 4; *ii*	positive	Mathews-Martin et al. 2020	Table 2	-0.333333333
Central European tick-borne encephalitis (for local edge search for the tick host, Ixodes ricinus)	micro-organism	Stefanoff et al. 2018	temperate	Table 2, Fig 4; *ii*	positive	Jennett et al. 2013	Fig 3	-0.261538462
Angelica sylvestris	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Devlaeminck et al. 2005	Appendix	1.081081081
Athyrium filix-femina	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Devlaeminck et al. 2005	Appendix	-1.081081081
Athyrium filix-femina	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Liira and Paal 2013	p. 459, Fig 5, Appendix C; *x*	-0.777777778
Calamagrostis phragmitoides	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Klimova et al. 2020	Table 1	0.75
Carex canescens	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Klimova et al. 2020	Table 1	1.5
Carex montana	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	positive	Bergman 1999	Figure 3; y	0.215510204
Carex pallescens	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Liira and Paal 2013	p. 459, Fig 5, Appendix C; *x*	-0.777777778
Carex pilulifera	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Devlaeminck et al. 2005	Appendix	-1.081081081
Carex remota	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Uria-Diez and Ibáñez 2014	Figure 3	1.125
Carex vaginata	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Liira and Paal 2013	p. 459, Fig 5, Appendix C; *x*	-0.777777778

Chrysosplenium alternifolium	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Liira and Paal 2013	p. 459, Fig 5, Appendix C; *x*	-0.777777778
Circaea alpina	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Devlaeminck et al. 2005	Appendix	1.081081081
Circaea alpina	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Liira and Paal 2013	p. 459, Fig 5, Appendix C; *x*	-0.777777778
Cirsium palustre	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Devlaeminck et al. 2005	Appendix	-1.081081081
Convallaria majalis	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	positive	Devlaeminck et al. 2005	Appendix	-0.890302067
Dryopteris carthusiana	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	positive	Liira and Paal 2013	p. 459, Fig 5, Appendix C; *x*	-0.777777778
Dryopteris expansa	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Liira and Paal 2013	p. 459, Fig 5, Appendix C; *x*	-0.777777778
Empetrum nigrum	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Hill et al. 2012	Fig 2, p. 388; *z*	0.436241611
Eriophorum vaginatum	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Pawlikowski et al. 2014	Table 1; *aa*	0
Galium uliginosum	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	positive	Liira and Paal 2013	p. 459, Fig 5, Appendix C; *x*	-0.777777778
Geranium sylvaticum	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Liira and Paal 2013	p. 459, Fig 5, Appendix C; *x*	-0.777777778
Goodyera repens	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Catling and Kostiuk 2011	Table 2	0.642857143
Gymnocarpium dryopteris	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Liira and Paal 2013	p. 459, Fig 5, Appendix C; *x*	-0.777777778
Luzula multiflora	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Devlaeminck et al. 2005	Appendix	0.227596017
Maianthemum bifolium	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Devlaeminck et al. 2005	Appendix	-1.081081081
Maianthemum bifolium	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Liira and Paal 2013	p. 459, Fig 5, Appendix C; *x*	-0.777777778
Oxalis acetosella	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Devlaeminck et al. 2005	Appendix	-0.544374161
Oxalis acetosella	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Liira and Paal 2013	p. 459, Fig 5, Appendix C; *x*	-0.777777778
Paris quadrifolia	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Liira and Paal 2013	p. 459, Fig 5, Appendix C; *x*	-0.777777778
Picea abies	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Esseen 2006	Table 2	0.038769425
Scirpus sylvaticus (wood club rush)	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	negative	Liira and Paal 2013	p. 459, Fig 5, Appendix C; *x*	-0.777777778
Solidago virgaurea	plant	Lehtila et al. 2020	temperate	Appendix S1 supp mat	positive	Liira and Paal 2013	p. 459, Fig 5, Appendix C; *x*	-0.777777778

a data during fall feeding period; no information about how far from an edge the "middle" of habitat was - assumed 50 m

b used panel (a) adult males as it has the most data; assumed the lowest number for each abundance range *c* adjusted for area surveyed, edge vs. interior, but no distance provided for interior, assumed 300 m

d largest distance highly variable (>100m), numbers not controlled for area surveyed at each distance

e response male density, same pattern for nest density (Table 3)

f divided actual numbers of territories by potential (simulated) numbers at edge and interior

g right panel because Table 2 shows higher abundance in untreated forest

h used the 13-m radius gaps as "edge" sites, interior sites were >200m from gaps

i average distance to clearcut edge for buffers is 34 m and average for references is 380 m; averaged response for mainstem and tributary sites at each distance

j used left panel because they are more abundant in treated than untreated forest

k same habitat on other side of road

l frequency/random points in distance classes

m well pad has no noise

n added 0.23 to all values in Figure to remove negative values

o no difference for nest density - Table 3

p data combine 2 species (Turdus rufiventris and Turdus leucomelas) but authors imply that they respond the same way

q not clear how far the interior sites were from the edge (assumed 100 m)

r added 4 to all values in Figure to remove negative values

s distance for interior sites set to 300 m as not provided

t interior sites were "at least" 100 m from edge

u present only > 250 m from edge

v data provided only for the one individual that showed a significant edge response

w proportion time spent in edge vs. interior; numbers are averages of (obs-exp) + 5 to make them all positive

x results in appendix C are for the species that decline from interior to edge (forest specialists) but I cannot determine which is which, so used the medians from Figure 2(a) for all of them

y data are from the "forest" side of the transects (right side of plot)

z used forest as "habitat" even though more abundant in heath, to match definiton of habitat from frag study

aa cover class = 100 both in the forest and at the forest edge

bb other species in Table 3 not included because they have mixed responses

cc provided by author

dd assuming that "edge length" refers to edge length of wheat fields in the landscape, but they are not explicit

ee not really clear how they measured edge density

ff divided landscape into forest (most abundant), agriculture and development; CONTAG is low for most aggregated (lowest frag) and high for most fragmented (interspersed)

gg samples are infected people

hh sampled in forest patches

ii response is infection rate in humans per county and predictor is edge density in county