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Abstract:	<p>Approximately 65% of primate species are facing extinction, with threats including the impacts of linear infrastructures such as roads, railways and powerlines, associated with habitat loss and fragmentation, direct and indirect mortality, and changes in animal behavioural patterns. Nevertheless, this is an often-overlooked topic in Primatology, and there is limited information on which regions and species are most affected by linear infrastructures. Here, we provide a global assessment of priority areas and primate species for conservation by integrating information from global-scale open-access datasets on the distributional ranges, traits, and threats to primate species and linear infrastructures, together with a systematic literature review and a questionnaire sent to Primatological Societies. We produced a bivariate map that reflects the patterns of co-occurrence of the Conservation Value and Infrastructure density. From this map we highlight Primate Mitigation Areas (regions with high Primate Conservation Value and Infrastructure density), which are areas where infrastructure mitigation should be prioritized; and the Primate Preservation Areas (regions with high Primate Conservation Value and low Infrastructure Density), which represent areas that should be preserved from further infrastructure development. Primate Mitigation Areas primarily include the Atlantic forest of Brazil, the Guinean Forests of West Africa and most of South-eastern Asia, whereas Primate Preservation Areas are found principally in the Amazon and Congo river basins. Our assessment also produced a list of priority species affected by infrastructures, with the great apes and gibbons ranking highest. Global infrastructure projects, and especially the Belt and Road Initiative, can seriously</p>	

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No Planet for Apes? Assessing global priority areas and species affected by linear infrastructures

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Abstract

Approximately 65% of primate species are facing extinction, with threats including the impacts of linear infrastructures such as roads, railways and powerlines, associated with habitat loss and fragmentation, direct and indirect mortality, and changes in animal behavioural patterns. Nevertheless, this is an often-overlooked topic in Primatology, and there is limited information on which regions and species are most affected by linear infrastructures. Here, we provide a global assessment of priority areas and primate species for conservation by integrating information from global-scale open-access datasets on the distributional ranges, traits, and threats to primate species and linear infrastructures, together with a systematic literature review and a questionnaire sent to Primatological Societies. We produced a bivariate map that reflects the patterns of co-occurrence of the Conservation Value and Infrastructure density. From this map we highlight Primate Mitigation Areas (regions with high Primate Conservation Value and Infrastructure density), which are areas where infrastructure mitigation should be prioritized; and the Primate Preservation Areas (regions with high Primate Conservation Value and low Infrastructure Density), which represent areas that should be preserved from further infrastructure development. Primate Mitigation Areas primarily include the Atlantic forest of Brazil, the Guinean Forests of West Africa and most of South-eastern Asia, whereas Primate Preservation Areas are found principally in the Amazon and Congo river basins. Our assessment also produced a list of priority species affected by infrastructures, with the great apes and gibbons ranking highest. Global infrastructure projects, and especially the Belt and Road Initiative, can seriously affect both priority areas (particularly Preservation Areas) and the most vulnerable species, due to the massive sprawl of linear infrastructures and associated human activity. Thus, we call for dedicated Strategic Environmental and Social Assessments throughout these different economic corridors within the BRI planning process, prior to developing the different

27 projects. Our assessment can serve as a tool to coordinate management actions and legislation around
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30 **Keywords:** Primates; Transportation infrastructures, Habitat loss and Fragmentation, Behavioural
31 changes, Belt and Road Initiative.

Introduction

Unsustainable human activities are the main driver negatively impacting global biodiversity, in particular non-human primates (hereafter primates), the majority of which are threatened with extinction (65% of species) or show marked population decline (75% of species) (Estrada et al. 2017, Carvalho et al. 2019). In general, the expansion of agriculture and (illegal) logging are the main threats, followed by livestock farming and ranching in the Central and South America, and hunting and trapping for bushmeat and illegal trade in mainland Africa, Madagascar and Asia (Estrada et al. 2017, Galán- Acedo et al. 2019). However, transportation infrastructures such as roads, railroads, powerlines, pipelines and artificial water channels, are also important and often overlooked drivers of the current biodiversity crisis (Laurance and Balmford 2013, Maxwell et al. 2016). The IUCN indicates that transportation infrastructures directly impact some 18% of primate species (92 of 512), but this number is likely to be highly underestimated as all human-related threats to primates are associated with linear infrastructure expansion (Arcus Foundation 2018). For example, agriculture expansion is intrinsically related to transportation and energy infrastructures (Hess et al. 2013, Maxwell et al. 2016), and deforestation in tropical forests mainly occurs near roads (Laurance et al. 2009, Barber et al. 2014, Ali et al. 2015).

