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Roadkill patterns in Latin American birds and mammals

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Abstract

Aim: Roads are a major threat for wildlife, degrading habitat and causing mortality via wildlife–vehicle collisions. In Latin America, the conjunction of high biodiversity and a rapidly expanding road network is reason for concern. We introduce an approach that combines species traits and habitat preferences to describe vulnerability and map areas of high roadkill risk. Thus, we present the first assessment of roadkill impacts for Latin American birds and mammals.

Location: Latin America.

Time period: 1994–2020.

Major taxa studied: Birds and mammals.

Methods: We compiled data from 85 roadkill surveys from Latin America that provided 1,691 roadkill rate estimates for 346 bird and 159 mammalian species, from which 520 rates from 249 birds and 457 rates from 103 mammals were used for analyses. We applied random forest models to predict observed roadkill rates considering species traits, habitat preferences and the geographical coordinates of each study to control for local and regional variation. Fitted models were used to predict spatial risks on Latin American roads for roadkilled birds and mammals across their areas of habitat.

Results: We found higher roadkill rates for larger birds and medium-sized mammals with faster reproduction (more clutches/litters per year and early maturity ages), higher population densities and wider use of habitats that included anthropized areas. In mammals, scavengers and those with diets based on invertebrates showed higher rates. Spatial predictions revealed higher rates on roads across Central America, northern Andean regions, eastern Brazil, Uruguay, central and eastern Argentina and southern Chile.

Main conclusions: This first comprehensive assessment for Latin America explores various drivers of roadkill risk for birds and mammals and identifies species and areas where existing roads can impact wildlife. Trait-based models fine-tuned with realistic spatial information that accounts for habitat suitability provide a valuable tool for the assessment of human impacts, including roads and traffic.

1 | INTRODUCTION

Transportation is key for many human activities, including commerce, tourism and education, which are essential for social and economic development (Forman et al., 2003). Unfortunately, this dependence on roads and vehicles can cause environmental destruction (Van Der Ree et al., 2015). Wildlife–vehicle collisions (hereafter roadkill) were found to be the second highest source of anthropogenic mortality for large and medium-sized mammals in North America, only surpassed by hunting (Collins & Kays, 2011). Road infrastructure can disrupt movement (Bischof et al., 2017; Cayuela et al., 2019; Chen & Koprowski, 2016) and prevent gene flow, leading to fragmentation and isolation of populations, loss of genetic diversity, and even genetic differentiation of populations (Clark et al., 2010; Jackson & Fahrig, 2011; Lesbarrères et al., 2006).

Latin America is a highly biodiverse region that includes seven global biodiversity hotspots (the Tropical Andes, Mesoamerica, Caribbean, Brazil's Atlantic Forest, Choco/Darien/Western Ecuador, Brazil's Cerrado and Central Chile) with very high concentrations of endemic vertebrates (Myers et al., 2000). This region currently has almost 3.5 million km of roads and is expected to have the highest rate of new road development globally in the near future (Meijer et al., 2018). For example, plans include construction and expansion of 12,000 km of roads in the Amazon Basin in the next 5 years (Vilela et al., 2020), which could lead to increased roadkill rates and affect local populations. The combination of high biodiversity and expanding infrastructure makes it urgent to assess how roads affect Latin American wildlife to facilitate sustainable development and effective mitigation.

Different habitat types and configurations have been shown to influence the risk of wildlife–vehicle collision. For example, amphibians are frequently roadkilled near forests (Braz & Rodrigues, 2016), birds are more affected in roads bordering pasturelands and fragmented forests (Medrano-Vizcaíno & Espinosa, 2021), some species of mammals, such as *Cerdocyon thous* and *Lepus europaeus*, are more vulnerable near water bodies (Freitas et al., 2015), and mortality of snakes is higher near pasturelands (Quintero-Ángel et al., 2012). Although habitat composition and configuration are important, they do not seem to explain wildlife mortality patterns fully. Species that use similar habitats can have different roadkill rates. For example, the crab-eating fox (*Cerdocyon thous*) and the white-eared opossum (*Didelphis albiventris*) are both habitat generalists that tolerate humanized areas (Cantor et al., 2010; De Barros Ferraz et al., 2010) but are affected very differently by roads: in a study conducted in Misiones-Argentina, the white-eared opossum made up 38.8% of total roadkills, whereas *Cerdocyon thous* represented only 3.3% (Bauni et al., 2017). Although variation in local abundance or density can explain, in part, the differences in roadkill rates (Caceres, 2011; Delgado-V, 2007; Medrano-Vizcaíno, 2015), rare species can also suffer high mortality. The western mountain

coati (*Nasuella olivacea*), an elusive carnivore whose ecology is scarcely known (Medrano-Vizcaíno & Gutiérrez-Salazar, 2020), was the second most roadkilled species in Envigado-Colombia (Delgado-V, 2007).

Diet, life history and morphology have been shown to influence roadkill risk in some regions of Latin America (Caceres, 2011; González-Suárez et al., 2018). Large body size, ground-foraging behaviour and a wider dietary breadth have been associated with roadkill risk in Brazilian birds (González-Suárez et al., 2018), whereas mammals at higher risks were those with diurnal habits, intermediate body masses, slow movements, smaller home ranges and scavenging behaviour (Caceres, 2011; González-Suárez et al., 2018). These types of trait-based predictive models can offer initial assessment tools to identify vulnerable species and areas. A few previous studies have adopted this approach at local (Leonan et al., 2018; Rincón-Aranguri et al., 2019) and national (González-Suárez et al., 2018) scales within Latin America, but local inferences might not be applicable to all regions and diverse wildlife communities in the Neotropics. Here, we present the first continental-scale assessment of roadkill risk for Latin American birds and mammals.

We compiled a comprehensive database of roadkill rates for >500 species of birds and mammals across Latin America and the Caribbean and applied machine learning methods to develop predictive models of roadkill vulnerability. Predictors included diet, life history and morphological traits that we hypothesized a priori could influence roadkill rates (Table 1). Going a step beyond previous work, we refined spatial predictions using habitat preferences to provide a more realistic assessment of roadkill risk. Our analyses identify generalized traits that make Latin American birds and mammals more vulnerable to roadkill and offer a continental risk assessment that reveals both vulnerable species and areas where road mortality rates might be particularly high.

2 | METHODS

We searched peer-reviewed publications and grey literature (e.g., academic theses and dissertations) to locate systematic roadkill surveys published before July 2020 using the keywords "roadkill", "wildlife vehicle collision", "road mortality" "road ecology", "birds roadkills", "mammals roadkills" plus the name of each country in Latin America. We also searched for these terms in Spanish and Portuguese to identify additional sources in those languages. From each identified study reporting roadkill data, we collected, for each species, the number of individual carcasses found as roadkill, descriptors of the survey design (time between surveys, total sampling period from first to last survey and length of road surveyed) and the geographical coordinates of the study area (central point). We used the IUCN nomenclature and synonyms to standardize all species names after correcting identified spelling mistakes. We assumed correct taxonomic identification of roadkill individuals from each study.

TABLE 1 Variables used as predictors of roadkill rates

Type of variable	Variable	Description	Hypotheses	Birds		Mammals	
				N_T	N_M	N_T	N_M
Geographical	Latitude and longitude	Geographical coordinates of the centroid of every study analysed	Roadkill rates can vary across areas owing to local factors, including traffic patterns, road and landscape features that could be captured broadly by coordinates	346 (100%)	249 (100%)	159 (100%)	103 (100%)
Morphological	Body mass	Median adult body mass (in kilograms)	Large sized species are more visible to drivers, which decreases their probability of being hit by vehicles	346 (100%)	249 (100%)	159 (100%)	103 (100%)
Life history	Age at maturity	Median age (in days) when individuals reach sexual maturity	Species with lower ages at maturity generally have higher local population abundances, which, in turn, can result in higher roadkill rates	89 (25.7%)	51 (20.5%)	110 (69.2%)	75 (72.8%)
	Litter/clutch size	Median number of offspring in each reproductive event	Species with larger litter sizes generally have higher local population abundances, which, in turn, can result in higher roadkill rates	330 (95.3%)	236 (94.8%)	146 (91.8%)	93 (90.3%)
	Litters/clutches per year	Median number of reproductive events per year	Species that have more litters per year generally have higher local population abundances, which, in turn, can result in higher roadkill rates	109 (31.5%)	68 (27.3%)	111 (69.8%)	71 (68.9%)
	Longevity	Median life span (in years)	Long-lived species have more opportunities to acquire experience and learn to cope with novel habitats, such as roads, which could result in lower roadkill rates	119 (34.3%)	76 (30.5%)	133 (83.6%)	92 (89.3%)
	Group size	Median size of social groups	More individuals can be roadkilled in a single collision if animals cross roads in groups. Given that group crossings are more likely to occur in social species, these species could have higher roadkill rates	232 (67.0%)	164 (65.9%)	85 (53.5%)	64 (62.1%)
	Home range	Median home range (in square kilometres)	Species with larger home ranges are more likely to encounter and cross roads, increasing their probabilities of being roadkilled	37 (10.7%)	27* (10.8%)	99 (62.3%)	73 (70.9%)
Activity	Activity	Categorical descriptors of the main time of daily activity: Diurnal or nocturnal	Driver visibility is reduced at night; therefore, collisions might be more common during that period, resulting in higher rates for nocturnal animals	326 (94.2%)	232 (93.2%)	159 (100%)	103 (100%)

(Continues)

TABLE 1 (Continued)

Type of variable	Variable	Description	Hypotheses	Birds		Mammals	
				N_T	N_M	N_T	N_M
	Population density	Median number of individuals per square kilometre	Higher population densities (local abundance) can increase roadkill because more individuals might be found near and on roads	103 (29.8%)	61 (24.5%)	61 (38.3%)	44 (42.7%)
Diet	Invertebrate diet (%)	Percentage of diet based on invertebrates	Invertebrates might be attracted to resources near roads, such as verges, in turn attracting animals with an invertebrate-based diet and increasing their exposure to roadkill	343 (99.1%)	246 (98.8%)	157 (98.7%)	102 (99.0%)
	Ectotherm vertebrate diet (%)	Percentage of diet based on ectotherm vertebrates	Ectotherm species can use roads for thermoregulation, which can attract their predators and increase their roadkill rates	343 (99.1%)	246 (98.8%)	157 (98.7%)	102 (99.0%)
	Scavenger diet (%)	Percentage of diet based on scavenging	Scavenger species can be attracted to roads to feed on dead animals, increasing their roadkill rates	343 (99.1%)	246 (98.8%)	157 (98.7%)	102 (99.0%)
	Seed diet (%)	Percentage of diet based on seeds	Road verges can provide food sources for seed-eaters and attract them to roads, increasing their roadkill rates	343 (99.1%)	246 (98.8%)	Not assessed	Not assessed
	Plant diet (%)	Percentage of diet based on plants	Road verges can provide food sources for herbivores and attract them to roads, increasing their roadkill rates	343 (99.1%)	246 (98.8%)	157 (98.7%)	102 (99.0%)
	Dietary breadth	Number of different categories consumed (out of 10 possible diet categories)	Species with a generalist diet can be attracted to diverse resources, such as road verge vegetation, prey feeding on verges and carrion, thus increasing their roadkill rates	343 (99.1%)	246 (98.8%)	157 (98.7%)	102 (99.0%)

TABLE 1 (Continued)

Type of variable	Variable	Description	Hypotheses	Birds		Mammals	
				N_T	N_M	N_T	N_M
Habitat	Artificial	Whether the species occur in artificial habitats (1 = yes, 0 = no)	Roads are very common in artificial habitats, hence species that use this habitat will be more exposed to roads	346 (100%)	249 (100%)	158 (99.4%)	103 (100%)
	Cropland	Whether the species occur in cropland habitats (1 = yes, 0 = no)	Roads are relatively common near croplands, and some species might be attracted to the resources in crops, hence species that use this habitat will be more exposed to roads	346 (100%)	249 (100%)	158 (99.4%)	104 (100%)
	Grassland	Whether the species occur in grassland habitats (1 = yes, 0 = no)	Roads can be relatively common near grasslands (particularly those in flat areas, which are more suitable for infrastructure), hence species that use this habitat will be more exposed to roads	346 (100%)	249 (100%)	158 (99.4%)	104 (100%)
	Forest	Whether the species occur in forest habitats (1 = yes, 0 = no)	Species that prefer forests are more likely to be specialists and avoid novel and altered areas, decreasing their roadkill rates	346 (100%)	249 (100%)	158 (99.4%)	104 (100%)
	Sparse vegetation	Whether the species occur in sparse vegetation habitats (1 = yes, 0 = no)	Areas with sparse vegetation can be associated with unproductive regions (with few animals) where roadkill rates will be lower	346 (100%)	249 (100%)	158 (99.4%)	104 (100%)
	Water bodies	Whether the species uses aquatic habitats (1 = yes, 0 = no)	Species that use water bodies might be less likely to cross roads (unsuitable habitat), resulting in lower roadkill rates. An alternative hypothesis is that species using water bodies might need to move if sources dry up and could cross roads while dispersing, increasing their roadkill risk	346 (100%)	249 (100%)	158 (99.4%)	104 (100%)
	Habitat breadth	Number of habitat types where a species occurs, from 10 possible types	Habitat generalists can occupy altered areas, including roads or places near roads, leading to higher roadkill rates	346 (100%)	249 (100%)	158 (99.4%)	104 (100%)

Notes: We report the number of species with available data and, in parentheses, the percentage from the total (N_T) of 346 birds and 159 mammals for which roadkill estimates were available and for the subset (N_M) of 249 birds and 103 mammals from more comprehensive studies used to fit the model. Missing trait data were imputed before analyses (see Methods). We also present a priori hypotheses for how each variable could influence roadkill rates. *Variables not included in the analysis.

Roadkill rates per species and study were calculated as the total number of carcasses found divided by the length of the road surveyed (in kilometres) and the study duration (in days). This daily rate was then converted to the number of individuals per kilometre per year (multiplying by 365), assuming a constant roadkill rate across the year. Given that detectability and survey intervals can influence the number of carcasses detected as roadkill, we adjusted these values with correction factors proposed by Santos et al. (2011), which estimate the timings of persistence of carcasses on roads among taxonomic groups. Then, roadkill rates were multiplied by correction factors based primarily on body size categories and survey intervals (a full list of correction factors is given in Supporting Information Appendix S1).

We also compiled species-level data for 22 variables that describe diet, life history, morphological traits and habitat preferences in birds and mammals (Table 1). The list of variables was initially the same for both groups, but home range was removed for birds owing to low data availability, and seed diet was excluded for mammals owing to low variability in the studied species, which made this variable uninformative. Trait data were collected from multiple published databases, books and published papers referenced in the Appendix (all trait and roadkill data are available in a public repository: https://figshare.com/s/6e48c050e84ee1ba6a12).

2.1 | Vulnerability to roadkill

Trait data are often not available for all species, but given that traits are generally correlated, imputation can be a useful method for handling missing values (Johnson et al., 2021). Before predicting roadkill rates, we imputed missing trait values using the default settings of the function "missForest" (maxiter = 10, ntree = 100) from the R package "missForest" (Stekhoven, 2013). This approach uses random forests iteratively to predict one trait using data from all other traits and has been shown to work well with multivariate data, outperforming other methods, such as *k*-nearest neighbours imputation or multivariate imputation (Stekhoven & Bühlmann, 2012). To account for uncertainty in imputed values, we generated and analysed 15 imputed datasets for birds and 15 for mammals. In addition, we fitted models excluding variables for which empirical data were available for <40% of species to ensure that results were not affected by heavily imputed variables. Previous studies found imputation of trait data to be reliable with ≤60% of missing values (Penone et al., 2014). Imputation was done using data for all species recorded as roadkill, but to fit the model predicting roadkill rates we consider that studies had been conducted using a diversity of sampling methods and covered different survey areas and periods. To reduce some of the variability in estimated rates attributable to methodological differences, we then fitted models using only studies with a minimum duration of 3 months, a minimum road length surveyed of 5 km, and a maximum survey interval of 7 days.

Following González-Suárez et al. (2018), we used machine learning random forest regression, which can capture nonlinear relationships and interactions among predictions, to predict roadkill rates.

This effective tool for prediction assembles multiple regression trees, with each constructed from a bootstrap sample of the original dataset. Approximately two-thirds of the samples form a bootstrap sample, while the other third is left out [out of bag samples (OOB samples); Breiman, 2001]. We trained models using all roadkill rates that met the methodological criteria described above because we considered that splitting the data to create a single test dataset could bias our taxonomically and spatially structured data. As a result, model fit might be overestimated.

Random forests were generated based on 2,000 regression trees using the function "randomForest" from the R package "randomForest" (Liaw & Wiener, 2002). We fitted separate models for birds and mammals because different relationships could exist for each class. These models included all trait variables and the taxonomic order of each species to account for evolutionary relatedness and similarities across taxa not reflected in the tested traits. The models also included as predictors the latitude and longitude of the central road point of the survey area of each study to account broadly for spatial variability and local factors affecting roadkill estimates.

Model performance was reported using the total variance explained, which is calculated as 1 – MSE/Variance_y, where mean square error (MSE) is the sum of squared residuals of the OOB sample/OOB sample size, and Variance_y is the variance in predicted values (Acharjee et al., 2011). We used permutation feature importance to evaluate how well different features (variables) predicted roadkill. The variable importance was calculated for each feature as the difference in MSE between 2,000 regression trees fitted with the original data and 2,000 trees fitted after the permutation of values in that variable. The average of these differences was divided by their standard deviation and reported as variable importance (we report 15 importance estimates for each variable obtained from the analyses of the 15 imputed datasets). Permutation of important variables results in lower variance explained (poorer model performance), whereas permutation of less important variables does not greatly reduce the variance explained. Owing to the stochastic nature of random forest, negative variable importance values can occur by chance, when permuting an uninformative variable, which results in slightly lower MSE than with the original data. These can be considered as effectively zero importance.

We also generated dependence plots using the function "partial" from the R package "pdp" (Greenwell, 2017). These are informative graphics to understand the relationship between the predicted response and predictor variables. These plots represented the prediction of roadkill rates for a given variable obtained by marginalizing the machine learning model output over the distribution of all other features, hence the function depends only on the focal variables with interactions with other variables included.

2.2 | Predicting spatial roadkill risks

We predicted roadkill rates for all Latin American birds and mammals reported as roadkill at least once in the compiled systematic surveys.

We defined current distribution areas for each species using IUCN maps (IUCN, 2021), considering only those polygons with certainty of presence (i.e., possible extant, possible extinct and extinct categories were removed). Additionally, for bird ranges for which migration classifiers are included, we selected breeding, no breeding and passage, removing those classed as vagrant. Given that distribution areas can include unsuitable habitat, the use of area of habitat has been recommended to provide a better representation of the true area used by the species (Brooks et al., 2019). Therefore, to reduce overestimation of risk by including areas where a species is unlikely to occur, we defined area of habitat by selecting only areas of the distribution range that matched the preferred habitats of each species. Habitats were delimited geographically using high-resolution (30 arc-sec^2, c. 1 km^2) land-cover datasets of 1998–2012 (Latham et al., 2014).

We then defined a 1° × 1° grid of Latin America and generated a list of species present in each grid cell, considering as present all whose area of habitat overlapped to any extent with the cell. Each grid was then considered as a potential study site, with location defined by the geographical coordinates of the centroid of the cell. Using the fitted random forest models, we then predicted roadkill rates for the species in each grid cell given trait values, taxonomy and the centroid coordinates of the cell. We used median rates per species and cell calculated from the 15 imputed datasets. For each grid cell, we then calculated the total roadkill rates per cell for birds and mammals by adding roadkill rates for all species in each class in that cell. Considering the length of all primary and secondary roads (Meijer et al., 2018) within each grid cell, we finally calculated the total predicted number of birds and mammals roadkilled per year in each cell by multiplying the total roadkill rate by the existing kilometres of road in each species habitat.