Linear infrastructures impact primates directly in different ways. Many primate species exploit home ranges that extend beyond the borders of protected areas or travel between protected areas, and thus encounter linear infrastructures in their pathway (Estrada et al. 2017, Moraes et al. 2018). In particular, arboreal species may have serious difficulties in crossing vegetation gaps caused by infrastructures, limiting their access to resources such as food and mating partners, and restructuring populations into smaller and often unviable populations (Grativol et al. 2001, Ascensão et al. 2019, Linden et al. 2020). Some species may avoid infrastructures due to disturbance such as traffic noise and increased human activity (Duarte et al. 2011), thus intensifying this barrier effect (Hickey et al. 2013, Clauzel et al. 2015). In addition, roads, railways and powerlines kill numerous animals due to collisions and electrocution, further depleting populations (Borda-de-Água et al. 2017, Katsis et al. 2018, Hetman et al. 2019, Cunneyworth and Duke 2020). Transportation infrastructures

also make hitherto isolated areas accessible to humans (Tablado and D’Amico 2017), increasing illegal and exploitative activities such as poaching and facilitating the spread of diseases (Suárez et al. 2013).

Linear infrastructures bring a series of threats to the conservation of wild primates that must be incorporated into landscape management plans. Moreover, the future impacts of the ongoing global expansion of infrastructure networks will be even more severe as an additional 25 million km of roads and railways are expected to be completed by 2050, 90% of which are in developing countries (Dulac 2013), namely in tropical regions that sustain exceptional biodiversity and vital ecosystem services (Laurance et al. 2001, 2015, Alamgir et al. 2017, Meijer et al. 2018). This massive infrastructure growth calls for a global assessment to identify those regions that are most likely to impact already threatened primate taxa, and to highlight areas of conflict between conservation and human development, as well as priority areas for preservation (i.e., regions currently lacking linear infrastructures). Likewise, it is important to identify species that are most at risk from transportation infrastructure impacts, to mitigate the impacts of the most problematic infrastructures and to provide landscape conditions, such as corridors that connect fragmented habitats and isolated populations, to ensure the long-term persistence of primates and their ecosystems.

Global assessments require integration of the knowledge and opinions of experts and conservation practitioners working in different primate regions and studying different primate species. However, relatively few studies have focused on the impacts of infrastructures on primates (Bezanson and McNamara 2019, Junker et al. 2020). Moreover, research on primate conservation has tended to focus on a limited number of taxa, such as chimpanzees (*Pan troglodytes*), macaques (*Macaca* sp.), howlers (*Alouatta* sp.), and capuchins (*Cebus/Sapajus* sp.), field sites, and protected areas, which tend to have lower densities of infrastructures, thus leaving out a vast proportion of primate range areas and species (Bezanson and McNamara 2019).

Here, we propose a framework for, and provide a global assessment of, the risk of infrastructures to primate survival, integrating information from published scientific studies and expert knowledge with current information on the spatial distribution of primate species, their conservation status, and spatial information on the location of infrastructures. This assessment

provides a basis for the proactive zoning of priority management areas for current and future primate conservation. While our focus is on primates, this framework is useful for any taxonomically defined research.

Methods

Species and infrastructure information

We restricted our assessment to the 475 species of primates evaluated by IUCN (>90% of known species), and used the IUCN spatial information on each species range (IUCN 2019). We follow Estrada et al.'s. (2017) classification of four regions of primate occurrence, including the Neotropics (Central and South America), mainland Africa, Madagascar, and Asia. We retrieved information on linear infrastructures (roads, railroads, powerlines, pipelines and water channels) from OpenStreetMap (OSM; www.openstreetmap.org) using a customized R script and the R package 'osmdata' (Padgham et al. 2017). To determine infrastructure density, we obtained data from OSM of all infrastructure spatial lines for each 50 km x 50 km grid inside primate range regions, reprojected them to an equal-area projection, and summed the total length of all linear infrastructures. We then downscaled this information to a higher resolution of 10 km x 10 km, averaging the length values by using a moving window of 10 km radius to match the resolution of each species range.