3 | RESULTS

3.1 | Roadkilled birds and mammals in Latin America

The full compiled roadkill dataset included 1,691 roadkill rate estimates, representing 346 bird species and 159 mammal species and 85 studies from 12 Latin American countries (Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Guatemala, Panama, Paraguay, Peru, Mexico and Venezuela). Most of the birds reported as roadkill are classified as Least Concern (LC) by the IUCN Red List (IUCN, 2021), with seven in higher risk categories, including three listed as Near Threatened (NT): yellow-faced Amazon parrot (*Alipiopsitta xanthops*), greater rhea (*Rhea Americana*) and eastern meadowlark (*Sturnella magna*); three as Vulnerable (VU): black-masked finch (*Coryphaspiza melanotis*), sharp-tailed tyrant (*Culicivora caudacuta*) and channel-billed toucan (*Ramphastos vitellinus*); and one as Endangered (EN): violet-throated metaltail (*Metallura baroni*).

The top roadkilled birds (those with the highest corrected rates; Table 2) are all listed as Least Concern and included the long-tailed mockingbird (*Mimus longicaudatus*; median roadkill rate across

studies: 1.56 individuals/km/year), the social flycatcher (*Myiozetetes similis*; median rate .98 individuals/km/year) and the groove-billed ani (*Crotophaga sulcirostris*; median rate .97 individuals/km/year). Among threatened birds, the violet-throated metaltail, listed as Endangered, had a roadkill rate of .26 individuals/km/year, which is relatively high considering that its distribution is restricted to the south of Ecuador, where only a few occurrences have been reported (13 records; Tinoco et al., 2009). Although potentially worrying, this roadkill rate was estimated from a single study with only two roadkilled individuals (Aguilar et al., 2019); mortality might be less frequent in other areas of the species distribution. Relatively high rates of .15 individuals/km/year were also reported for the eastern meadowlark, which is listed as Near Threatened.

The top roadkilled mammals are listed as Least Concern (Table 2), but 23 species have higher IUCN risk status. Fourteen species are listed as Near Threatened; eight as Vulnerable: brown howler monkey (*Alouatta guariba*), greater naked-tailed armadillo (*Cabassous tatouay*), bristle-spined rat (*Chaetomys subspinosus*), northern tiger cat (*Leopardus tigrinus*), Brazilian dwarf brocket (*Mazama nana*), giant anteater (*Myrmecophaga tridactyla*), giant armadillo (*Priodontes maximus*) and lowland tapir (*Tapirus terrestris*); and one as Endangered: tapeti (*Sylvilagus brasiliensis*). In addition, two roadkilled mammals are listed as Data Deficient: Azara's agouti (*Dasyprocta azarae*) and red brocket (*Mazama americana*).

The Andean white-eared opossum (*Didelphis pernigra*; LC) had the highest reported rate (4.68 individuals/km/year), followed by the Sechuran fox (*Lycalopex sechurae*; NT) with a rate of 3.44 individuals/km/year, and the common opossum (*Didelphis marsupialis*; LC) with a median rate of 1.45 individuals/km/year. Although rates for the common opossum are lower, this species has been reported as roadkilled in 17 studies from six countries (Brazil, Colombia, Ecuador, Mexico, Panama and Peru), whereas the Andean white-eared opossum and the Sechuran fox were reported in only one study in Ecuador and Peru, respectively.

3.2 | Vulnerability to roadkill

Thirty-five of the compiled studies did not meet our methodological criteria (see Methods), hence models were fitted using 50 studies conducted in nine countries (Argentina, Brazil, Chile, Colombia, Ecuador, Guatemala, Mexico, Panama and Peru), which provided 520 roadkill rate estimates for 249 bird species and 457 roadkill rates for 103 mammals. Random forest models explained on average (across models fitted for the 15 imputed datasets) 57.3% of the observed variance in bird roadkill rates (SD across the 15 datasets; .002), and 47.7% for mammals (SD across the 15 datasets; .002). The latitude and longitude (location) of the study were the most important variables for both taxonomic groups (Figure 1). These were expected a priori to be important because they are the only variables that could explain observed within-species variability in rates. In addition, several traits were also identified as relevant predictors in each taxonomic group (Figure 1). Among birds, larger species

Class	Order	Scientific name	IUCN status	Number of studies	Roadkill rate (individuals/km/year)
Aves	Passeriformes	*Mimus longicaudatus*	LC	1	1.561
	Passeriformes	*Myiozetetes similis*	LC	2	.979
	Cuculiformes	*Crotophaga sulcirostris*	LC	2	.971
	Pelecaniformes	*Bubulcus ibis*	LC	2	.929
	Caprimulgiformes	*Amazilia tzacatl*	LC	1	.908
	Accipitriformes	*Rostrhamus sociabilis*	LC	1	.888
	Passeriformes	*Geospizopsis unicolor*	LC	1	.785
	Passeriformes	*Platyrinchus cancrominus*	LC	1	.762
	Falconiformes	*Caracara cheriway*	LC	1	.760
	Passeriformes	*Ochthornis littoralis*	LC	1	.730
Mammalia	Didelphimorphia	*Didelphis pernigra*	LC	1	4.681
	Carnivora	*Lycalopex sechurae*	NT	1	3.436
	Didelphimorphia	*Didelphis marsupialis*	LC	16	1.453
	Pilosa	*Choloepus hoffmanni*	LC	3	.859
	Rodentia	*Galea flavidens*	LC	1	.706
	Rodentia	*Oligoryzomys flavescens*	LC	1	.652
	Pilosa	*Tamandua mexicana*	LC	5	.594
	Carnivora	*Conepatus chinga*	LC	5	.532
	Carnivora	*Lycalopex gymnocercus*	LC	3	.355
	Pilosa	*Bradypus variegatus*	LC	2	.312

Notes: We report species name, IUCN Red List status (LC = least concern; NT = near threatened), the number of studies in which that species was reported as roadkill and the estimated roadkill rate (when data were available for more than one study, we calculated a median rate across studies using corrected values). The number of studies and observed rates are reported considering those studies that met the methodological criteria (minimum duration of 3 months, a minimum road length surveyed of 5 km, and a maximum survey interval of 7 days) that we consider to provide more reliable estimates.

(>2.5 kg) with a higher population density had higher roadkill rates, as did those with a shorter lifespan, <5 years; age at sexual maturity <500 days; and at least two clutches per year (Figure 2). More generalist birds, with wider habitat breadths (occupying more than five different habitats) and that regularly use artificial habitat, croplands, grasslands and water bodies, also had higher roadkill rates (Figure 2). Among mammals, species with adult body mass between 2 and 35 kg, faster life histories (life spans <10 years; age at maturity <500 days), higher population density, scavenger and invertebrate diets, smaller home ranges (<10 km) and generalist habits (habitat breadth more than five categories) had higher mortality rates (Figure 3). Cuculiformes birds and Pilosa mammals were the taxonomic orders with the highest roadkill rates.
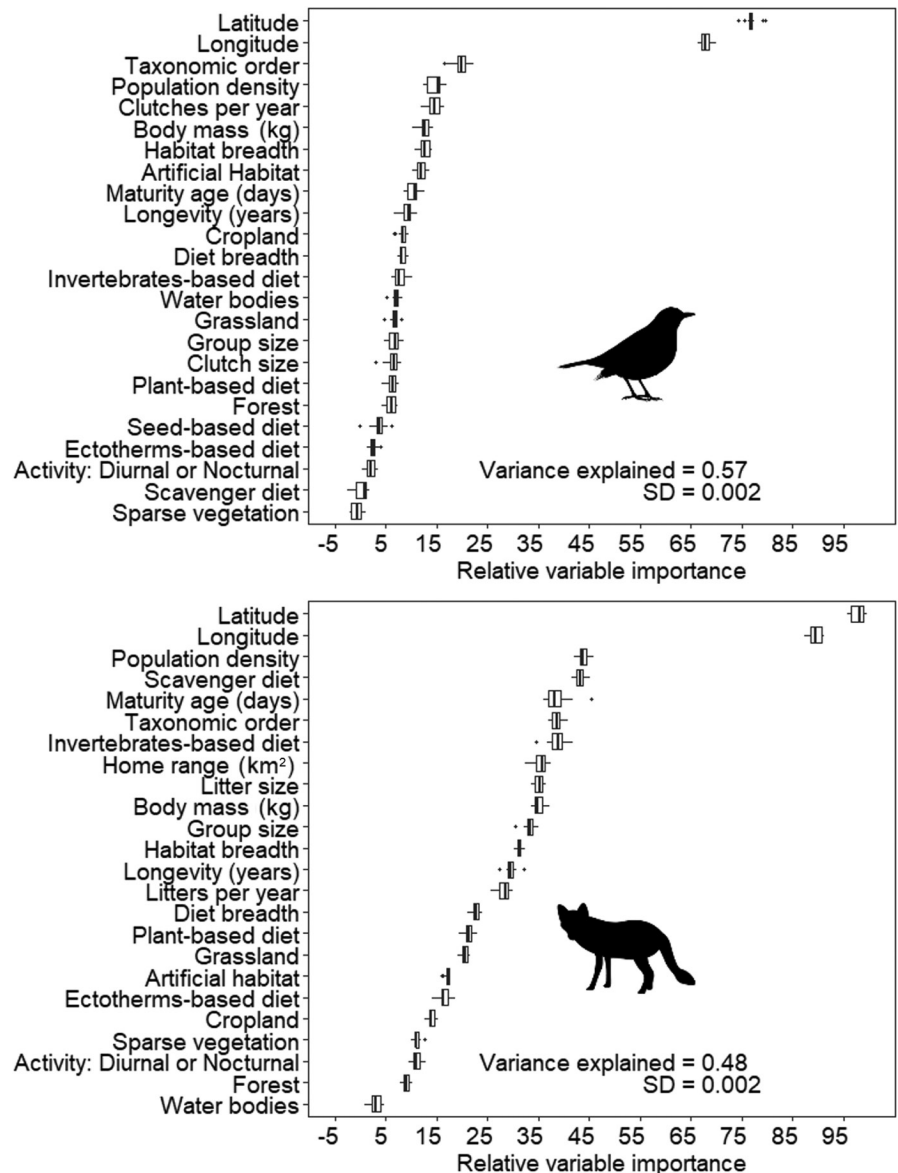
Models that excluded trait variables with <40% of empirical values (more imputed values; clutches per year, longevity, maturity age and population density for birds) produced qualitatively similar results, suggesting that including highly imputed variables did not influence our inferences (Supporting Information Appendix S2).

3.3 | Roadkill risk maps

Our analyses predict that 12,431,670 birds and 5,136,373 mammals can be killed on Latin American primary and secondary roads each year. These high numbers are likely to underestimate total mortality, because we calculated risk cautiously, only for species reported in systematic studies included in our database (i.e., species known to be susceptible to roadkill). However, it is likely that many other Latin American birds and mammals are susceptible to collisions (particularly those in regions where no road surveys have been conducted). Moreover, our calculations did not consider tertiary, illegal and unofficial roads, which could increase these numbers dramatically.

Areas with higher mortality rates were mainly located across all Central America, northern Venezuela, northern and western Colombia, Ecuador, western Perú, southern Chile, central and eastern Argentina, Uruguay and eastern Brazil. Generally, areas with high road densities resulted in high estimates of mortality per year (Figure 4a,b); however, some areas with a high road density, such

FIGURE 1 Relative importance of variables considered in random forest regression models to predict bird and mammal roadkill rates. Boxplots show results for models fitted to each of the 15 imputed datasets (trait data were not available for all species, and missing values were imputed 15 times to capture uncertainty). We also report the total variance explained, reported as the median and standard deviation calculated from the 15 models fitted for different imputed datasets.
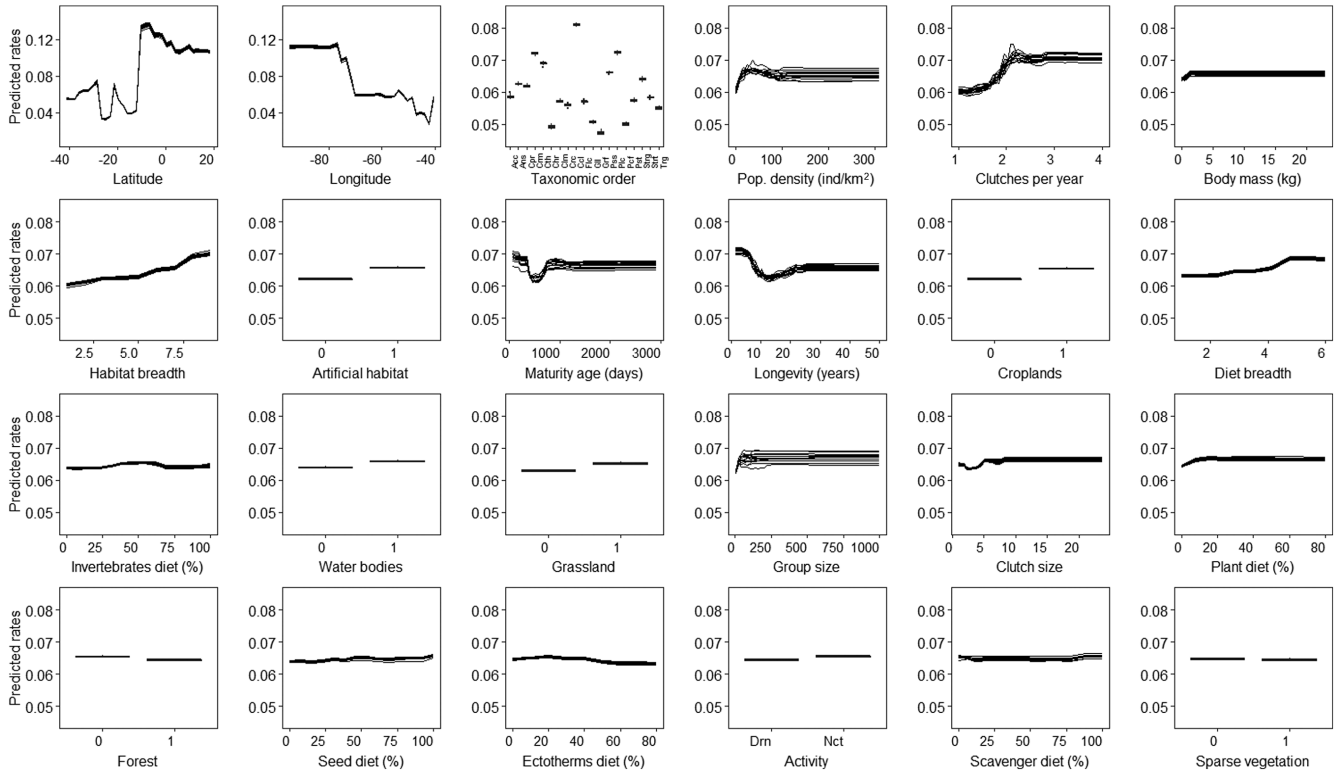

4 | DISCUSSION

Our compilation revealed a diversity of birds and mammals killed on Latin American roads owing to collision with vehicles. Although most of these species are common and non-threatened, there are some taxa of conservation concern reported as roadkill that should be considered for future research and targeted mitigation. Observed roadkill rates were associated with several life-history traits,

as the Caribbean region, Paraguay and western Brazil (border with Bolivia), showed low roadkill rates. High roadkill rates were not the direct result of higher richness of species known to be roadkilled (those in our dataset). Some areas with high richness, such as northern Bolivia, southern Brazil and the south-east of Paraguay, did not show high estimates. On the contrary, some high-risk areas in Central America, north-east and south-east Ecuador, central and eastern Argentina and Uruguay have relatively low richness (Figure 5).

ecological traits, morphological traits and habitat preferences. In particular, we found higher roadkill rates in larger birds and medium-sized mammals; likewise, shorter life expectancies, wider habitat breadths and early maturity ages were related to higher mortality for birds and mammals. Our predictive maps revealed areas of high mortality in Central America, the Northern Andean region (Venezuela, Colombia, Ecuador and Peru), southern Chile, central and eastern Argentina, Uruguay and eastern Brazil.

4.1 | Vulnerability to roadkill

Body mass was one of the traits associated with road mortality of birds, with larger species (>2.5 kg) generally being more likely to die on roads. Bird body sizes mostly varied between 3 g and 5.7 kg (median weight: 55 g) in our dataset, with an extreme value of 23 kg for *Rhea americana*. In contrast, mammalian sizes in the roadkill dataset ranged from 5 g to 207 kg (median weight: 1.15 kg), and in this group
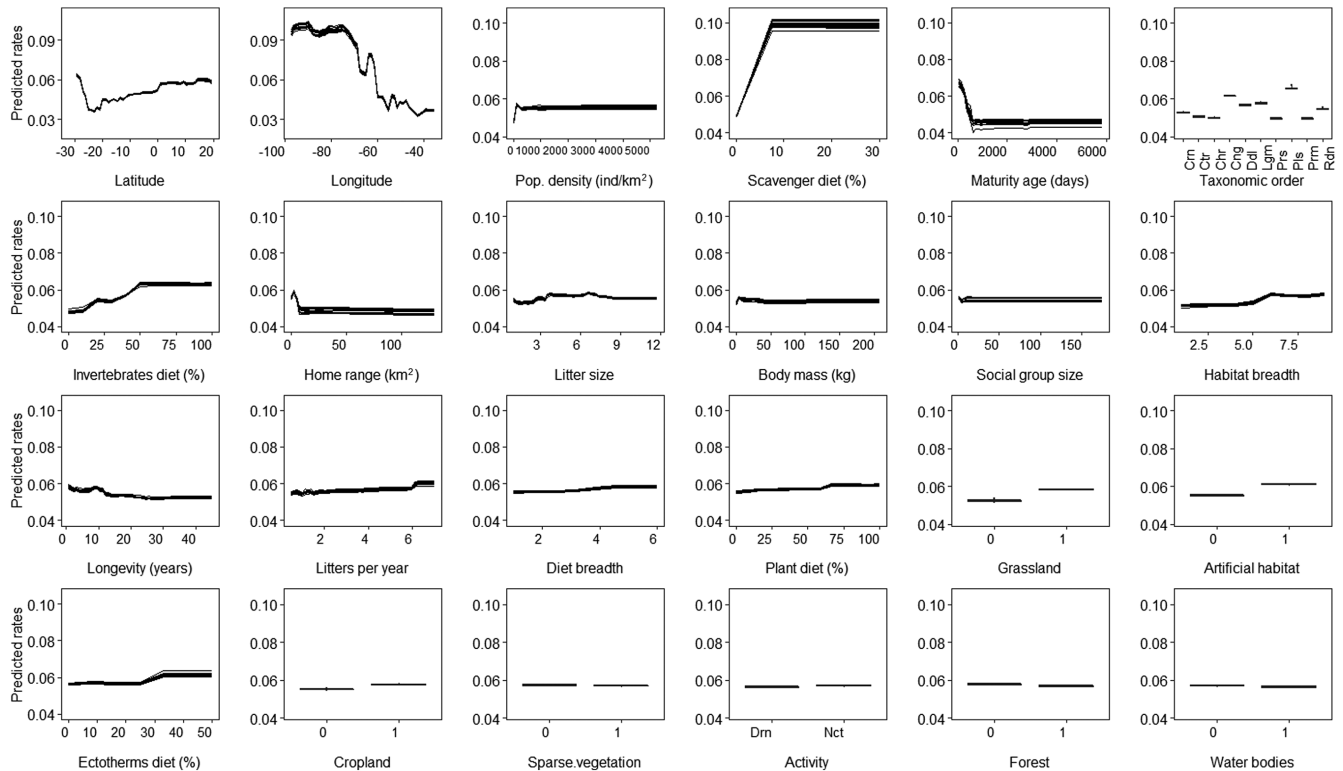
FIGURE 2 Dependence plots showing changes in predicted roadkill rates for birds for each tested predictor variable. Predictors are shown in descending order of relative variable importance (Figure 1). Each panel shows results for the 15 models fitted for different imputed datasets (trait data were not available for all species, and missing values were imputed 15 times to capture uncertainty). For numerical predictors we show 15 lines and for categorical variables we show boxplots representing the distribution of predicted rates. For habitat preferences (artificial habitat, cropland, forest, grassland, sparse vegetation and water bodies), category 1 indicates species that uses that habitat, and category 0 indicates no use. Note that owing to a wider range of predicted values, the y-axis scale for latitude and longitude is different from the rest of the variables.

higher roadkill rates were associated with species of intermediate sizes (with a peak at *c*. 3 kg). This pattern of higher risk in medium-sized mammals is similar to that found in Brazil by González-Suárez et al. (2018) and might be explained, in part, by the ability of vehicle drivers to detect and avoid collisions with larger animals. In addition, lower rates for larger animals could be associated with lower population density or local abundances; indeed, larger mammals have been shown to avoid roads, leading to lower population densities near roads or areas with more roads (D'Amico et al., 2016; Rytwinski & Fahrig, 2012). Among Latin American mammals, large carnivores, such as the jaguar (*Panthera onca*), have much lower population densities near roads (Espinosa et al., 2018). Indeed, we found that bird and mammal species with higher species-level population densities (expected to be on average more locally abundant) were more likely to have high roadkill rates. We note that although estimates of local abundance (or density) were not available, it is likely that some of the within-species variation in roadkill rates reflects variation in local abundance.

We also found that long-lived animals are less likely to be road-killed. As mentioned in our hypotheses, species with longer life spans could have more opportunity to learn new skills and acquire experience with new environments, such as roads, reducing their

risks (Street et al., 2017). However, the relationship could also reflect variation in local abundance because longer life spans are associated with larger body size and slower reproductive rates, which can influence roadkill risk.

Generalists, those with wider diets and habitat breadths, were also more likely to have high roadkill rates. This is likely to reflect greater exposure to roads because generalists can be more likely to visit a variety of environments and be less reluctant to approach roads, and they take advantage of any food resource, such as rubbish thrown from vehicles, carcasses and species that use road verge vegetation. Generalist mammals have been found to use roads extensively in order to obtain food and move across habitats (Hill et al., 2021), and other studies found also that generalist/omnivorous mammals are more vulnerable to roadkill (Cook & Blumstein, 2013). Indeed, we found that mammals with a scavenger and invertebrate-based diet had higher roadkill rates. Scavengers can be directly attracted to roadkill on roads (Rød-Eriksen et al., 2020), increasing their exposure to circulating vehicles and their risk of collision. Insects can also be locally abundant on roads because they can be attracted to decomposing carcasses, verge vegetation resources and light sources near roads and, in turn, attract insectivores to roads.
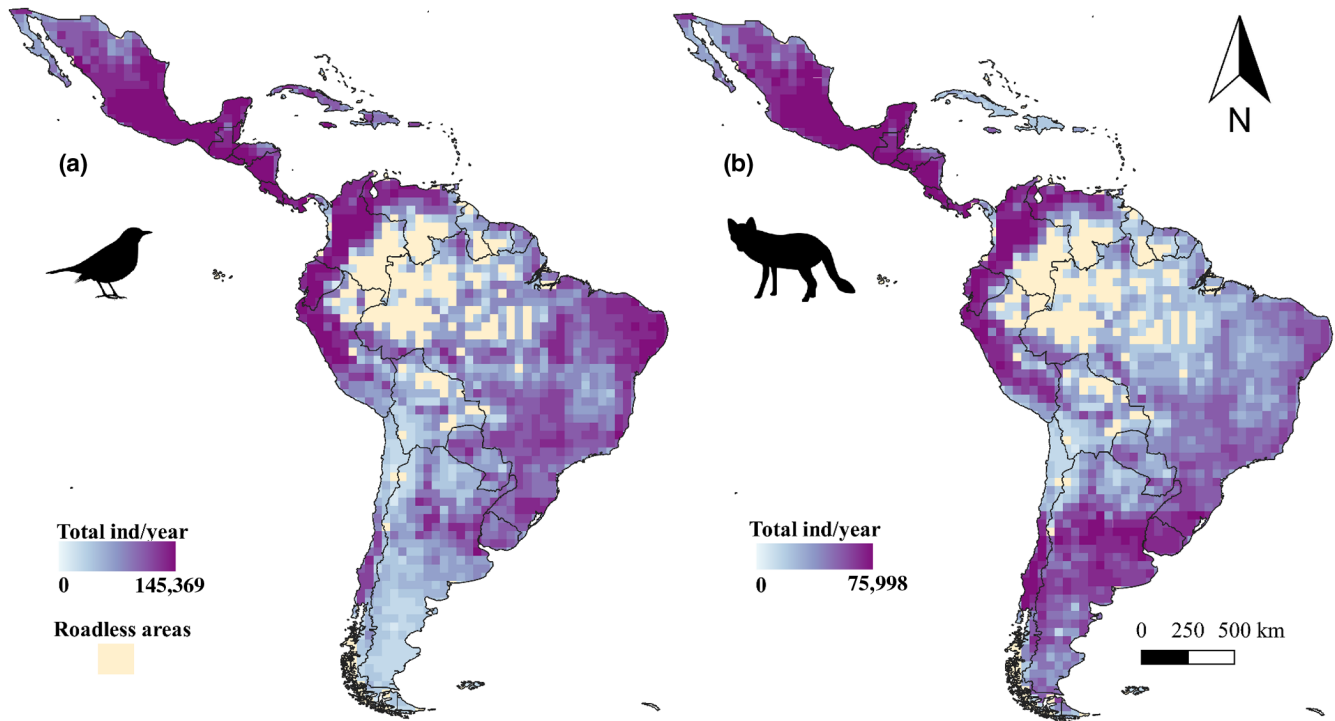
FIGURE 3 Dependence plots showing changes in predicted roadkill rates for mammals for each tested predictor variable. Predictors are shown in descending order of relative variable importance (Figure 1). Each panel shows results for the 15 models fitted for different imputed datasets (trait data were not available for all species, and missing values were imputed 15 times to capture uncertainty). For numerical predictors we show 15 lines and for categorical variables we show boxplots representing the distribution of predicted rates. For habitat preferences (artificial habitat, cropland, forest, grassland, sparse vegetation and water bodies), category 1 indicates species that uses that habitat, and category 0 indicates no use. Note that owing to a wider range of predicted values, the y-axis scale for latitude and longitude is different from the rest of the variables.

Faster reproductive rates, early maturity ages and more litters or clutches per year were related to higher roadkill mortality. These variables might be relevant owing to the association with variation in local abundance or density, because species with faster reproduction rates generally have higher local abundance. In addition, previous work found an association between seasonal roadkill patterns and mating periods (Ascensão et al., 2019; Canova & Balestrieri, 2019). Given that mating behaviour should be more frequent in species with more reproductive events per year, this can lead to more individuals of those species moving across areas looking for mates, and they are more likely to encounter roads.

Previous local studies found that open areas, such as grasslands and croplands, are associated with higher vertebrate roadkill rates (de Freitas et al., 2014; Medrano-Vizcaíno & Espinosa, 2021; Seo et al., 2013; Silva et al., 2019), which is supported by our large-scale results, particularly for birds. These habitat types might be working as ecological traps; for instance, croplands might offer a great quantity of food resources for certain species, which could die on roads when approaching these resources, whereas pasturelands might act as corridors to approach crops. Although the same relationship was found for mammals, habitat variables were not as important for predicting mammalian roadkill rates.

Although traits were relevant predictors, as expected, much of the variation in roadkill rates was explained by location. Strong geographical patterns are common in large-scale studies, reflecting environmental variation and within-species variability that cannot be captured by species-level trait data (as mentioned in our hypothesis). In our case, fitting simpler models that ignored location and its interaction with trait effects (models excluding latitude and longitude) resulted in lower variance explained: 3.04% for birds (SD across the 15 datasets: .004) and 24.9% for mammals (SD across the 15 datasets: .001) (Supporting Information Appendix S3). The particularly low value for birds might reflect distinct regional trait relationships, such that traits have different effects in different regions (such interactions would be captured in the complete regression trees). For example, two studies exploring how traits influence roadkill rates in European birds reported different patterns. Grilo et al. (2020) found that body mass and diet were among the most important traits for predicting bird roadkill rates when using regression trees that allowed for nonlinear relationships and interactions with geographical location. Meanwhile, Morelli et al. (2020) used linear regression models that did not account for location or tested nonlinearities and reported a weak association with body mass and no relationship with diet.

FIGURE 4 Predicted total number of (a) birds and (b) mammals to be roadkilled each year in Latin America and the Caribbean. Total numbers were calculated by multiplying roadkill rates [individuals (ind) per kilometre per year] predicted for each species and grid cell using random regression models and species traits and location data (for all variables, see Table 1) by the total length of existing main roads (in kilometres) in each grid cell. Grid cells with no predictions (cream colour) represent areas where roads are not present.

Alternatively, we might have missed important traits to explain roadkill rates in birds, such as mode of locomotion and movement patterns. Birds with a low-flight behaviour tend to be more road-killed, which has been observed for owls (Kociolek et al., 2015), and more mobile birds were identified as generally more susceptible to negative effects of roads (Rytwinski & Fahrig, 2012). However, for most of our studied species those data were not available; for example, concerning mobility, we were able to collect home range data for only 10% of bird species. Finally, it is possible that traits are overall poorer predictors of road impacts in birds than in mammals. Future work considering additional taxonomic groups and comparing different areas will be useful to understand further how trait-based approaches can contribute to our understanding of road mortality patterns across different taxa.
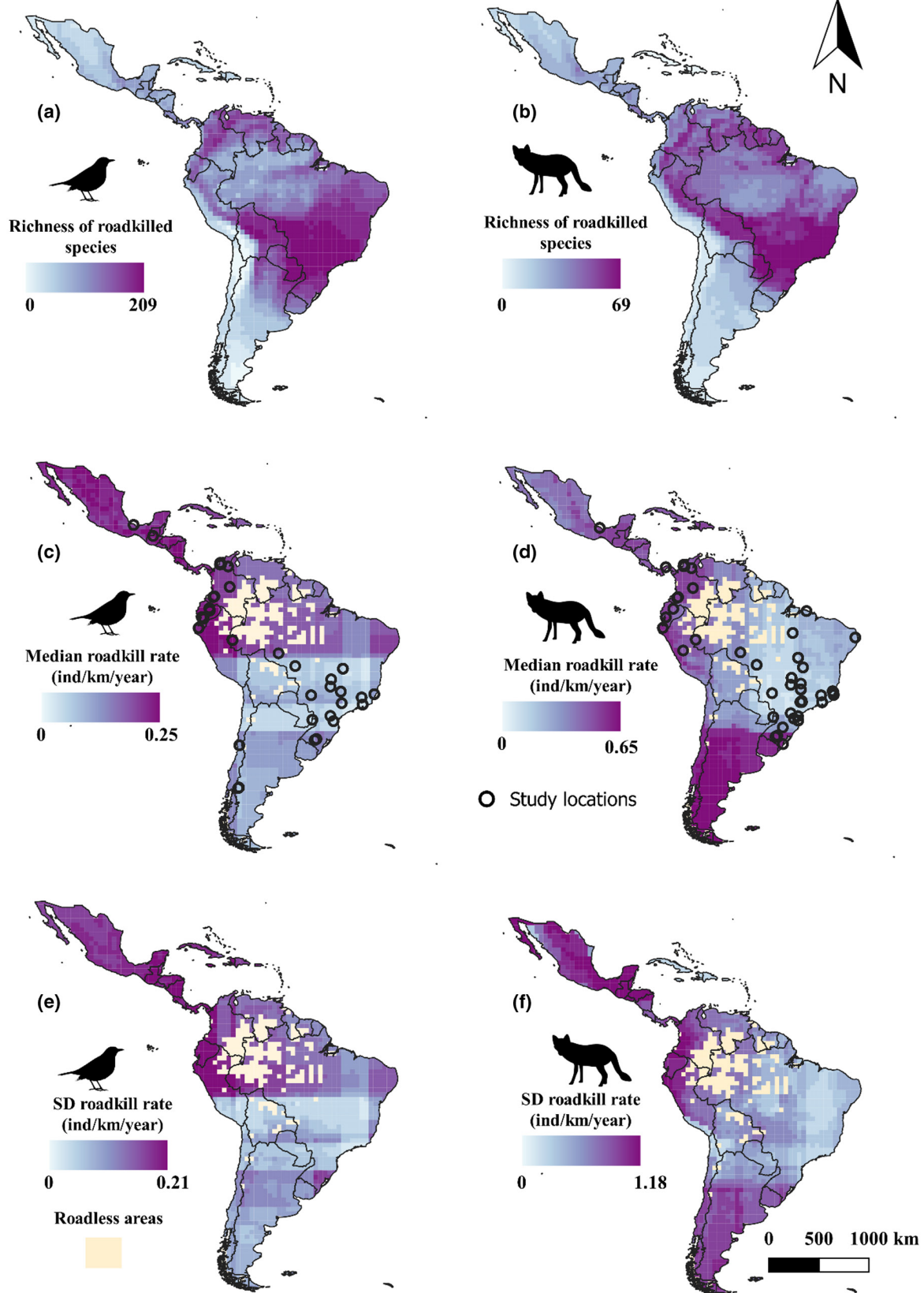
4.2 | Roadkill risk maps

Our predictions offer a worrying picture, with potentially >12 million birds and >5 million mammals dying each year across main Latin American roads. Furthermore, these estimates reflect only those species with observed roadkill. The Latin America and Caribbean region is home to *c.* 4,613 bird species and *c.* 1,859 mammal species (IUCN, 2021), of which our dataset included 7.50% of birds and 8.55% of mammals. Even if some species show road-avoidance

behaviour and are less likely to be roadkilled, road mortality risks for >90% of the avian and mammalian biodiversity are still unknown, and thus, the total number of roadkilled birds and mammals is likely to be much higher than what we estimate here.

Predicted risks from the existing road network are worrying. Unfortunately, Latin America is projected to have one of the highest rates of future road development in the world (Meijer et al., 2018), which is likely to cause even greater impacts on wildlife. For example, we were able to obtain data on planned roads for Ecuador (MTOP, 2016), a country with high predicted roadkill rates. Considering the existing network of 16,647.65 km of primary and secondary roads (Meijer et al., 2018), our model predicts 420,861 birds and 119,599 mammals roadkilled each year. Those numbers were predicted to increase by 9.3% (39,321 additional birds and 11,174 additional mammals) with the development of 1,555.4 km of new roads planned by 2030 (MTOP, 2016). As mentioned above, the real roadkill numbers are likely to be much higher because our dataset represents <20% of the avian and mammalian biodiversity of Ecuador.

Our paper provides insights into how roadkill can impact wildlife in Latin America, but there are some limitations of the data used for analyses. For instance, we assumed that taxonomic identification of roadkill was correct, but it is possible that a few carcasses could have been misclassified. Although it is not possible for us to correct potential taxonomic misidentification, errors are likely to be rare

FIGURE 5 (a,b) Species richness of roadkilled (a) birds and (b) mammals. (c,d) Predicted median roadkill rates [individuals (ind) per kilometre per year] for (c) birds and (d) mammals obtained by averaging species estimates obtained for each species and grid cell using random regression models and species traits and location data (see Table 1 for all variables). (e,f) Standard deviation of the predicted rates values among species within each cell for (e) birds and (f) mammals. In panels c and d, we show the locations of the roadkill surveys used for analyses (those that met our methodological criteria). Note that in panels c–f, cream colour indicates areas without any roads.

because unrecognized carcasses are generally listed as unclassified. Taxonomic disagreements or new classifications could also affect the data. For example, the common tapeti (*Sylvilagus brasiliensis*) was considered until 2018 as a widely distributed species, but in 2019 it was separated into several species. The name *Sylvilagus brasiliensis* now refers to tapeti found only in Pernambuco-Brazil (Ruedas & Smith, 2019). Given that our data included studies conducted before 2019 when the taxon was re-evaluated, we compiled roadkill records that mention the common tapeti from 18 studies across five countries (Argentina, Brazil, Costa Rica, Ecuador and Mexico), none within the new restricted distribution. To map roadkill, we used current IUCN distribution data, which means that projected roadkill numbers for tapeti were limited to a small region, potentially under-representing the risk for other tapeti species. Although it is beyond of the scope of our study (and non-trivial) to reclassify records into new species, we expect these disparities to be minor and not to bias our results.

Our work contributes to highlight the value of combining models based on traits and habitat preferences to gain a better understanding and predict the threats and impacts from human activities. This approach can be applied widely to investigate other taxonomic groups and geographical areas. For instance, although very high roadkill rates for herpetofauna have been reported in several studies across the world, our understanding of which traits influence risk and the development of predictive models remain limited. Trait data can be useful, but readily available compiled sources remain relatively rare. Increased efforts to provide access to natural history description and standardized datasets will be very valuable to apply this approach and gain further insights into how roads impact wildlife. Additionally, systematic studies that report road impacts, including roadkill rates, in a clear, easy-to-use way are also essential (Silva et al., 2021). Some areas remain unstudied, but it is likely that some have been surveyed but the data remain unpublished or were presented only in monitoring reports that can be difficult to obtain and do not always report raw values (e.g., providing only summary values across taxonomic groups instead of detailed roadkill observations). Easier access to roadkill survey data is essential to build improved models that lead to better decisions for wildlife conservation.

In conclusion, this first continental-scale evaluation of roadkill risk for Latin American birds and mammals offers several useful outputs, identifying Latin American species and areas with higher road mortality. This approach, wherein trait-based models are fine-tuned with realistic spatial information (by considering habitat suitability of species), is a valuable tool for the evaluation of human impacts, including roads and traffic, and we hope that this will be used increasingly by ecologists and managers.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

All data used for analyses including roadkill rates, and associated life-history, ecological, morphological traits and habitat preferences for birds and mammals from Latin America are available as appendices.

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REFERENCES

Acharjee, A., Kloosterman, B., de Vos, R. C. H., Werij, J. S., Bachem, C. W. B., Visser, R. G. F., & Maliepaard, C. (2011). Data integration and network reconstruction with ~omics data using random forest regression in potato. *Analytica Chimica Acta*, *705*(1–2), 56–63. https://doi.org/10.1016/J.ACA.2011.03.050

Aguilar, J. M., Nieto, A., Espinoza, N., Loja, G., Tinoco, B. A., & Boris, A. (2019). Assessing patterns of bird roadkills in a high Andean Ecuadorian national park. *Studies on Neotropical Fauna and Environment*, *54*(3), 149–156. https://doi.org/10.1080/01650521.2019.1649953

Ascensão, F., Yogui, D., Alves, M., Medici, E. P., & Desbiez, A. (2019). Predicting spatiotemporal patterns of road mortality for medium-large mammals. *Journal of Environmental Management*, *248*, 109320. https://doi.org/10.1016/j.jenvman.2019.109320

Bauni, V., Anfuso, J., & Schivo, F. (2017). Mortalidad de fauna silvestre por atropellamientos en el bosque atlántico del Alto Paraná, Argentina. *Ecosistemas*, *26*(3), 54–66. https://doi.org/10.7818/ECOS.2017.26-3.08

Bischof, R., Steyaert, S. M. J. G., & Kindberg, J. (2017). Caught in the mesh: Roads and their network-scale impediment to animal movement. *Ecography*, *40*(12), 1369–1380. https://doi.org/10.1111/ecog.02801

Braz, V. D. S., & Rodrigues, F. (2016). Wild vertebrate roadkill in the Chapada dos Veadeiros National Park, Central Brazil. *Biota Neotropica*, *16*(1), 1–11. https://doi.org/10.1590/1676-0611-BN-2014-0182

Breiman, L. (2001). Random forests. *Machine Learning*, *45*(1), 5–32. https://doi.org/10.1023/A:1010933404324

Brooks, T. M., Pimm, S. L., Resit Akç, H., Buchanan, G. M., Butchart, S. H. M., Foden, W., Hilton-Taylor, C., Hoffmann, M., Jenkins, C. N., Joppa, L., Li, B. V., Menon, V., Ocampo-Peñ, N., & Rondinini, C. (2019). Measuring terrestrial area of habitat (AOH) and its utility for the IUCN red list the International Union for Conservation of nature (IUCN) red list of threatened species includes assessment of extinction risk for. *Trends in Ecology & Evolution*, *34*(11), 977–986. https://doi.org/10.1016/j.tree.2019.06.009

Caceres, N. C. (2011). Biological characteristics influence mammal road kill in an Atlantic Forest-Cerrado interface in South-Western Brazil. *Italian Journal of Zoology*, *78*(3), 379–389. https://doi.org/10.1080/11250003.2011.566226

Canova, L., & Balestrieri, A. (2019). Long-term monitoring by roadkill counts of mammal populations living in intensively cultivated landscapes. *Biodiversity and Conservation*, *28*(1), 97–113. https://doi.org/10.1007/s10531-018-1638-3

Cantor, M., Ferreira, L. A., Silva, W. R., & Setz, E. Z. F. (2010). Potential seed dispersal by *Didelphis albiventris* (Marsupialia, Didelphidae)

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in highly disturbed environment. *Biota Neotropica*, *10*(2), 45–51. https://doi.org/10.1590/s1676-06032010000200004

Cayuela, H., Bonnaire, É., Astruc, G., & Besnard, A. (2019). Transport infrastructure severely impacts amphibian dispersal regardless of life stage. *Scientific Reports*, *9*(1), 8214. https://doi.org/10.1038/s41598-019-44706-1

Chen, H. L., & Koprowski, J. L. (2016). Barrier effects of roads on an endangered forest obligate: Influences of traffic, road edges, and gaps. *Biological Conservation*, *199*, 33–40. https://doi.org/10.1016/J.BIOCON.2016.03.017

Clark, R. W., Brown, W. S., Stechert, R., & Zamudio, K. R. (2010). Roads, interrupted dispersal, and genetic diversity in timber rattlesnakes. *Conservation Biology*, *24*(4), 1059–1069. https://doi.org/10.1111/j.1523-1739.2009.01439.x

Collins, C., & Kays, R. (2011). Causes of mortality in north American populations of large and medium-sized mammals. *Animal Conservation*, *14*(5), 474–483. https://doi.org/10.1111/j.1469-1795.2011.00458.x

Cook, T. C., & Blumstein, D. T. (2013). The omnivore's dilemma: Diet explains variation in vulnerability to vehicle collision mortality. *Biological Conservation*, *167*, 310–315. https://doi.org/10.1016/j.biocon.2013.08.016

D'Amico, M., Périquet, S., Román, J., & Revilla, E. (2016). Road avoidance responses determine the impact of heterogeneous road networks at a regional scale. *Journal of Applied Ecology*, *53*(1), 181–190. https://doi.org/10.1111/1365-2664.12572

De Barros Ferraz, K. M. P. M., De Siqueira, M. F., Martin, P. S., Esteves, C. F., & Do Couto, H. T. Z. (2010). Assessment of Cerdocyon thous distribution in an agricultural mosaic, southeastern Brazil. *Mammalia*, *74*(3), 275–280. https://doi.org/10.1515/MAMM.2010.036

de Freitas, C. H., Justino, C. S., & Setz, E. Z. (2014). Road-kills of the giant anteater in South-Eastern Brazil: 10 years monitoring spatial and temporal determinants. *Wildlife Research*, *41*(8), 673–680. https://doi.org/10.1071/WR14220

Delgado-V, C. (2007). Muerte de mamíferos por vehículos en la vía del Escobero, Envigado (Antioquia), Colombia. *Actualidades Biológicas*, *29*(87), 235–239.

Espinosa, S., Celis, G., & Branch, L. C. (2018). When roads appear jaguars decline: Increased access to an Amazonian wilderness area reduces potential for jaguar conservation. *PLoS One*, *13*(1), e0189740. https://doi.org/10.1371/journal.pone.0189740

Forman, R., Sperling, D., Bissonette, J., Clevenger, A., Cutshall, C., Dale, V., Fahrig, L., France, R., Goldman, C., Heanue, K., Jones, J., Swanson, F., Turrentine, T., & Winter, T. (2003). *Road ecology: Science and solutions*. Island Press.

Freitas, D., de Oliveira, A., Ciocheti, G., Vieira, M., & Matos, D. (2015). How landscape features influence road-kill of three species of mammals in the Brazilian savanna? *Oecologia Australis*, *18*, 35–45. https://doi.org/10.4257/oeco.2014.18.05.02

González-Suárez, M., Zanchetta Ferreira, F., & Grilo, C. (2018). Spatial and species-level predictions of road mortality risk using trait data. *Global Ecology and Biogeography*, *27*(9), 1093–1105. https://doi.org/10.1111/geb.12769

Greenwell, B. M. (2017). Pdp: An R package for constructing partial dependence plots. *The R Journal*, *9*(1), 421–436.

Grilo, C., Koroleva, E., Andrášik, R., Bíl, M., & González-Suárez, M. (2020). Roadkill risk and population vulnerability in European birds and mammals. *Frontiers in Ecology and the Environment*, *18*(6), 323–328. https://doi.org/10.1002/fee.2216

Hill, J. E., De Vault, T. L., & Belant, J. L. (2021). A review of ecological factors promoting road use by mammals. *Mammal Review*, *51*(2), 214–227. https://doi.org/10.1111/mam.12222

IUCN. (2021). *The IUCN red list of threatened species. Version 2021-1.* IUCN. https://www.iucnredlist.org

Jackson, N. D., & Fahrig, L. (2011). Relative effects of road mortality and decreased connectivity on population genetic diversity. *Biological Conservation*, *144*(12), 3143–3148. https://doi.org/10.1016/j.biocon.2011.09.010

Johnson, T. F., Isaac, N. J. B., Paviolo, A., & González-Suárez, M. (2021). Handling missing values in trait data. *Global Ecology and Biogeography*, *30*(1), 51–62. https://doi.org/10.1111/geb.13185

Kociolek, A., Grilo, C., & Jacobson, S. (2015). Flight doesn't solve everything: Mitigation of road impacts on birds. In *Handbook of road ecology* (pp. 281–289). John Wiley & Sons. https://doi.org/10.1002/9781118568170.ch33

Latham, J., Cumani, R., Rosati, I., & Bloise, M. (2014). FAO global land cover SHARE. *Database Beta-Release Verion 1.0*, 40. http://www.glcn.org/downs/prj/glcshare/GLC_SHARE_beta_v1.0_2014.pdf

Leonan, R., Novaes, M., Laurindo, R. S., Dornas, R. A. P., Esbérard, C. E. L., & Bueno, C. (2018). On a collision course: The vulnerability of bats to roadkills in Brazil. *Mastozoología Neotropical*, *14*(1), 115–128. https://doi.org/10.31687/saremMN.18.25.1.0.11

Lesbarrères, D., Primmer, C. R., Lodé, T., & Merilä, J. (2006). The effects of 20 years of highway presence on the genetic structure of Rana dalmatina populations. *Ecoscience*, *13*(4), 531–538. https://doi.org/10.2980/1195-6860(2006)13[531:TEOYOH]2.0.CO;2

Liaw, A., & Wiener, M. (2002). Classification and regression by random forest. *R News*, *2*(3), 18–22. http://www.stat.berkeley.edu/

Medrano-Vizcaíno, P. (2015). *Efecto de las carreteras en la mortalidad de vertebrados en un área megadiversa: Los Andes Tropicales del Ecuador* [Master thesis]. Pontificia Universidad Católica del Ecuador.

Medrano-Vizcaíno, P., & Espinosa, S. (2021). Geography of roadkills within the tropical Andes biodiversity hotspot: Poorly known vertebrates are part of the toll. *Biotropica*, *53*, 820–830. https://doi.org/10.1111/btp.12938

Medrano-Vizcaíno, P., & Gutiérrez-Salazar, P. (2020). Current and future suitable habitat areas for Nasuella olivacea (gray, 1865) in Colombia and Ecuador and analysis of its distribution across different land uses. *Biodiversity Data Journal*, *8*, 1–13. https://doi.org/10.3897/bdj.8.e49164

Meijer, J. R., Huijbregts, M. A. J., Schotten, K. C. G. J., & Schipper, A. M. (2018). Global patterns of current and future road infrastructure. *Environmental Research Letters*, *13*(6), 064006. https://doi.org/10.1088/1748-9326/aabd42

Morelli, F., Rodríguez, R. A., Benedetti, Y., & Delgado, J. D. (2020). Avian roadkills occur regardless of bird evolutionary uniqueness across Europe. *Transportation Research Part D: Transport and Environment*, *87*(September), 102531. https://doi.org/10.1016/j.trd.2020.102531

MTOP. (2016). Plan estratégico de movilidad 2013–2037. In *Ministerio de Transporte y Obras Publicas*.

Myers, N., Mittermeler, R. A., Mittermeler, C. G., Da Fonseca, G. A. B., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, *403*(6772), 853–858. https://doi.org/10.1038/35002501

Penone, C., Davidson, A. D., Shoemaker, K. T., Di Marco, M., Rondinini, C., Brooks, T. M., Young, B. E., Graham, C. H., & Costa, G. C. (2014). Imputation of missing data in life-history trait datasets: Which approach performs the best? *Methods in Ecology and Evolution*, *5*(9), 961–970. https://doi.org/10.1111/2041-210X.12232

Quintero-Ángel, A., Osorio-Dominguez, D., Vargas-Salinas, F., & Saavedra-Rodríguez, C. A. (2012). Roadkill rate of snakes in a disturbed landscape of Central Andes of Colombia. *Herpetology Notes*, *5*, 99–105.

Rincón-Aranguri, M., Urbina-Cardona, N., Galeano, S. P., Bock, B. C., & Páez, V. P. (2019). Road kill of snakes on a highway in an Orinoco ecosystem: Landscape factors and species traits related to their mortality. *Tropical Conservation Science*, *12*, 194008291983083. https://doi.org/10.1177/1940082919830832

Rød-Eriksen, L., Skrutvold, J., Herfindal, I., Jensen, H., & Eide, N. E. (2020). Highways associated with expansion of boreal scavengers into the alpine tundra of Fennoscandia. *Journal of Applied Ecology*, *57*, 1861–1870. https://doi.org/10.1111/1365-2664.13668

Ruedas, L. & Smith, A. T. (2019). *Sylvilagus brasiliensis. The IUCN red list of threatened species.* https://doi.org/10.2305/IUCN.UK.2019-2.RLTS.T87491102A45191186.en.

Rytwinski, T., & Fahrig, L. (2012). Do species life history traits explain population responses to roads? A meta-analysis. *Biological Conservation*, *147*(1), 87–98. https://doi.org/10.1016/j.biocon.2011.11.023

Santos, S. M., Carvalho, F., & Mira, A. (2011). How long do the dead survive on the road? Carcass persistence probability and implications for road-kill monitoring surveys. *PLoS One*, *6*(9), e25383. https://doi.org/10.1371/journal.pone.0025383

Seo, C., Thorne, J. H., Choi, T., Kwon, H., & Park, C. H. (2013). Disentangling roadkill: The influence of landscape and season on cumulative vertebrate mortality in South Korea. *Landscape and Ecological Engineering*, *11*(1), 87–99. https://doi.org/10.1007/s11355-013-0239-2

Silva, C., Simões, M. P., Mira, A., & Santos, S. M. (2019). Factors influencing predator roadkills: The availability of prey in road verges. *Journal of Environmental Management*, *247*, 644–650. https://doi.org/10.1016/j.jenvman.2019.06.083

Silva, I., Crane, M., & Savini, T. (2021). The road less traveled: Addressing reproducibility and conservation priorities of wildlife-vehicle collision studies in tropical and subtropical regions. *Global Ecology and Conservation*, *27*, 1–12. https://doi.org/10.1016/j.gecco.2021.e01584

Stekhoven, D. (2013). *missForest: Nonparametric missing value imputation using random forest*. R package version 1.4.

Stekhoven, D., & Bühlmann, P. (2012). Missforest-non-parametric missing value imputation for mixed-type data. *Bioinformatics*, *28*(1), 112–118. https://doi.org/10.1093/bioinformatics/btr597

Street, S. E., Navarrete, A. F., Reader, S. M., & Laland, K. N. (2017). Coevolution of cultural intelligence, extended life history, sociality, and brain size in primates. *Proceedings of the National Academy of Sciences of the United States of America*, *114*(30), 7908–7914. https://doi.org/10.1073/pnas.1620734114

Tinoco, B., Atudillo, P., Latta, S. C., & Graham, C. H. (2009). Distribution, ecology and conservation of an endangered Andean hummingbird: The violet-throated Metaltail (*Metallura baroni*). *Bird Conservation International*, *19*, 63–76.

Van Der Ree, R., Smith, D. J., & Grilo, C. (2015). The ecological effects of linear infrastructure and traffic: Challenges and opportunities of rapid global growth. In *Handbook of road ecology* (pp. 1–9). John Wiley & Sons. https://doi.org/10.1002/9781118568170.ch1

Vilela, T., Harb, A. M., Bruner, A., Da Silva Arruda, V. L., Ribeiro, V., Alencar, A. A. C., Grandez, A. J. E., Rojas, A., Laina, A., & Botero, R. (2020). A better Amazon road network for people and the environment. *Proceedings of the National Academy of Sciences of the United States of America*, *117*(13), 7095–7102. https://doi.org/10.1073/pnas.1910853117

BIOSKETCH

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

APPENDIX

Data sources

Abba, A. M., & Gonzalez, E. (2014). *Dasypus hybridus* (Southern Long-Nosed Armadillo). The IUCN red list of threatened species. https://www.iucnredlist.org/species/6288/47440329

Abba, A. M., Lima, E., & Superina, M. (2014). *Euphractus sexcinctus* (Yellow Armadillo). The IUCN red list of threatened species. https://www.iucnredlist.org/species/8306/47441708

Adárraga-Caballero, M. A., & Gutiérrez-Moreno, L. C. (2019). Mortalidad de vertebrados silvestres en la carretera Troncal del Caribe, Magdalena, Colombia. *Biota Colombiana*, *20*(1), 106–119. https://doi.org/10.21068/c2019.v20n01a07

Aguilar, J. M., Nieto, A., Espinoza, N., Loja, G., Tinoco, B. A., & Boris, A. (2019). Assessing patterns of bird roadkills in a high Andean Ecuadorian national park. *Studies on Neotropical Fauna and Environment*, *54*(3), 149–156. https://doi.org/10.1080/01650521.2019.1649953

Almeida, L. B., Queirolo, D., Mello Beisiegel, B., & Oliveira, T. G. (2013). Avaliação do risco de extinção do gato-mourisco, *Puma yagouaroundi* (Geoffroy Saint-Hilaire, 1803), no Brasil. *Biodiversidade Brasileira*, *3*(1), 99–106.

Alvarez, J., Willig, M. R., Knox Jones, J., Jr, & Webster, Wm. D. (1991). *Glossophaga soricina*. *Mammalian Species*, *379*, 1–7. https://doi.org/10.2307/3504146/2600655

Álvarez-Castañeda, S. T., Castro-Arellano, I., Lacher, T., & Vázquez, E. (2017). *Cratogeomys fulvescens* (Oriental Basin Pocket Gopher). The IUCN red list of threatened species. https://www.iucnredlist.org/species/136215/22217087

Álvarez-Castañeda, S. T., Lacher, T., & Vázquez, E. (2016a). *Dipodomys phillipsii* (Phillip's Kangaroo Rat). The IUCN red list of threatened species. https://www.iucnredlist.org/species/92463503/22228991

Álvarez-Castañeda, S. T., Lacher, T., & Vázquez, E. (2016b). *Xerospermophilus perotensis* (Perote Ground Squirrel). The IUCN red list of threatened species. https://www.iucnredlist.org/species/20489/22264586

Álvarez-Castañeda, S. T., & Reid, F. (2016). *Microtus mexicanus* (Mexican Vole). The IUCN red list of threatened species. https://www.iucnredlist.org/species/13443/115113184

Amori, G. (2016). *Sciurus aestuans*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/20003/22248406

Anacleto, T. C. S., Arteaga, M., Superina, M., & Abba, A. M. (2014a). *Dasypus kappleri* (Greater Long-nosed Armadillo). The IUCN red list of threatened species. https://www.iucnredlist.org/species/6289/47440608

Anacleto, T. C. S., Miranda, F., Medri, I., Cuellar, E., Abba, A. M., & Superina, M. (2014b). *Priodontes maximus* (Giant Armadillo). The IUCN red list of threatened species. https://www.iucnredlist.org/species/18144/47442343

Anacleto, T. C. S., Smith, P., Abba, A. M., & Superina, M. (2014c). *Dasypus septemcinctus* (Brazilian Lesser Long-nosed Armadillo). The IUCN red list of threatened species. https://www.iucnredlist.org/species/6293/47441509

Artavia, A., Jiménez, M., Martínez Salinas, A., Pomareda, E., Araya Gamboa, D., & Arévalo Huezo, E. (2015). Registro de mamíferos silvestres en la sección de la ampliación de la Ruta 32, Limón, Costa Rica. *Brenesia*, *83–84*, 37–46.

Ascensão, F., Desbiez, A. L. J., Medici, E. P., & Bager, A. (2017). Spatial patterns of road mortality of medium-large mammals in Mato Grosso do Sul, Brazil. *Wildlife Research*, *44*(2), 135–146. https://doi.org/10.1071/WR16108

Asher, M., De Oliveira, E. S., & Sachser, N. (2004). Social system and spatial organization of wild guinea pigs (*Cavia aperea*) in a natural population. *Journal of Mammalogy*, *85*(4), 788–796. https://doi.org/10.1644/BNS-012

Astúa, D., de la Sancha, N., & Costa, L. (2015). *Didelphis aurita* (Brazilian Common Opossum). The IUCN red list of threatened species. https://www.iucnredlist.org/species/40500/197310366

Astúa, D., Lew, D., Costa, L. P., & Pérez-Hernandez, R. (2021). *Didelphis marsupialis* (Common Opossum). The IUCN red list of threatened species. https://www.iucnredlist.org/species/40501/197310576

Attademo, A. M., Peltzer, P. M., Lajmanovich, R. C., Elberg, G., Junges, C., Sanchez, L. C., & Bassó, A. (2011). Wildlife vertebrate mortality in roads from Santa Fe Province, Argentina. *Revista Mexicana de Biodiversidad*, *82*(3), 915–925. https://doi.org/10.22201/ib.20078706e.2011.3.783

Azevedo, F. C., Lemos, F. G., Almeida, L. B., Campos, C. B., Beisiegel, B. M., Paula, R. C., Junior, P. G. C., Ferraz, K. M. P. M. B., & Oliveira, T. G. (2013). Avaliação do risco de extinção da onça-parda *Puma concolor* (Linnaeus, 1771) no Brasil. *Biodiversidade Brasileira*, *3*(1), 107–121.

Baldi, R., Novaro, A., Funes, M., Walker, S., Ferrando, P., Failla, M., & Carmanchahi, P. (2009). Guanaco management in Patagonian rangelands: A conservation opportunity on the brink of collapse. In *Wild Rangelands: Conserving Wildlife While Maintaining Livestock in Semi-Arid Ecosystems* (pp. 266–290). John Wiley & Sons. https://doi.org/10.1002/9781444317091.CH10

Banks, R. C., Weckstein, J. D., Remsen, J. V., & Johnson, K. P. (2013). Classification of a clade of New World doves (Columbidae: Zenaidini). *Zootaxa*, *3669*(2), 184–188. https://doi.org/10.11646/zootaxa.3669.2.11

Barbanti-Duarte, J. M., Vogliotti, A., dos Santos-Zanetti, E., de Oliveira, M. L., Tiepolo, L. M., Rodrigues, F. L., & de Almeida, L. B. (2012a). Avaliação do risco de extinção do veado-mateiro *Mazama americana* Erxleben, 1777, no Brasil José. *Biodiversidade Brasileira*, *2*(1), 33–441.

Barbanti-Duarte, J. M., Vogliotti, A., dos Santos Zanetti, E., de Oliveira, M. L., Tiepolo, L. M., Rodrigues, L. F., & Bonjorne de Almeida, L. (2012b). Avaliação do Risco de Extinção do Veado-catingueiro *Mazama gouazoubira* G. Fischer [von Waldheim], 1814, no Brasil. *Biodiversidade Brasileira*, *2*(1), 50–58.

Barnhill, R. A., Weyer, D., Young, W. F., Smith, K. G., & James, D. A. (2005). Breeding biology of jabirus (*Jabiru mycteria*) in Belize. *Wilson Bulletin*, *117*(2), 142–153. https://doi.org/10.1676/04-078

Barquez, R., & Diaz, M. (2015a). *Artibeus fimbriatus* (Fringed Fruit-eating Bat). The IUCN red list of threatened species. https://www.iucnredlist.org/species/2126/21999829

Barquez, R., & Diaz, M. (2015b). *Phyllostomus hastatus*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/17218/22135955

Barquez, R., & Diaz, M. (2015c). *Platyrrhinus lineatus*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/17565/21987212

Barquez, R., & Diaz, M. (2016). *Lasiurus ega* (Southern Yellow Bat). The IUCN red list of threatened species. https://www.iucnredlist.org/species/11350/22119259

Barquez, R., Diaz, M., Gonzalez, E., Rodriguez, A., Incháustegui, S., & Arroyo-Cabrales, J. (2015a). *Tadarida brasiliensis*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/21314/22121621

Barquez, R., Perez, S., Miller, B., & Diaz, M. (2015b). *Glossophaga soricina*. The IUCN red list of threatened species. Retrieved 26 January 2022, from: https://www.iucnredlist.org/species/9277/22107768

Barquez, R., Perez, S., Miller, B., & Diaz, M. (2015c). *Artibeus lituratus* (Great Fruit-eating Bat). The IUCN red list of threatened species. https://www.iucnredlist.org/species/2136/21995720

Barquez, R., Perez, S., Miller, B., & Diaz, M. (2015d). *Carollia perspicillata* (Seba's Short-tailed Bat). The IUCN red list of threatened species. https://www.iucnredlist.org/species/3905/22133716

Barquez, R., Perez, S., Miller, B., & Diaz, M. (2015e). *Noctilio albiventris* (Lesser Bulldog Bat). The IUCN red list of threatened species. https://www.iucnredlist.org/species/14829/22019978

Barquez, R., Perez, S., Miller, B., & Diaz, M. (2015f). *Noctilio leporinus* (Greater Bulldog Bat). The IUCN red list of threatened species. https://www.iucnredlist.org/species/14830/22019554

Barquez, R., Rodriguez, B., Miller, B., & Diaz, M. (2015g). *Molossus molossus*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/13648/22106602

Barquez, R., Rodriguez, B., Miller, B., & Diaz, M. (2015h). *Molossus rufus*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/13644/22107969

Barri, F. R. (2010). Evaluación preliminar de la mortandad de mastofauna nativa por colisión con vehículos en tres rutas argentinas. *Ecología Aplicada*, *9*(1–2), 161. https://doi.org/10.21704/rea.v9i1-2.406

Bastos, D. F. O., Souza, R. A. T., Zina, J., & da Rosa, C. A. (2019). Seasonal and spatial variation of road-killed vertebrates on br-330, Southwest Bahia, Brazil. *Oecologia Australis*, *23*(3), 388–402. https://doi.org/10.4257/oeco.2019.2303.01

Bauni, V., Anfuso, J., & Schivo, F. (2017). Mortalidad de fauna silvestre por atropellamientos en el bosque atlántico del Alto Paraná, Argentina. *Ecosistemas*, *26*(3), 54–66. https://doi.org/10.7818/ECOS.2017.26-3.08

Beck-King, H., Von Helversen, O., & Beck-King, R. (1999). Home range, population density, and food resources of *Agouti paca* (Rodentia: Agoutidae) in Costa Rica: A study using alternative methods. *Biotropica*, *31*(4), 675–685. https://doi.org/10.1111/J.1744-7429.1999.TB00417.X

Beisiegel, B. M., Lemos, F. G., Azevedo, F. C., Queirolo, D., & Pinto, R. S. (2013). Avaliação do risco de extinção do cachorro-do-mato *Cerdocyon thous* (Linnaeus, 1766) no Brasil. *Biodiversidade Brasileira—BioBrasil*, *1*, 138–145.

Belao, M., Bocon, R., Christo, S., de Souza, M., & Souza Junior, J. (2014). Incidentes De Mamíferos Na Rodovia Br-277, Paraná—Brasil. *Publicatio UEPG: Ciencias Biologicas e Da Saude*, *20*(1), 37–41. https://doi.org/10.5212/publ.biologicas.v.20i1.0004

Benavides, C., Arce, A., & Pacheco, L. F. (2017). Home range and habitat use by pacas in a montane tropical forest in Bolivia. *Acta Amazonica*, *47*(3), 227–236. https://doi.org/10.1590/1809-4392201603163

Bernal, N. (2016). *Cavia aperea* (Brazilian Guinea Pig). The IUCN red list of threatened species. https://www.iucnredlist.org/species/86257782/22189256

Berta, A. (1982). *Cerdocyon thous*. *Mammalian Species*, *186*, 1–4. https://doi.org/10.2307/3503974

Berta, A. (1986). *Atelocynus microtis*. *Mammalian Species*, *256*, 1–3. https://doi.org/10.2307/3503815

Best, T. L. (1995). *Sciurus variegatoides*. *Mammalian Species*, *500*, 1–6. https://doi.org/10.2307/3504282

Best, T. L., & Ceballos, G. (1995). *Spermophilus perotensis*. *Mammalian Species*, *507*, 1–3. https://doi.org/10.2307/0.507.1

Best, T. L., & Skupski, M. P. (1994). *Perognathus flavus*. *Mammalian Species*, *471*, 1–10. https://doi.org/10.2307/3504251

Bezerra, B., Bicca-Marques, J., Miranda, J., Mittermeier, R. A., Oliveira, L., Pereira, D., Ruiz-Miranda, C., Valença Montenegro, M., da Cruz, M., & do Valle, R. R. (2018). *Callithrix jacchus* (Common Marmoset). The IUCN red list of threatened species. https://www.iucnredlist.org/species/41518/191705043

Bicca-Marques, J., Jerusalinsky, L., Mittermeier, R.A., Pereira, D., Ruiz-Miranda, C., Rímoli, J., Valença Montenegro, M., & do Valle, R. R. (2018). *Callithrix penicillata* (Black-pencilled Marmoset). The IUCN red list of threatened species. https://www.iucnredlist.org/species/41519/191705321

Bonvicino, C., D'Elia, G., & Teta, P. (2016). *Oligoryzomys nigripes* (Black-footed Pygmy Rice Rat). The IUCN red list of threatened species. https://www.iucnredlist.org/species/15253/22358209

Bonvicino, C. R., Oliveira, J. A., & D'Andrea, P. S. (2008). *Guia dos roedores do Brasil, com chaves para gêneros baseadas em caracteres externos*. OPAS/OMS.

Bookhout, T. A., & Baker, R. H. (1984). Michigan mammals. *The Journal of Wildlife Management*, *48*(3), 1062–1063. https://doi.org/10.2307/3801475

Boubli, J., Alves, S. L., Buss, G., Carvalho, A., Ceballos-Mago, N., Lynch Alfaro, J., Messias, M., Mittermeier, R. A., Palacios, E., Ravetta, A., Rumiz, D. I., Rylands, A. B., Stevenson, P., & de la Torre, S. (2018). *Sapajus apella* (Black-capped Capuchin). The IUCN red list of threatened species. https://www.iucnredlist.org/species/172351505/192594550

Bravo, S. P., & Sallenave, A. (2003). Foraging behavior and activity patterns of *Alouatta caraya* in the northeastern Argentinean flooded forest. *International Journal of Primatology*, *24*, 825–846. https://doi.org/10.1023/A:1024680806342

Bravo-Naranjo, V., Piñones-Cañete, C., Norambuena, H. V., & Zuleta, C. (2019). Puntos calientes y factores asociados al atropello de aves rapaces en una ruta costera de la zona semiárida de Chile Central. *Ornitología Neotropical*, *30*, 208–216.

Braz, V. D. S., & Rodrigues, F. (2016). Wild vertebrate roadkill in the Chapada dos Veadeiros National Park, Central Brazil. *Biota Neotropica*, *16*(1), e0182. https://doi.org/10.1590/1676-0611-BN-2014-0182

Brito, D., Astua de Moraes, D., Lew, D., & de la Sancha, N. (2015a). *Metachirus nudicaudatus* (Brown Four-eyed Opossum). The IUCN red list of threatened species. https://www.iucnredlist.org/species/40509/197311536

Brito, D., Astua de Moraes, D., Lew, D., Soriano, P. (2015b). *Marmosa murina* (Linnaeus's Mouse Opossum). The IUCN red list of threatened species. https://www.iucnredlist.org/species/40505/197308868

Brito, D., Astua de Moraes, D., Lew, D., Soriano, P., & Emmons, L. (2015c). *Caluromys philander* (Bare-tailed Woolly Opossum). The IUCN red list of threatened species. https://www.iucnredlist.org/species/3649/197321055

Brooks, D. M. (1992). Notes on group size, density, and habitat association of the Pampas Fox (*Dusicyon gymnocerus*) in the Paraguayan Chaco. *Mammalia*, *56*(2), 314–316. https://doi.org/10.1515/mamm-1992-0223

Brown, D. E., & Smith, A. T. (2019). *Lepus callotis* (White-sided Jackrabbit). The IUCN red list of threatened species. https://www.iucnredlist.org/species/11792/45177499

Brum, T. R., Santos-Filho, M., Canale, G. R., & Ignácio, A. R. A. (2018). Effects of roads on the vertebrates diversity of the Indigenous Territory Paresi and its surrounding. *Brazilian Journal of Biology*, *78*(1), 125–132. https://doi.org/10.1590/1519-6984.08116

Bueno, C., Sousa, C. O. M., & Freitas, S. R. (2015). Habitat or matrix: which is more relevant to predict road-kill of vertebrates? *Brazilian Journal of Biology*, *75*(4 suppl 1), 228–238. https://doi.org/10.1590/1519-6984.12614

Cáceres, N. C. (2003). Use of the space by the opossum *Didelphis aurita* Wied-Newied (Mammalia, Marsupialia) in a mixed forest fragment of southern Brazil. *Revista Brasileira de Zoologia*, *20*(2), 315–322. https://doi.org/10.1590/s0101-81752003000200023

Caceres, N. C. (2011). Biological characteristics influence mammal road kill in an Atlantic Forest-Cerrado interface in southwestern Brazil. *Italian Journal of Zoology*, *78*(3), 379–389. https://doi.org/10.1080/11250003.2011.566226

Cameron, G. N., & Spencer, S. R. (1981). *Sigmodon hispidus*. *Mammalian Species*, *158*, 1–9. https://doi.org/10.2307/3504057

Campos, C., Tognelli, M., & Ojeda, R. (2001). *Dolichotis patagonum*. *Mammalian Species*, *652*, 1–5. https://doi.org/10.2307/0.652.1

Carmignotto, A. P., Solari, S., de la Sancha, N., & Costa, L. (2015). *Gracilinanus agilis* (Agile Gracile Opossum). The IUCN red list of threatened species. https://www.iucnredlist.org/species/9417/22169828

Carvajal, V., & Díaz, F. (2016). Registro de mamíferos silvestres atropellados y hábitat asociados en El Cantón de La Fortuna, San Carlos, Costa Rica. *Biocenosis*, *30*, 49–58.

Carvalho, C. F., Custódio, A. E. I., & Junior, O. M. (2015). Wild vertebrates roadkill aggregations on the BR-050 highway, state of Minas Gerais, Brazil. *Bioscience Journal*, *31*(3), 951–959. https://doi.org/10.14393/bj-v31n3a2015-27468

Carvalho-Roel, C. F., Iannini-Custódio, A. E., & Marçal Júnior, O. (2019). Do roadkill aggregations of wild and domestic mammals overlap? *Revista de Biología Tropical*, *67*(1), 47–60. https://doi.org/10.15517/RBT.V67I1.33011

Cassola, F. (2016a). *Heterogeomys cherriei* (Cherrie's Pocket Gopher). The IUCN red list of threatened species. https://www.iucnredlist.org/species/96802567/22215515

Cassola, F. (2016b). *Peromyscus maniculatus* (North American Deermouse). The IUCN red list of threatened species. https://www.iucnredlist.org/species/16672/22360898

Cassola, F. (2016c). *Peromyscus truei*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/16694/115137578

Cassola, F. (2016d). *Reithrodontomys megalotis*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/19410/115151098

Castillo-R, J. C., Urmendez-M, D., & Zambrano-G, G. (2015). Mortalidad de fauna por atropello vehicular en un sector de la vía panamericana entre popáyan y patía. *Boletin Cientifico Del Centro de Museos*, *19*(2), 207–219.

Castro-Arellano, I., Timm, R., & Álvarez-Castañeda, S. T. (2016). *Heteromys irroratus*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/12074/22225187

Castro-Arellano, I., & Vázquez, E. (2016). *Peromyscus difficilis*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/16658/115135855

Castro-Arellano, I., Zarza, H., & Medellín, R. A. (2000). *Philander opossum*. *Mammalian Species*, *638*, 1–8. https://doi.org/10.2307/0.638.1

Catzeflis, F., Patton, J., Percequillo, A., Bonvicino, C. R., & Weksler, M. (2017). *Chaetomys subspinosus* (Bristle-spined Rat). The IUCN red list of threatened species. https://www.iucnredlist.org/species/4366/22213335

Catzeflis, F., Patton J., Percequillo, A., & Weksler, M. (2016a). *Dasyprocta azarae*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/6278/22198654

Catzeflis, F., Patton J., Percequillo, A., & Weksler, M. (2016b). *Kerodon rupestris* (Rock Cavy). The IUCN red list of threatened species. https://www.iucnredlist.org/species/10988/22190269

Cavalcanti, G. N., Fontoura-Rodrigues, M. L., Rodrigues, F. H. G., & Rodrigues, L. A. (2013). Avaliação do risco de extinção da jaritataca *Conepatus semistriatus* (Boddaert, 1785) no Brasil. *Biodiversidade Brasiliera*, *3*(1), 248–254.

Cazzadore, K. C. (2007). Estudo do Comportamento Alimentar e de Forrageio de um Grupo de Macacos-Prego (*Cebus apella*) no Parque Estadual Matas do Segredo, Campo Grande [Master thesis]. Universidade Catolica Dom Bosco.

Ceron, K., Bôlla, D. A. S., De Mattia, D. L., Carvalho, F., & Zocche, J. J. (2017). Roadkilled bats (Mammalia: Chiroptera) in two highways of Santa Catarina state, Southern Brazil. *Oecologia Australis*, *21*(2), 207–212. https://doi.org/10.4257/oeco.2017.2102.12

Cervantes, F. A., Lorenzo, C., Vargas, J., & Holmes, T. (1992). *Sylvilagus cunicularius*. *Mammalian Species*, *412*, 1–4. https://doi.org/10.2307/3504074

Chacón, E. R. (2011). Atropello de vertebrados en una carretera secundaria en Costa Rica. *UNED Research Journal*, *3*(1), 81–84.

Chapman, J. A., Hockman, J. G., & Ojeda, M. M. (1980). *Sylvilagus floridanus*. *Mammalian Species*, *136*, 1–8. https://doi.org/10.2307/3504055

Chiarello, A., & Moraes-Barros, N. (2014a). *Bradypus tridactylus* (Pale-throated Three-toed Sloth). The IUCN red list of threatened species. https://www.iucnredlist.org/species/3037/47436865

Chiarello, A., & Plese, T. (2014b). *Choloepus didactylus* (Linné's Two-toed Sloth). The IUCN red list of threatened species. https://www.iucnredlist.org/species/4777/47439542

Cintra, R., & Yamashita, C. (1990). Habitats, abundância e ocorrência das espécies de aves do Pantanal de Poconé, Mato Grosso, Brasil. *Papéis Avulsos de Zoologia*, *37*(1), 1–21.

Cloutier, D., & Thomas, D. W. (1992). *Carollia perspicillata*. *Mammalian Species*, *417*, 1–9. https://doi.org/10.2307/3504157

Coelho, I. P., Kindel, A., & Coelho, A. V. P. (2008). Roadkills of vertebrate species on two highways through the Atlantic Forest Biosphere Reserve, southern Brazil. *European Journal of Wildlife Research*, *54*(4), 689–699. https://doi.org/10.1007/s10344-008-0197-4

Contreras, M., & González, F. (2018). Mortalidad de mamíferos pequeños y medianos en carretera transistmica (Panamá-Colón). *Revista Científica Centros*, *7*(2), 63–72.

Cooke, R. S. C., Eigenbrod, F., & Bates, A. E. (2019). Projected losses of global mammal and bird ecological strategies. *Nature Communications*, *10*, 2279. https://doi.org/10.1038/s41467-019-10284-z

Cornely, J. E., & Baker, R. J. (1986). *Neotoma mexicana*. *Mammalian Species*, *262*, 1–7. https://doi.org/10.2307/3504054

Corrêa, L. L. C., Silva, D. E., de Oliveira, S. V., Finger, J. V. G., dos Santos, C. R., & Petry, M. V. (2017). Levantamento de vertebrados atropelados em rodovias do sul do Brasil. *Acta Scientiarum—Biological Sciences*, *39*(2), 219–225. https://doi.org/10.4025/actascibiolsci.v39i2.33788

Cossíos, E. D. (2010). *Lycalopex sechurae* (Carnivora: Canidae). *Mammalian Species*, *42*(848), 1–6. https://doi.org/10.1644/848.1

Costa, A. S., Ascensão, F., & Bager, A. (2015). Mixed sampling protocols improve the cost-effectiveness of roadkill surveys. *Biodiversity and Conservation*, *24*(12), 2953–2965. https://doi.org/10.1007/s10531-015-0988-3

Costa, L. P., Astua de Moraes, D., Brito, D., Lew, D., & Tarifa, T. (2015). *Caluromys lanatus* (Brown-eared Woolly Opossum). The IUCN red list of threatened species. https://www.iucnredlist.org/species/3648/197310136

Costa, L. S. (2011). Levantamento de mamíferos silvestres de pequeno e médio porte atropelados na BR 101, entre os municípios de joinville e piçarras, Santa Catarina. *Bioscience Journal*, *27*(4), 666–672.

Costa, R. R. G. F., & Dias, L. A. (2013). Mortalidade de vertebrados por atropelamento em um trecho da GO-164, no sudoeste goiano. *Revista de Biotecnologia & Ciência*, *2*(2), 58–74.

Cuarón, A. D., Helgen, K., & Reid, F. (2016a). *Conepatus semistriatus* (Striped Hog-nosed Skunk). The IUCN red list of threatened species. https://www.iucnredlist.org/species/41633/45210987

Cuarón, A. D., Helgen, K., Reid, F., Pino, J., & González-Maya, J. F. (2016b). *Nasua narica*. The IUCN red list of threatened species. https://doi.org/10.2305/IUCN.UK.2016-1.RLTS.T41683A45216060.EN

Cuarón, A. D., Reid, F., González-Maya, J. F., & Helgen, K. (2016c). *Galictis vittata* (Greater Grison). The IUCN red list of threatened species. https://www.iucnredlist.org/species/41640/45211961

Cuarón, A. D., Reid, F., Helgen, K., & González-Maya, J. F. (2016d). *Eira barbara* (Tayra). The IUCN red list of threatened species. https://www.iucnredlist.org/species/41644/45212151

Cuarón, A. D., Shedden, A., Rodríguez-Luna, E., de Grammont, P. C., Link, A., Palacios, E., Morales, A., & Cortés-Ortiz, L. (2008). *Alouatta palliata* (Mantled Howler Monkey). The IUCN red list of threatened species. https://www.iucnredlist.org/species/39960/190425583

Cuyckens, G. A. E., Mochi, L. S., Vallejos, M., Perovic, P. G., & Biganzoli, F. (2016). Patterns and composition of road-killed wildlife in Northwest Argentina. *Environmental Management*, *58*, 810–820. https://doi.org/10.1007/s00267-016-0755-6

da Cunha, H. F., Moreira, F. G. A., & Silva, S. S. (2010). Atropelamento de vertebrados silvestres na rodovia GO-060 entre Goiânia e Iporá Estado de Goiás, Brasil. *Acta Scientiarum—Biological Sciences*, *32*(3), 257–263. https://doi.org/10.4025/actascibiolsci.v32i3.4752

Da Cunha Tavares, V., & Velazco, P. M. (2010). *Platyrrhinus recifinus* (Chiroptera: Phyllostomidae). *Mammalian Species*, *42*(859), 119–123. https://doi.org/10.1644/859.1

da Silva, D., & Martins, V. (2012). Vertebrados silvestres atropelados na BR 158, RS, Brasil. *Revista Biotemas*, *25*(4), 229–235. https://doi.org/10.5007/2175-7925.2012v25n4p229

da Silva, K. F. M., & Barros Henriques, R. P. (2009). Ecologia de População e Área de Vida do Tatu-Mirim (*Dasypus septemcinctus*) em um Cerrado no Brasil Central. *Edentata*, *10*, 48–53. https://doi.org/10.1896/020.010.0103

da Silva, P. (2014). Avifaunal diversity in a mangrove reserve in Guyana, South America. *International Journal of Science, Environment and Technology*, *3*(1), 23–32.

Dalponte, J., & Courtenay, O. (2008). *Lycalopex vetulus* (Hoary Fox). The IUCN red list of threatened species. https://www.iucnredlist.org/species/6926/87695615

de Araújo, D. R., Ribeiro, P., & Teles, L. T. (2019). Can human demographic or biological factors influence mammal roadkill? A case study in the GO-060 highway. *Oecologia Australis*, *23*(1), 16–27. https://doi.org/10.4257/OECO.2019.2301.02

de Barros, F. M., Granzinolli, M. A. M., Pereira, R. J. G., & Motta, J. C. (2010). Home range and habitat use by the roadside hawk, *Rupornis magnirostris* (Gmelin, 1788) (Aves: Falcaniformes) in southeastern Brazil. *Journal of Natural History*, *45*(1–2), 65–75. https://doi.org/10.1080/00222933.2010.520756

de Carvalho, N. C., Bordignon, M. O., & Shapiro, J. T. (2014). Velozes e furiosos: Um olhar sobre a morte de animais na rodovia MS-080, centro-oeste do Brasil. *Iheringia—Serie Zoologia*, *104*(1), 43–49. https://doi.org/10.1590/1678-4766201410414349

de La Ossa, J., & Galván-Guevara, S. (2015). Registro de mortalidad de fauna silvestre por colisión vehicular en la carretera Toluviejo – ciénaga La Caimanera, Sucre, Colombia. *Biota 16*, 67–77.

de La Ossa-Nadjar, O., & De La Ossa V. J. (2015). Vehicle collisions with wild fauna on the two roads that pass through the Montes De María, Sucre, Colombia Atropellamiento De Fauna Silvestre En Las Dos Vías Que Circundan Los Montes De María. *Revista U.D.C.A. Actualidad & Divulgación Científica*, *18*(2), 503–511.

de la Rosa, C. L., & Nocke, C. C. (2000). *A guide to the carnivores of Central America*. University of Texas Press. https://doi.org/10.7560/716049-FM/HTML

de la Sancha, N., Brito, D., & Costa, L. (2016a). *Philander frenatus* (Southeastern Four-eyed Opossum). The IUCN red list of threatened species. https://www.iucnredlist.org/species/136375/22177125

de la Sancha, N., Pérez-Hernandez, R., Costa, L. P., Brito, D., & Cáceres, N. (2016b). *Philander opossum* (Gray Four-eyed Opossum). The IUCN red list of threatened species. https://www.iucnredlist.org/species/40516/22176779

de Lamo, D. A., Sanborn, A. F., Carrasco, C. D., & Scott, D. J. (1998). Daily activity and behavioral thermoregulation of the guanaco (*Lama guanicoe*) in winter. *Canadian Journal of Zoology*, *76*(7), 1388–1393. https://doi.org/10.1139/z98-070

de Oliveira, T. G. (1998). *Herpailurus yagouaroundi*. *Mammalian Species*, *578*, 1–6. https://doi.org/10.2307/3504500

de Paula, R. C., Rodrigues, F. H. G., Queirolo, D., Jorge, R. P. S., Lemos, F. G., & de Almeida Rodrigues, L. (2013). Avaliação do risco de extinção do lobo-guará *Chrysocyon brachyurus* (Illiger, 1815) no Brasil. *Biodiversidade Brasileira*, *1*, 146–159.

de Souza, J. C., da Cunha, V. P., & Markwith, S. H. (2015). Spatiotemporal variation in human-wildlife conflicts along highway BR-262 in the Brazilian Pantanal. *Wetlands Ecology and Management*, *23*(2), 227–239. https://doi.org/10.1007/S11273-014-9372-4

DeMatteo, K., Michalski, F., & Leite-Pitman, M. R. P. (2011). *Speothos venaticus*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/20468/9203243

Desbiez, A. L. J., Keuroghlian, A., de Mello Beisiegel, B., Medici, E. P., Gatti, A., Pontes, A. R. M., de Campos, C. B., de Tófoli, C. F., Júnior, E. A. M., de Azevedo, F. C. (2012). Avaliação do risco de extinção do cateto *Pecari tajacu* Linnaeus, 1758, no Brasil. *Biodiversidade Brasileira*, *3*, 74–83.

Dietz, J. M. (1985). *Chrysocyon brachyurus. Mammalian Species*, *3*(234), 1. https://doi.org/10.2307/3503796

Dowler, R. C., & Genoways, H. H. (1978). *Liomys irroratus. Mammalian Species*, *82*, 1–6. https://doi.org/10.2307/3503813

Duarte, J. M. B., Piovezan, U., Zanetti, E. S., Ramos, H. G. C., Tiepolo, L. M., Vogliotti, A., Oliveira, M. L., Rodrigues, L. F., & Almeida, L. B. (2012a). Avaliação do risco de extinção do cervo-do-pantanal *Blastocerus dichotomus* Illiger, 1815, no Brasil. *Biodiversidade Brasileira*, *3*, 3–14.

Duarte, J. M. B., Varela, D., Piovezan, U., Beccaceci, M. D., & Garcia, J. E. (2016). *Blastocerus dichotomus* (Marsh Deer). The IUCN red list of threatened species. https://www.iucnredlist.org/species/2828/22160916

Duarte, J. M. B., Vogliotti, A., Zanetti, E. dos S., Oliveira, M. L. de, Tiepolo, L. M., Rodrigues, L. F., Almeida, L. B. de, & Braga, F. G. (2012b). Avaliação do risco de extinção do veado-campeiro *Ozotoceros bezoarticus* Linnaeus, 1758, no Brasil. *Biodiversidade Brasileira*, *3*, 20–32.

Dunnum, J., & Bernal, N. (2019). *Ctenomys minutus* (Tiny Tuco-tuco). The IUCN red list of threatened species. https://www.iucnredlist.org/species/5815/22194130

Durán, I. (2018). Atropellamiento vial de fauna silvestre en la carretera entre los municipios de Villavicencio-Barranca de Upía (Meta), Colombia [Bachelor thesis]. Universidad de los Llanos.

Eisenberg, J., & Redford, K. H. (1999). *Mammals of the Neotropics: Brazil*. University of Chicago Press.

Emmons, L. H., & Feer, F. (1990). *Neotropical rainforest mammals: A field guide*. University of Chicago Press. https://doi.org/10.1016/0169-5347(91)90062-3

Emmons, L. (2016). *Cuniculus paca*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/699/22197347

Emmons, L., & Helgen, K. (2016). *Nasua nasua* (South American Coati). The IUCN red list of threatened species. https://www.iucnredlist.org/species/41684/45216227

Emmons, L., & Reid, F. (2016). *Dasyprocta leporina*, Red-rumped Agouti. The IUCN red list of threatened species. https://doi.org/10.2305/IUCN.UK.2016-2.RLTS.T89497102A22197762.en

Emmons, L., Schiaffini, M., & Schipper, J. (2016). *Conepatus chinga*. Molina's Hog-nosed Skunk. The IUCN red list of threatened species. https://www.iucnredlist.org/species/41630/45210528

Encarnação, C. D. (1987). *Contribuição à ecologia dos tatus (Xenarthra, Dasypodidae) da Serra da Canastra, Minas Gerais* [Master thesis]. Universidade Federal do Rio de Janeiro.

Ernest, S. K. M. (2003). Life history characteristics of placental nonvolant mammals. *Ecology*, *84*(12), 3402. https://doi.org/10.1890/02-9002

Feldhamer, G. A., Thompson, B. C., & Chapman, J. A. (2004). *Wild mammals of North America: Biology, management, and conservation*. Johns Hopkins University Press.

Fernandes, M. E. B., & Aguiar, N. O. (1993). Evidências sobre a adaptação de primatas neotropicais em áreas de mangue com ênfase no macaco-prego *Cebus apella apella. A Primatologia No Brasil*, *4*, 67–80.

Ferreira, C. M. M., De Aquino Ribas, A. C., Casella, J., & Mendes, S. L. (2014). Spatial variation of mammal road kills in a restinga area in Espírito Santo State, southeast Brazil. *Neotropical Biology and Conservation*, *9*(3), 125–133. https://doi.org/10.4013/NBC.2014.93.02

Filius, J., van der Hoek, Y., Jarrín-V, P., & van Hooft, P. (2020). Wildlife roadkill patterns in a fragmented landscape of the Western Amazon. *Ecology and Evolution*, *10*, 6623–6635. https://doi.org/10.1002/ece3.6394

Fischer, W., Godoi, R. F., & Filho, A. C. P. (2018). Roadkill records of reptiles and birds in Cerrado and Pantanal landscapes. *Check List* *14*(5), 845–876. https://doi.org/10.15560/14.5.845

Freitas, Justino, C. S., & Setz, E. Z. F. (2014). Road-kills of the giant anteater in south-eastern Brazil: 10 years monitoring spatial and temporal determinants. *Wildlife Research*, *41*(8), 673–680. https://doi.org/10.1071/WR14220

Gardner, A. (2007). *Mammals of South America: volume 1: marsupials, xenarthrans, shrews, and bats*. University of Chicago Press.

Godoy Martinez, P. J. (2017). *Impactos de la carretera sobre la fauna silvestre, tramo Huancabamba–Tunqui en la carreteraOxapampa–Pozuzo del Parque Nacional Yanachaga Chemillen (Pasco)* [Master thesis]. Universidad Nacional Agraria La Molina.

González, B. A., Palma, R. E., Zapata, B., & Marín, J. C. (2006). Taxonomic and biogeographical status of guanaco *Lama guanicoe* (Artiodactyla, Camelidae). *Mammal Review*, *36*(2), 157–178. https://doi.org/10.1111/J.1365-2907.2006.00084.X

González, M. (2018). *Mortalidad de fauna silvestre por efecto vehicular en el área de influencia de la Reserva Ecológica Manglares de Churute durante la época seca y húmeda* [Bachelor thesis]. Universidad de Guayaquil.

González, S., Maldonado, J. E., Ortega, J., Talarico, A. C., Bidegaray-Batista, L., Garcia, J. E., & Duarte, J. M. B. (2009). Identification of the endangered small red brocket deer (*Mazama bororo*) using noninvasive genetic techniques (Mammalia; Cervidae). *Molecular Ecology Resources*, *9*(3), 754–758. https://doi.org/10.1111/J.1755-0998.2008.02390.X

Gonzalez, S., Jackson, J., & Merino, M. L. (2016). *Ozotoceros bezoarticus* (Pampas Deer). The IUCN red list of threatened species. https://www.iucnredlist.org/species/15803/22160030

González-Gallina, A., Benítez-Badillo, G., Rojas-Soto, O. R., & Hidalgo-Mihart, M. G. (2013). The small, the forgotten and the dead: Highway impact on vertebrates and its implications for mitigation strategies. *Biodiversity and Conservation*, *22*, 325–342. https://doi.org/10.1007/s10531-012-0396-x

Grilo, C., de Resende Cardoso, T., Solar, R., & Bager, A. (2016). Do the size and shape of spatial units jeopardize the road mortality-risk factors estimates? *Perspectives in Ecology and Conservation*, *14*(1), 8–13. https://doi.org/10.1016/J.NCON.2016.01.001

Grosselet, M., Villa, B., & Ruiz, G. (2004). Afectaciones a vertebrados por vehiculos automotores en 1.2 km De Carretera En El Istmo De Tehuantepec. *Proceedings of the Fourth International Partners in Flight Conference: Tundra to Tropics*, 227–231.

Gumier-Costa, F., & Sperber, C. F. (2009). Roadkills of vertebrates in Carajas National Forest, Para, Brazil. *Acta Amazonica*, *39*(2), 459–466. https://doi.org/10.1590/S0044-59672009000200027

Hacklander, K., & Schai-Braun, S. (2019). *Lepus europaeus* (European Hare). The IUCN red list of threatened species. https://www.iucnredlist.org/species/41280/45187424

Haverschmidt, F. (1965). The utilisation of mangroves by South American birds. *Ibis*, *107*(4), 540–542. https://doi.org/10.1111/J.1474-919X.1965.TB07338.X

Hayssen, V. (2010). *Bradypus variegatus* (Pilosa: Bradypodidae). *Mammalian Species*, *42*(850), 19–32. https://doi.org/10.1644/850.1

Hayssen, V. (2011a). *Choloepus hoffmanni* (Pilosa: Megalonychidae). *Mammalian Species*, *43*(873), 37–55. https://doi.org/10.1644/873.1

Hayssen, V. (2011b). *Tamandua tetradactyla* (Pilosa: Myrmecophagidae). *Mammalian Species*, *43*(875), 64–74. https://doi.org/10.1644/875.1

Hayssen, V., Miranda, F., & Pasch, B. (2012). *Cyclopes didactylus* (Pilosa: Cyclopedidae). *Mammalian Species*, *44*(895), 51–58. https://doi.org/10.1644/895.1

Hegel, C. G. Z. (2012). Mamíferos silvestres atropelados na rodovia rs-135 e entorno. *Biotemas*, *25*(2), 165–170. https://doi.org/10.5007/2175-7925.2012v25n2p165

Helgen, K., Kays, R., Pinto, C., González-Maya, J. F., & Schipper, J. (2016a). *Bassaricyon gabbii* (Northern Olingo). The IUCN red list of threatened species. https://www.iucnredlist.org/species/48637946/45196211

Helgen, K., Kays, R., & Schipper, J. (2016b). *Potos flavus* (Kinkajou). The IUCN red list of threatened species. https://www.iucnredlist.org/species/41679/45215631

Helgen, K., & Reid, F. (2016). *Mustela frenata* (Long-tailed Weasel). The IUCN red list of threatened species. https://www.iucnredlist.org/species/41654/45213820

Helgen, K., & Schiaffini, M. (2016). *Galictis cuja* (Lesser Grison). The IUCN red list of threatened species. https://www.iucnredlist.org/species/41639/45211832

Hengemühle, A., & Vargas Cademartori, C. (2008). Levantamento de mortes de vertebrados silvestres devido a atropelamento em um trecho da estrada do mar (RS-389). *Biodiversidade Pampeana*, *6*(2), 4–10.

Hilty, S. L. (2003). *Birds of Venezuela*. Princeton University Press. https://doi.org/10.1515/9781400834099

Hoffmeister, D. F. (1981). *Peromyscus truei*. *Mammalian Species*, *161*, 1–5. https://doi.org/10.2307/3503851

Holland, A. E., Byrne, M. E., Bryan, A. L., DeVault, T. L., Rhodes, O. E., & Beasley, J. C. (2017). Fine-scale assessment of home ranges and activity patterns for resident black vultures (*Coragyps atratus*) and turkey vultures (*Cathartes aura*). *PLoS ONE*, *12*(7), e0179819. https://doi.org/10.1371/JOURNAL.PONE.0179819

Hurtado-Gonzales, J. L., & Bodmer, R. E. (2004). Assessing the sustainability of brocket deer hunting in the Tamshiyacu-Tahuayo Communal Reserve, northeastern Peru. *Biological Conservation*, *116*(1), 1–7. https://doi.org/10.1016/S0006-3207(03)00167-8

Kasper, C. B., Bornholdt, R., & de Almeida Rodrigues, L. (2013a). Avaliação do risco de extinção do Furão grande *Galictis vittata* (Schreber, 1776) no Brasil. *Biodiversidade Brasileira*, *3*(1), 211–215.

Kasper, C. B., Cunha, F. P., & Fontoura-Rodrigues, M. L. (2013b). Avaliação do risco de extinção do Zorrilho *Conepatus chinga* (Molina, 1782) no Brasil. *Biodiversidade Brasileira*, *3*(1), 240–247.

Kasper, C. B., Leuchtenberger, C., Bornholdt, R., Mendes-Pontes, A. R., & de Mello-Beiseigel, B. (2013c). Avaliação do risco de extinção do Furão *Galictis cuja* (Molina, 1782) no Brasil. *Biodiversidade Brasileira*, *3*(1), 203–210.

Kays, R. (2018). *Canis latrans* (Coyote). The IUCN red list of threatened species. https://www.iucnredlist.org/species/3745/163508579

Keuroghlian, A., Desbiez, A., Reyna-Hurtado, R., Altrichter, M., Beck, H., Taber, A., & Fragoso, J. M. V. (2013). *Tayassu pecari* (White-lipped Peccary). The IUCN red list of threatened species. https://www.iucnredlist.org/species/41778/44051115

King, J. A. (1968). *Biology of Peromyscus (Rodentia)*. The American Society of Mammalogists.

Koprowski, J., Roth, L., Reid, F., Woodman, N., Timm, R., & Emmons, L. (2017). *Sciurus aureogaster*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/20006/22248035

Kurta, A., & Lehr, G. C. (1995). *Lasiurus ega*. *Mammalian Species*, *515*, 1–7. https://doi.org/10.2307/3504278

Lacher, T., Timm, R., & Álvarez-Castañeda, S. T. (2016a). *Neotoma mexicana*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/14590/115123126

Lacher, T., Timm, R., & Álvarez-Castañeda, S. T. (2016b). *Perognathus flavus*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/16635/115135061

Lacher, T., Timm, R., & Álvarez-Castañeda, S. T. (2016c). *Otospermophilus variegatus* (Rock Squirrel). The IUCN red list of threatened species. https://www.iucnredlist.org/species/20495/22263993

Leeuwenberg, F., & Resende, S. L. (1994). Ecologia de cervideos na reserva ecologica do IBGE-DF: Manejo e densidade de populacoes. *Cadernos de Geociencias*, *11*, 89–95.

Lefebvre, G., Poulin, B., & McNeil, R. (1994). Temporal dynamics of mangrove bird communities in Venezuela with special reference to migrant warblers. *The Auk*, *111*(2), 405–415. https://doi.org/10.2307/4088604

Lemos, F. G. (2016). *Ecologia e conservação da raposa-do-campo (Lycalopex vetulus) e interações com canídeos simpátricos em áreas antropizadas do Brasil* [PhD thesis]. Universidade Federal de Uberlândia. https://doi.org/10.14393/ufu.te.2019.1207

Lemos, F. G., Cavalcanti De Azevedo, F., De Mello Beisiegel, B., Pinto, R., Jorge, S., Cunha De Paula, R., Henrique, F., Rodrigues, G., Lívia, &, & Rodrigues, A. (2013). Avaliação do risco de extinção da raposa-do-campo *Lycalopex vetulus* (Lund, 1842) no Brasil. *Biodiversidade Brasileira*, *3*(1), 160–171.

Lorenzo, C., & Lanier, H. C. (2019). *Sylvilagus cunicularius* (Mexican Cottontail). The IUCN red list of threatened species. https://www.iucnredlist.org/species/21211/45181292

Loughry, J., McDonough, C., & Abba, A. M. (2014). *Dasypus novemcinctus* (Nine-banded Armadillo). The IUCN red list of threatened species. https://www.iucnredlist.org/species/6290/47440785

Lucherini, M. (2016a). *Lycalopex griseus* (Chilla). The IUCN red list of threatened species. https://www.iucnredlist.org/species/6927/111975602

Lucherini, M. (2016b). *Lycalopex gymnocercus* (Pampas Fox). The IUCN red list of threatened species. https://www.iucnredlist.org/species/6928/85371194

Lucherini, M., Eizirik, E., de Oliveira, T., Pereira, J., & Williams, R. S. (2016). *Leopardus colocolo* (Pampas Cat). The IUCN red list of threatened species. https://www.iucnredlist.org/species/15309/97204446

MacDonald, D. (2006). *The Encyclopedia of Mammals*. Oxford University Press.

MacGregor-Fors, I. (2010). How to measure the urban-wildland ecotone: Redefining 'peri-urban' areas. *Ecological Research 25*, 883–887. https://doi.org/10.1007/S11284-010-0717-Z

Machado, N. G., Rocha, L. A., Silva, N. D., Silva, D. F. N., Florêncio, F. P., & Fernandes, T. B. S. (2017). Biodiversity in urban green space: a case study in the neotropics. *Nativa*, *5*(5), 320–329.

Mader, W. J. (1982). Ecology and breeding habits of the Savanna Hawk in the Llanos of Venezuela. *The Condor*, *84*(3), 261–271. https://doi.org/10.2307/1367368

Maffei, L., & Taber, A. B. (2003). Area de acción de *Mazama americana* (Cervidae) en un bosque seco de Bolivia. *Ecología En Bolivia*, *38*(2), 179–180.

Mancini, P. L., Reis-Neto, A. S., Fischer, L. G., Silveira, L. F., & Schaeffer-Novelli, Y. (2018). Differences in diversity and habitat use of avifauna in distinct mangrove areas in São Sebastião, São Paulo, Brazil. *Ocean & Coastal Management*, *164*, 79–91. https://doi.org/10.1016/J.OCECOAMAN.2018.02.002

Marcus, M. J. (1984). *Behavioral ecology of paca (*Agouti paca*) on Barro Colorado Island, Panama* [Master thesis]. University of Maine.

Mares, M., & Ojeda, R. B. (1989). *Guide to the mammals of Salta Province, Argentina*. University of Oklahoma Press.

Marinho-Filho, J., & Emmons, L. (2016). *Coendou prehensilis* (Brazilian Porcupine). The IUCN red list of threatened species. https://www.iucnredlist.org/species/101228458/22214580

Marshall, L. G. (1978a). *Lutreolina crassicaudata. Mammalian Species*, *91*, 1–4. https://doi.org/10.2307/3503877

Marshall, L. G. (1978b). *Chironectes minimus. Mammalian Species*, *109*, 1–6. https://doi.org/10.2307/0.109.1

Martinelli, M. M., & Volpi, T. A. (2011). Mamíferos atropelados na Rodovia Armando Martinelli (ES-080), Espírito Santo, Brasil. *Natureza on Line*, *9*(3), 113–116.

Max-Planck Institute. (2021). *DATLife Database* [Max-Planck Institute for Demographic Research (Ed.)]. www.datlife.org

Mayer, J. J., & Wetzel, R. M. (1987). *Tayassu pecari. Mammalian Species*, *293*, 1–7. https://doi.org/10.2307/3503865

Mazó, G. (2019). *Atropellamiento de fauna en un tramo de la ruta Villeta-Alberdi, Central, Paraguay*. Universidad Nacional de Asunción.

McKay, W. D. (1980). The influence of agriculture on avian communities near Villavicencio, Colombia. *Wilson Bulletin*, *92*(3), 381–389.

McManus, J. J. (1974). *Didelphis virginiana. Mammalian Species*, *3*(40), 1–6. https://doi.org/10.2307/3503783

Medici, E. P., Flesher, K., Beisiegel, B. M., Keuroghlian, A., Desbiez, A. L. J., Gatti, A., Pontes, A. R. M., Campos, C. B., Tófoli, C. F., Júnior, E. A. M., Azevedo, F. C., Pinho, G. M., Cordeiro, J. L. P., Júnior, T. S. S., Morais, A. A., Mangini, P. R., Rodrigues, L. F., & Almeida, L. B. (2012). Avaliação do risco de extinção da anta brasileira *Tapirus terrestris* Linnaeus, 1758, no Brasil. *Biodiversidade Brasileira*, *3*, 103–116.

Medrano-Vizcaíno, P. (2015). *Efecto de las carreteras en la mortalidad de vertebrados en un área megadiversa: Los Andes Tropicales del Ecuador* [Master thesis]. Pontificia Universidad Católica del Ecuador.

Melo, E. S., & Santos-Filho, M. (2007). Efeitos da BR-070 na Província Serrana de Cáceres, Mato Grosso, sobre a comunidade de vertebrados silvestres. *Revista Brasileira de Zoociências*, *9*(2), 185–192.

Mendes, S. L., Rylands. A. B., Kierulff, M. C. M., & de Oliveira, M. (2008). *Alouatta guariba* (Brown Howler Monkey). The IUCN red list of threatened species. https://www.iucnredlist.org/species/39916/190417874

Mendes Pontes, A. R., & Chivers, D. J. (2002). Abundance, habitat use and conservation of the olingo *Bassaricyon* sp. in Maracá Ecological Station, Roraima, Brazilian Amazonia. *Studies on Neotropical Fauna and Environment*, *37*(2), 105–109. https://doi.org/10.1076/SNFE.37.2.105.8577

Meneguetti, D. U. O., Meneguetti, N. F. S. P., & Trevisan, O. (2010). Georreferenciamento e reavaliação da mortalidade por atropelamento de animais silvestres na linha 200 entre os municipios de Ouro Preto do Oeste e Vale do Paraíso—RO. *Revista Científica Da Faculdade de Educação e Meio Ambiente*, *1*(1), 58–64.

Meza-Joya, F. L., Ramos, E., & Cardona, D. (2019). Spatio-temporal patterns of mammal road mortality in Middle Magdalena Valley, Colombia. *Oecologia Australis*, *23*(3), 575–588. https://doi.org/10.4257/oeco.2019.2303.15

Milli, M. S., & Passamani, M. (2006). Impacto da Rodovia Josil Espíndula Agostini (ES-259) sobre a mortalidade de animais silvestres (Vertebrata) por atropelamento. *Natureza on Line*, *4*(2), 40–46.

Minias, P., & Podlaszczuk, P. (2017). Longevity is associated with relative brain size in birds. *Ecology and Evolution*, *7*(10), 3558–3566. https://doi.org/10.1002/ECE3.2961

Miranda, F., Bertassoni, A., & Abba, A. M. (2014a). *Myrmecophaga tridactyla* (Giant Anteater). The IUCN red list of threatened species. https://www.iucnredlist.org/species/14224/47441961

Miranda, F., Fallabrino, A., Arteaga, M., Tirira, D. G., Meritt, D. A., & Superina, M. (2014b). *Tamandua tetradactyla* (Southern Tamandua). The IUCN red list of threatened species. https://www.iucnredlist.org/species/21350/47442916

Miranda, F., Meritt, D. A., Tirira, D. G., & Arteaga, M. (2014c). *Cyclopes didactylus* (Silky Anteater). The IUCN red list of threatened species. https://www.iucnredlist.org/species/6019/47440020

Miranda, F. R., Chiarello, A. G., Röhe, F., Miranda, G. H. B., & Vaz, S. M. (2015). *Avaliação do Risco de Extinção de* Cyclopes didactylus

(Linnaeus, 1758). Instituto Chico Mendes Para La Conservación de La Biodiversidad.

Miranda, F. R., Chiarello, A. G., Röhe, F., Braga, F. G., Mourão, G. M., Miranda, G. H. B., Silva, K. F. M., Faria-Corrêa, M. A., Vaz, S. M., & Belentani, S. C. S. (2014d). Avaliação do risco de extinção de *Myrmecophaga tridactyla* Linnaeus 1758 no Brasil. In *Avaliação Do Risco de Extinção de Xenartros Brasileiros* (pp. 89–105). Instituto Chico Mendes de Conservação da Biodiversidade.

Miranda, J. E. S., Umetsu, R. K., de Melo, F. R., Melo, F. C. S. A., Pereira, K. F., & Oliveira, S. R. (2017). Roadkill in the Brazilian cerrado savanna: Comparing five highways in southwestern Goiás. *Oecologia Australis*, *21*(3), 337–349. https://doi.org/10.4257/oeco.2017.2103.10

Mittermeier, R. A., Urbani, B., Rylands, A. B., & Régis, T. (2021). *Saguinus midas* (Golden-handed Tamarin). The IUCN red list of threatened species. https://www.iucnredlist.org/species/41525/192552538

Mones, A., & Ojasti, J. (1986). *Hydrochoerus hydrochaeris*. *Mammalian Species*, *264*, 1–7. https://doi.org/10.2307/3503784

Monroy, M., De La Ossa-Lacayo, A., & De La Ossa V, J. (2015). Tasa de atropellamiento de fauna silvestre en la vía San Onofre—María la baja, Caribe Colombiano. *Revista de La Asociación Colombiana de Ciencias Biológicas*, *27*, 88–95. https://doi.org/10.47499/revistaaccb.v1i27.106

Moraes-Barros, N., Chiarello, A., & Plese, T. (2014). *Bradypus variegatus* (Brown-throated Sloth). The IUCN red list of threatened species. https://www.iucnredlist.org/species/3038/47437046

Morales-Mavil, J., Villa-Cañedo, J., Aguilar, S., & Barragán, L. (1997). Mortalidad de vertebrados silvestres en una carretera asfaltada de la región de los Tuxtlas, Veracruz, México. *La Ciencia y El Hombre*, *27*, 7–23.

Murray, J. L., & Gardner, G. L. (1997). *Leopardus pardalis*. *Mammalian Species*, *548*, 1–10. https://doi.org/10.2307/3504082

Musser, G., Hutterer, R., Kryštufek, B., Yigit, N., & Mitsain, G. (2021). *Mus musculus* (House Mouse). The IUCN red list of threatened species. https://www.iucnredlist.org/species/13972/197519724

Myhrvold, N. P., Baldridge, E., Chan, B., Sivam, D., Freeman, D. L., & Ernest, S. K. M. (2015). An amniote life-history database to perform comparative analyses with birds, mammals, and reptiles. *Ecology*, *96*(11), 3109. https://doi.org/10.1890/15-0846R.1

Navarrete, D., & Ortega, J. (2011). *Tamandua mexicana* (Pilosa: Myrmecophagidae). *Mammalian Species*, *43*(874), 56–63. https://doi.org/10.1644/874.1

Nielsen, C., & Lanier, H. C. (2019). *Sylvilagus floridanus* (Eastern Cottontail). The IUCN red list of threatened species. https://www.iucnredlist.org/species/41299/45191626

Nielsen, C., Thompson, D., Kelly, M., & Lopez-Gonzalez, C. A. (2015). *Puma concolor* (Puma). The IUCN red list of threatened species. https://www.iucnredlist.org/species/18868/97216466

Novaro, A. J. (1997). *Pseudalopex culpaeus*. *Mammalian Species*, *558*, 1–8. https://doi.org/10.2307/3504483

Nowak, R. (1999). *Walker's mammals of the world*. Johns Hopkins University Press.

Oaks, E. C., Young, P. J., Kirkland, G. L., & Schmidt, D. F. (1987). *Spermophilus variegatus*. *Mammalian Species*, *272*, 1–8. https://doi.org/10.2307/3503949

Ohana, J., Bertassoni, A., Miranda, F., Mourão, G., Miranda, G., Costa, J., Silva, K., Fariacorrêa, M., & Belentani, S. (2015). *Avaliação do risco de extinção de* Tamandua tetradactyla *Linnaeus, 1758 no Brasil*. In Avaliação Do Risco de Extinção de Xenartros Brasileiros (pp. 107–116). Instituto Chico Mendes de Conservação da Biodiversidade.

Ojeda, R., Bidau, C., & Emmons, L. (2016). *Myocastor coypus* (Coypu). The IUCN red list of threatened species. https://www.iucnredlist.org/species/14085/121734257

Ojeda, V. S., Trejo, A. R., Seijas, S., & Chazarreta, L. (2015). Highway network expansion in Andean Patagonia: A warning notice from rufous-legged owls. *49*(2), 201–209. https://doi.org/10.3356/0892-1016-49.2.201

Oliveira, T. G., Almeida, L. B., & Campos, C. B. (2013a). Avaliação do risco de extinção da jaguatirica *Leopardus pardalis* (Linnaeus, 1758) no Brasil. *Biodiversidade Brasileira*, *3*(1), 66–75.

Oliveira, T. G., & Cassaro, K. (2006). *Guia de Campo dos Felinos do Brasil*. Instituto Pró-Carnívoros.

Oliveira, T. G., Paviolo, A., Schipper, J., Bianchi, R. C., Payan, E., & Carvajal, S. V. (2015). *Leopardus wiedii*, Margay. *The IUCN* red list of threatened species. https://www.iucnredlist.org/species/11511/50654216

Oliveira, T. G., Tortato, M. A., Almeida, L. B., & Beisiegel, B. D. M. (2013b). Avaliação do risco de extinção do Gato-do-mato *Leopardus tigrinus* (Schreber, 1775) no Brasil Tadeu. *Biodiversidade Brasileira*, *3*(1), 56–65.

Omena Junior, R., Pantoja Lima, J., Wendt Santos, A. L., Aguiar Ribeiro, G. A., & Rocha Aride, P. H. (2012). Caracterização da fauna de vertebrados atropelada na rodovia BR 174, Amazonas, Brasil. *Revista Colombiana de Ciencia Animal*, *4*(2), 291–307.

Ortega, J., & Arita, H. T. (1997). *Mimon bennettii*. *Mammalian Species*, *549*, 1–4. https://doi.org/10.2307/3504246

Ortega, J., Navarrete, D., & Maldonado, J. E. (2012). Non-invasive sampling of endangered neotropical river otters reveals high levels of dispersion in the Lacantun River System of Chiapas, Mexico. *Animal Biodiversity and Conservation*, *35*, 59–69.

Ortega Reyes, J., Tirira, D. G., Arteaga, M., & Miranda, F. (2016). *Tamandua mexicana* (Northern Tamandua). The IUCN red list of threatened species. https://www.iucnredlist.org/species/21349/47442649

Ottoni, I., de Oliveira, F. F. R., & Young, R. J. (2009). Estimating the diet of urban birds: The problems of anthropogenic food and food digestibility. *Applied Animal Behaviour Science*, *117*(1–2), 42–46. https://doi.org/10.1016/J.APPLANIM.2008.11.002

Pacifici, M., Santini, L., Di Marco, M., Baisero, D., Francucci, L., Marasini, G. G., Visconti, P., & Rondinini, C. (2013). Generation length for mammals. *Nature Conservation*, *5*, 89–94. https://doi.org/10.3897/NATURECONSERVATION.5.5734

Padilla, M., & Dowler, R. C. (1994). *Tapirus terrestris. Mammalian Species*, *481*, 1–8. https://doi.org/10.2307/3504109

Paes, C. M., & Povaluk, M. (2012). Atropelamento de animais silvestres na Rodovia Federal BR-116, trecho administrado pela Concessionária Autopista Planalto Sul. *Saúde e Meio Ambiente: Revista Interdisciplinar*, *1*(2), 26–40. https://doi.org/10.24302/sma.v1i2.285

Patton, J. L., Pardiñas, U. F. J., & D'Elía, G. (2015). *Mammals of South America, Vol. 2. Rodents*. University of Chicago Press.

Paviolo, A., Crawshaw, P., Caso, A., de Oliveira, T., Lopez-Gonzalez, C. A., Kelly, M., De Angelo, C., & Payan, E. (2015). *Leopardus pardalis* (Ocelot). The IUCN red list of threatened species. https://www.iucnredlist.org/species/11509/97212355

Payan, E., & Oliveira, T. (2016). *Leopardus tigrinus* (Northern Tiger Cat). The IUCN red list of threatened species. https://www.iucnredlist.org/species/54012637/50653881

Payán, E., Soto, C., Díaz-Pulido, A., Benítez, A., & Hernández, A. (2013). Wildlife road crossing and mortality: lessons for wildlife friendly road design in Colombia. *International Conference on Ecology and Transportation, August 2015*, 1–18.

Pereira, A. P. F. G., Andrade, F. A. G., & Fernandes, M. E. B. (2006). Dois anos de monitoramento dos atropelamentos de mamíferos na rodovia PA-458, Bragança, Pará. *Boletim Do Museu Paraense Emílio Goeldi, Ciências Naturais*, *1*(3), 77–83.

Pereira, J., Lucherini, M., & Trigo, T. (2015). *Leopardus geoffroyi* (Geoffroy's Cat). *The IUCN* red list of threatened species, 1–14. https://www.iucnredlist.org/species/15310/50657011

Pérez, E. M. (1992). *Agouti paca. Mammalian Species*, *404*, 1–7. https://doi.org/10.2307/3504102

Pérez-Hernandez, R., Brito, D., Tarifa, T., Cáceres, N., Lew, D., & Solari, S. (2016a). *Chironectes minimus* (Water Opossum). The IUCN red list of threatened species. https://www.iucnredlist.org/species/4671/22173467

Pérez-Hernandez, R., Lew, D., & Solari, S. (2016b). *Didelphis virginiana* (Virginia Opossum). The IUCN red list of threatened species. https://www.iucnredlist.org/species/40502/22176259

Perin, M. A. A. (2010). *Aspectos ecológicos do cervo-do-pantanal Blastocerus dichotomus (Illiger, 1815) (Mammalia: Cervidae): animais reintroduzidos e ou nascidos na estação ecológica de Jataí, nordeste do estado de São Paulo, município de Luís Antônio* [Master thesis]. Universidade Federal de Juiz de Fora.

Pesquero, M. A., Corrêa, A. G., Pesquero, M. F., & De Paula, H. M. (2014). Feeding of nestlings of the Amazonian Motmot (*Momotus momota*) in southern Goiás, Brazil. *Revista Brasileira de Ornitologia 2014 22:3*, *22*(3), 288–291. https://doi.org/10.1007/BF03544262

Pinder, L. (1997). *Niche overlap among brown brocket deer, pampas deer, and cattle in the Pantanal of Brazil* [PhD thesis]. University of Florida.

Pinheiro, B. F., & Turci, L. C. B. (2013). Vertebrados atropelados na estrada da Variante (BR-307), Cruzeiro do Sul, Acre, Brasil. *Natureza on Line*, *11*(2), 68–78.

Pinowski, J. (2005). Roadkills of vertebrates in Venezuela. *Revista Brasileira de Zoologia*, *22*(1), 191–196. https://doi.org/10.1590/s0101-81752005000100023

Pinsky, M., & McCauley, D. (2019). Home range and body size data compiled from the literature for marine and terrestrial vertebrates. Biological and Chemical Oceanography Data Management Office (BCO-DMO). https://doi.org/10.1575/1912/BCO-DMO.752795.1

Pinto, M. C. M. (2006). *Padrão comportamental de um grupo de macacos-prego (Cebus apella cay, Illiger, 1815) no Parque Estadual Matas do Segredo, Campo Grande, Mato Grosso do Sul* [Master thesis]. Universidade Federal de Mato Grosso do Sul.

Pires, A. S., Koeler Lira, P., Fernandez, F. A. S., Schittini, G. M., & Oliveira, L. C. (2002). Frequency of movements of small mammals among Atlantic Coastal Forest fragments in Brazil. *Biological Conservation*, *108*(2), 229–237. https://doi.org/10.1016/S0006-3207(02)00109-X

Pitman, R. L., & de Mello Beisiegel, B. (2013). Avaliação do risco de extinção do cachorro-do-mato-de-orelhas-curtas *Atelocynus microtis* (Sclater, 1883) no Brasil. *Biodiversidade Brasileira*, *1*, 133–137.

Pitman, R. L., & Williams, R. (2004). *Ecology and conservation of the short eared dog (*Atelocynus microtis*) at Cocha Cashu Biological Station, Peru* (2nd edn). IUCN/SSC Canids Specialist Group.

Plese, T., & Chiarello, A. (2014). *Choloepus hoffmanni* (Hoffmann's two-toed sloth). The IUCN red list of threatened species. https://www.iucnredlist.org/species/4778/47439751

Poglayen-Neuwall, I., & Toweill, D. E. (1988). *Bassariscus astutus. Mammalian Species*, *327*, 1–8. https://doi.org/10.2307/3504321

Portella, A. (2015). Ecologia de Kerodon acrobata (Rodentia : Caviidae) em fragmentos de mata seca associados a afloramentos calcários no Cerrado do Brasil Central [PhD thesis]. Universidade de Brasília. https://doi.org/10.26512/2015.09.T.19426

Previatto, D. M., Mizobe, R. S., & Posso, S. R. (2013). Birds as potential pollinators of the *Spathodea nilotica* (Bignoniaceae) in the urban environment. *Brazilian Journal of Biology*, *73*(4), 737–741. https://doi.org/10.1590/S1519-69842013000400008

Queirolo, D., Almeida, L. B., Beisiegel, B. M., & Oliveira, T. G. (2013a). Avaliação do risco de extinção do Gato-palheiro *Leopardus colocolo* (Molina, 1782) no Brasil. *Biodiversidade Brasileira*, *3*(1), 91–98.

Queirolo, D., Kasper, C. B., & Beisiegel, B. M. (2013b). Avaliação do risco de extinção do graxaim-do-campo *Lycalopex gymnocercus* (G. Fischer, 1814) no Brasil. *Biodiversidade Brasileira*, *3*(1), 172–178.

Ramos-Abrantes, M. M., Carreiro, A. N., Araújo, D. V. F., Souza, J. G., Lima, J. P. R., Cezar, H. R. A., Leite, L. S., & Abrantes, S. H. F. (2018). Vertebrados silvestres atropelados na rodovia BR-230, Paraíba, Brasil. *Pubvet*, *12*(1), 1–7. https://doi.org/10.22256/pubvet.v12n1a5.1-7

Redford, K. H., & Eisenberg, J. F. (1992). *Mammals of the Neotropics, Volume 2, The Southern Cone: Chile, Argentina, Uruguay, Paraguay*. University of Chicago Press.

Reid, F., Helgen, K., & González-Maya, J. F. (2016). *Procyon cancrivorus* (Crab-eating Raccoon). The IUCN red list of threatened species. https://www.iucnredlist.org/species/41685/45216426

Reid, F., Schipper, J., & Timm, R. (2016). *Bassariscus astutus* (Ringtail). The IUCN red list of threatened species. https://www.iucnredlist.org/species/41680/45215881

Reis, N. R., Peracchi, A. L., Fregonezi, M. N., & Rossaneis., B. K. (2010). Mamíferos do Brasil: guia de identificação. In *Mamíferos do Brasil*. Technical Books Editora.

Rheingantz, M. L., & Trinca, C. S. (2015). *Lontra longicaudis* (Neotropical Otter). *The IUCN* red list of threatened species. https://www.iucnredlist.org/species/12304/164577708

Ridgely, R., & Greenfield, P. (2006). *Aves del Ecuador, Guia de Campo*. Fundación de conservación Jocotoco.

Rímoli, J., Ludwig, G., Lynch Alfaro, J., Melo, F., Mollinedo, J., & dos Santos, M. (2018). *Sapajus cay* (Azara's Capuchin). The IUCN red list of threatened species. https://www.iucnredlist.org/species/136366/192593536

Roach, N. (2016). *Dolichotis patagonum*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/6785/22190337

Roach, N., & Naylor, L. (2016). *Coendou insidiosus*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/20631/22213745

Rocha, E. C., Silva, J., Silva, P. M., Vale, V. S., & Araújo, M. S. (2018). Atropelamentos de tatu-canastra *Priodontes maximus* (Kerr, 1792) em uma rodovia no Cerrado goiano e sua relação com a paisagem do entorno. *Multi-Science Journal*, 1(12), 1–4. https://doi.org/10.33837/MSJ.V1I12.569

Rodrigues, L. A., Ponte, A. R. M., & Rocha-Campos, C. C. (2013). Avaliação do risco de extinção da Irara *Eira barbara* (Linnaeus, 1758) no Brasil. *Biodiversidade Brasileira*, 31, 195–202.

Rodríguez-Castro, K. G., Ciocheti, G., Ribeiro, J. W., Ribeiro, M. C., & Galetti, P. M., Jr. (2017). Using DNA barcode to relate landscape attributes to small vertebrate roadkill. *Biodiversity and Conservation*, 26, 1161–1178. https://doi.org/10.1007/s10531-017-1291-2

Rojas, O., & Avendaño, C. (2018). Áreas y variables ambientales espaciales relacionadas en el atropellamiento y cruce de la fauna silvestre en la carretera de la Franja Transversal del Norte, Cobán, Guatemala. *Ciencia, Tecnología y Salud*, 5(2), 111–124.

Rylands, A. B., & Kierulff, M. C. M. (2015). *Sapajus libidinosus* (Bearded Capuchin, Black-striped Capuchin). IUCN red list of threatened species. https://www.iucnredlist.org/species/136346/192593226

Rylands, A. B., & Mendes, S. (2018). *Callithrix geoffroyi* (Geoffroy's Tufted-ear Marmoset). The IUCN red list of threatened species. https://www.iucnredlist.org/species/3572/191701212

Sampaio, E., Lim, B., & Peters, S. (2016). *Platyrrhinus recifinus*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/17572/21971681

Santini, L., Isaac, N. J. B., & Ficetola, G. F. (2018). TetraDENSITY: A database of population density estimates in terrestrial vertebrates. *Global Ecology and Biogeography*, 27(7), 787–791. https://doi.org/10.1111/GEB.12756

Santos, M., Aguirre, L. F., Vázquez, L. B., & Ortega, J. (2003). *Phyllostomus hastatus*. *Mammalian Species*, 722, 1–6. https://doi.org/10.1644/0.722.1

Saranholi, B. H., Bergel, M. M., Ruffino, P. H. P., Rodríguez-C, K. G., Ramazzotto, L. A., de Freitas, P. D., & Galetti, P. M. (2016). Roadkill hotspots in a protected area of Cerrado in Brazil: planning actions to conservation. *Revista MVZ Córdoba*, 21(2), 5441–5448. https://doi.org/10.21897/RMVZ.609

Sássi, C. M., Nascimento, A. A. T., Miranda, R. F. P., & Carvalho, G. D. (2013). Levantamento de animais silvestres atropelados em trecho da rodovia BR482. *Arquivo Brasileiro de Medicina Veterinaria e Zootecnia*, 65(6), 1883–1886. https://doi.org/10.1590/S0102-09352013000600041

Sayol, F., Sol, D., & Pigot, A. L. (2020). Brain size and life history interact to predict urban tolerance in birds. *Frontiers in Ecology and Evolution*, 8, 58. https://doi.org/10.3389/FEVO.2020.00058/BIBTEX

Secco, H., Gomes, L. A., Lemos, H., Mayer, F., Machado, T., Guerreiro, M., & Gregorin, R. (2017). Road and landscape features that affect bat roadkills in southeastern Brazil. *Oecologia Australis*, 21(3), 323–336. https://doi.org/10.4257/oeco.2017.2103.09

Seijas, A. E., Araujo-Quintero, A., & Velásquez, N. (2013). Mortalidad de vertebrados en la carretera Guanare-Guanarito, estado Portuguesa, Venezuela. *Revista de Biologia Tropical*, 61(4), 1619–1636. https://doi.org/10.15517/rbt.v61i4.12803

Shump, K. A., & Shump, A. U. (1982). *Lasiurus borealis*. *Mammalian Species*, 183, 1–6. https://doi.org/10.2307/3503843

Sick, H. (1997). *Ornitologia brasileira [Brazilian ornithology]*. Editora Nova Fronteira.

Silva, A. N., Nunes, R., Estrela, D. C., Malafaia, G., & Castro, A. L. S. (2016). Behavioral repertoire of the poorly known Red-legged Seriema, *Cariama cristata* (Cariamiformes: Cariamidae). *Revista Brasileira de Ornitologia 2016 24:2*, 24(2), 73–79. https://doi.org/10.1007/BF03544333

Silva, D. E., Liberato, L., Corrêa, C., & Oliveira, S. V. (2013). Monitoramento de vertebrados atropelados em dois trechos de rodovias na Região Central do Rio Grande do Sul—Brasil. *Revista de Ciências Ambientais*, 7(1), 27-36.

Silva, F. C., Silva, G. G., de Chagas, M. O., & Henriques Jung, D. M. (2014). Bird community composition in an urban area in southern Brazil. *Neotropical Biology and Conservation*, 9(2), 78–90. https://doi.org/10.4013/NBC.2014.92.02

Silva, K. F. M., Costa, J. F., Anacleto, T. C. S., & Timo, T. P. C. (2015a). Avaliação do risco de extinção de *Euphractus sexcinctus* (Linnaeus, 1758) no Brasil. In *Avaliação do risco de extinção dos Xenartros Brasileiros* (pp. 197–207). Instituto Chico Mendes de Conservação da Biodiversidade.

Silva, K. F. M., Costa, J. F., Anacleto, T. C. S., & Timo, T. P. C. (2015b). Avaliação do risco de extinção de *Dasypus novemcinctus* Linnaeus, 1758 no Brasil. In *Avaliação do risco de extinção dos Xenartros Brasileiros* (pp. 173–182). Instituto Chico Mendes de Conservação da Biodiversidade.

Silveira, L. (1995). Notes on the distribution and natural history of the pampas cat, *Felis colocolo*, in Brazil. *Mammalia*, 59, 284–288.

Smith, A. T., & Brown, D. E. (2019). *Sylvilagus audubonii* (Desert Cottontail). The IUCN red list of threatened species. https://www.iucnredlist.org/species/41297/45190821

Sol, D., & Senar, J. C. (1995). Urban pigeon populations: Stability, home range, and the effect of removing individuals. *Canadian Journal of Zoology*, *73*(6), 1154–1160. https://doi.org/10.1139/z95-137

Solari, S. (2016). *Anoura caudifer* (Tailed Tailless Bat). The IUCN red list of threatened species. https://www.iucnredlist.org/species/88108473/88185102

Solari, S. (2019). *Mimon bennettii* (Golden Bat). The IUCN red list of threatened species. https://www.iucnredlist.org/species/13559/22105562

Solari, S., & Lew, D. (2015). *Caluromys derbianus* (Central American Woolly Opossum). The IUCN red list of threatened species. https://www.iucnredlist.org/species/3650/22175821

Sousa, M., & Miranda, P. (2010). Mamíferos terrestres encontrados atropelados na rodovia BR-230/PB entre Campina Grande e João Pessoa. *Revista de Biologia e Farmácia*, *4*(2), 72–82.

Souza, F. (1995). A study of group structure and home range size of *Crotophaga ani* and *Guira guira* in São Paulo, Brasil (Cuculiformes: Cuculidae). *Ararajuba*, *3*, 72–74.

Tacutu, R., Craig, T., Budovsky, A., Wuttke, D., Lehmann, G., Taranukha, D., Costa, J., Fraifeld, V. E., & De Magalhães, J. P. (2013). Human ageing genomic resources: Integrated databases and tools for the biology and genetics of ageing. *Nucleic Acids Research*, *41*, D1027–D1033. https://doi.org/10.1093/NAR/GKS1155

Tamburello, N., Côté, I. M., & Dulvy, N. K. (2015). Energy and the scaling of animal space use. *The American Naturalist*, *186*(2), 196–211. https://doi.org/10.1086/682070

Taube, E., Keravec, J., Vié, J.-C., & Duplantier, J.-M. (2001). Reproductive biology and postnatal development in sloths, *Bradypus* and *Choloepus*: review with original data from the field (French Guiana) and from captivity. *Mammal Review*, *31*(3–4), 173–188. https://doi.org/10.1111/J.1365-2907.2001.00085.X

Thiollay, J. (1989). Area requirements for the conservation of rain forest raptors and game birds in French Guiana. *Conservation Biology*, *3*(2), 128–137. https://doi.org/10.1111/J.1523-1739.1989.TB00065.X

Timm, R., Cuarón, A. D., Reid, F., Helgen, K., & González-Maya, J. F. (2016). *Procyon lotor* (Northern Raccoon). The IUCN red list of threatened species. https://www.iucnredlist.org/species/41686/45216638

Tirira, D. (2017). *Guía de campo de los mamíferos del Ecuador*, 2nd edn. Murciélago blanco.

Torga, K., Franchin, A. G., & Júnior, O. M. (2007). A avifauna em uma seção da área urbana de Uberlândia, MG. *Biotemas*, *20*(1), 7–17.

Torres Pinheiro, R., Dornas, T., dos Santos Reis, E., de Oliveira Barbosa, M., & Rodello, D. (2008). Birds of the urban area of Palmas, TO: composition and conservation. *Revista Brasileira de Ornitologia—Brazilian Journal of Ornithology*, *16*(4), 339–347.

Tortato, M. A., Oliveira, T. G., Almeida, L. B., & Beisiegel, B. M. (2013). Avaliação do risco de extinção do gato-maracajá *Leopardus wiedii* (Schinz, 1821) no Brasil. *Biodiversidade Brasileira*, *1*, 76–83.

Trejo, A., & Seijas, S. (2003). Una estimación de aves muertas en ruta en el Parque Nacional Nahuel Huapi, noroeste de la Patagonia Argentina. *Hornero*, *18*(2), 97–101.

Trinca, C. S., Jaeger, C. F., & Eizirik, E. (2013). Molecular ecology of the neotropical otter (*Lontra longicaudis*): Non-invasive sampling yields insights into local population dynamics. *Biological Journal of the Linnean Society*, *109*(4), 932–948. https://doi.org/10.1111/bij.12077

Turci, L. C. B., & Bernarde, P. S. (2009). Vertebrate roadkills on State Highway 383, Rondonia, Brazil. *Biotemas*, *22*(1), 121–127.

Urmendez, D., Castillo, J., & Zambrano, G. (2017). Mortalidad de vertebrados silvestres por atropello vehicular en 13 kilómetros de la vía Panamericana en el municipio del Patía. *Revista Novedades Colombianas*, *12*(1), 57–64.

Valadão, R. M., Bastos, L. F., & Castro, C. P. (2018). Atropelamentos de vertebrados silvestres em quatro rodovias no Cerrado, Mato Grosso, Brasil. *Multi-Science Journal*, *1*(12), 62–74. https://doi.org/10.33837/msj.v1i12.447

Valadão, R. M., Marçal Júnior, O., & Franchin, A. G. (2006). A avifauna no Parque Municipal Santa Luzia, zona urbana de Uberlândia, Minas Gerias. *Journal of Biosciences*, *22*(2), 97–108.

Varela, D., Flesher, K., Cartes, J. L., de Bustos, S., Chalukian, S., Ayala, G., & Richard-Hansen, C. (2019). *Tapirus terrestris* (Lowland Tapir). The IUCN red list of threatened species. https://www.iucnredlist.org/species/21474/45174127

Vargas-Salinas, F., Delgado-Ospina, I., & López-Aranda, F. (2011). Mortalidad por atropello vehicular y distribución de anfibios y reptiles en un bosque subandino en el occidente de Colombia. *Caldasia*, *33*(1), 121–138.

Vázquez, E., Reid, F., & Cuarón, A. D. (2016). *Coendou mexicanus*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/20629/22214103

Vázquez, J., Farías, V., Rodríguez-Martínez, L., Bautista, A., Palacios-Roque, G., & Martínez-Gómez, M. (2013). Ámbito hogareño del conejo mexicano (*Sylvilagus cunicularius*) en un bosque templado del centro de México. *Therya*, *4*(3), 581–595.

Vázquez Rodríguez, J., Ros Peña, F., & Madi Tojeiro, Y. (2016). Arrollamientos de zorros (*Cerdocyon thous* y *Urocyon cinereoargenteus*) en la autopista Barquisimeto-Acarigua, región centro occidental de Venezuela. *Ecotrópicos*, *29*(1–2), 49–56.

Vázquez Rodríguez, J., Ros Peña, F., & Madi Tojeiro, Y. (2018). Registro de aves rapaces arrolladas en la autopista Barquisimeto-Acarigua, Venezuela. *Boletín Del Centro de Investigaciones Biológicas*, *52*(2), 101–112.

Velazco, P., & Patterson, B. (2017). *Sturnira lilium* (Little Yellow-shouldered Bat). The IUCN red list of threatened species. https://www.iucnredlist.org/species/88159688/22049384

Vieira, E., Bonvicino, C. R., D'elia, G., & Pardinas, U. (2016). *Nectomys squamipes*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/14475/115122358

Vizcaino, S. F., & Loughry, W. J. C. N.-N. (2008). *The biology of the Xenarthra*. University Press of Florida.

Vuilleumier, F. (1985). Forest birds of Patagonia: Ecological geography, speciation, endemism, and faunal history. *Ornithological Monographs*, *36*, 255–304. https://doi.org/10.2307/40168287

Walker, R. S., Novaro, A. J., Perovic, P., Palacios, R., Donadio, E., Lucherini, M., Pia, M., & López, M. S. (2007). Diets of three

species of Andean carnivores in high-altitude deserts of Argentina. *Journal of Mammalogy*, *88*(2), 519–525. https://doi.org/10.1644/06-MAMM-A-172R.1

Webster, Wm. D., & Knox Jones, J., Jr. (1982). *Reithrodontomys megalotis*. *Mammalian Species*, *167*, 1–5. https://doi.org/10.2307/3504020

Weiss, L. P., & Vianna, V. O. (2012). Levantamento do impacto das rodovias BR-376, BR-373 e BR-277, trecho de Apucarana a Curitiba, Paraná, no atropelamento de animais silvestres. *Publicatio UEPG: Ciencias Biologicas e Da Saude*, *18*(2), 121–133. https://doi.org/10.5212/publ.biologicas.v.18i2.0007

Weksler, M. (2016). *Galea flavidens* (Yellow-toothed Cavy). The IUCN red list of threatened species. https://www.iucnredlist.org/species/8823/22189525

Weksler, M., & Bonvicino, C. R. (2005). Taxonomy of pigmy rice rats genus *Oligoryzomys* Bangs, 1900 (Rodentia, Sigmodontinae) of the Brazilian Cerrado, with the description of two new species. *Archivos Do Museu Nacional Do Rio de Janeiro*, *63*(1), 113–130.

Weksler, M., Bonvicino, C. R., D'elia, G., Pardinas, U., Teta, P., & Jayat, J. (2016a). *Oligoryzomys flavescens* (Yellow Pygmy Rice Rat). The IUCN red list of threatened species. https://www.iucnredlist.org/species/15247/115126612

Weksler, M., Queirolo, D., Brito, D., Pardinas, U., & Teta, P. (2016b). *Holochilus brasiliensis*. The IUCN red list of threatened species. https://www.iucnredlist.org/species/10217/115095907

Wilkins, K. T. (1989). *Tadarida brasiliensis*. *Mammalian Species*, *331*, 1–10. https://doi.org/10.2307/3504148

Wilman, H., Belmaker, J., Simpson, J., C., de la Rosa, C., Rivadeneira, M. M., & Jetz, W. (2014). EltonTraits 1.0: Species-level foraging attributes of the world's birds and mammals. *Ecology*, *95*(7), 2027. https://doi.org/10.1890/13-1917.1

Wilson, D. E., & Ruff, S. (1999). *The Smithsonian book of North American mammals*. Smithsonian Institution Press.

Woods, C. A., Contreras, L., Willner-Chapman, G., & Whidden, H. P. (1992). *Myocastor coypus*. *Mammalian Species*, *398*, 1–8. https://doi.org/10.2307/3504182

Xavier, G. A. A., de Miranda Mourão, G., Costa, J. F., & de Moraes-Barros, N. (2015). Avaliação do risco de extinção de *Bradypus variegatus* Schinz, 1825 no Brasil. In *Avaliação do risco de extinção dos Xenartros Brasileros* (pp. 35–51). Instituto Chico Mendes de Conservação da Biodiversidade.

Ximenez, A. (1975). *Felis geoffroyi*. *Mammalian Species*, *54*, 1–4. https://doi.org/10.2307/3504071

Yesquen, F. (2018). *Muerte de vertebrados por atropello en la red vial distrital de Tambo grande*, *Piura* [Bachelor thesis]. Universidad Nacional de Piura.

Zanzini, A. C. S., Machado, F. S., de Oliveira, J. E., & de Oliveira, E. C. M. (2018). Roadkills of medium and large-sized mammals on highway BR-242, midwest Brazil: A proposal of new indexes for evaluating animal roadkill rates. *Oecologia Australis*, *22*(3), 248–257. https://doi.org/10.4257/oeco.2018.2203.04