Literature review

To better understand which infrastructure-related impacts have been examined by field researchers, we searched for publications focusing on primates and the main impacts associated with linear infrastructures: direct killing (e.g. roadkill, electrocution), indirect killing (e.g. poaching), habitat loss and fragmentation (including barrier effects), behavioural changes (e.g. foraging along roads), and chemical pollution (Forman and Alexander 1998, Forman et al. 2003, Van der Ree et al. 2015, Borda-de-Água et al. 2017, Biasotto and Kindel 2018). We used the ISI Web of Science (www.webofknowledge.com) to search for articles, notes and letters appearing in ecology-related

journals, specifically in the categories *Biodiversity Conservation*, *Ecology*, *Environmental Sciences* and *Zoology*. We considered only the Science Citation Index Expanded (SCI-EXPANDED) for 1900-present. We performed five searches, each focusing on a different main infrastructure-related impact (searches performed on December 2020). Each search used the common terms: “(primate* OR lemur* OR galago* OR lorisd* OR tarsier* OR monkey* OR ape* OR simian*) AND (road* OR highway* OR motorway* OR railway* OR railroad* OR rail* OR powerline* OR power-line* OR “power line*” OR canal* OR drain* OR pipeline*)”, and the following specific terms for each impact (in bold): **Direct mortality**: common terms together with “(roadkill* OR road-kill* OR “road kill*” OR collision* OR electrocution* OR drowning*)”. **Indirect mortality**: common terms together with “(poaching* OR trade* OR hunting* or bushmeat*)”. **Fragmentation**: common together with “(fragmentation OR avoidance OR ‘barrier effect’ OR ‘connectivity reduction’ OR movement* OR dispersal OR ‘home-range*’ OR ‘home range*’)”. **Behaviour change**: common terms together with “(behaviour* OR behaviour* OR alert* OR disturbance* OR stress* OR ‘flight initiation distance’ OR facilitation* OR attraction* OR habituation* OR foraging* OR ‘ecological trap’)”. **Pollution**: common terms together with “(pollution* OR pollutant* OR contaminant*)”. Our searches yielded 21 publications for Direct mortality, 37 for Indirect mortality, 87 for Fragmentation, 121 for Behaviour change and 32 for Pollution. Seventy-four publications were ultimately eligible for information collection i.e., included information on infrastructure impacts, target species/taxa and country (or countries) of study area.

Questionnaire to primatologists

We collected information from researchers and conservation practitioners working with primates through an online survey using Google Forms (available in <https://forms.gle/gytJHz84rDAaeYBo6>). In our questionnaire, we asked if the researcher works (or worked) with primates (Q1); and, if so, we asked the researcher to rank the severity of the five impacts associated with linear infrastructures, based on her/his experience and perceptions (Q2); which taxa are more vulnerable to those impacts (Q3); in which countries (up to five) is urgent action needed to improve primate conservation in

response to the threats of linear infrastructures (Q4); and how much more important than Least concern (LC) are the IUCN conservation categories Critically endangered (CR), Endangered (EN), Vulnerable (VU), Near threatened (NT), Data deficient (DD), and Not evaluated (NE) (Q5). Scores ranged 1 (the value given for LC) meaning no difference to LC, to 10, i.e., considered to be a 10 times higher priority than LC species. We introduced the form with the text “The purpose of this questionnaire is to understand where the different Primate experts are developing their research throughout the world, and how they perceive linear infrastructures as a threat for conservation. By linear infrastructures we mean roads, railroads, power lines, water channels (human made) and pipelines”. We distributed the form was across the main primatological societies throughout the world (see Acknowledgments for a complete list). We assumed that people from these societies would be the most experienced researchers and conservation practitioners, and thus have the most detailed and up-to-date knowledge of the impacts of linear infrastructures on primate species and their habitats.

Detecting priority areas for management

We calculated the median scores obtained in the online survey about the IUCN conservation categories (Q5) to obtain a relative weight of the categories CR, EN, VU, NT, DD and NE compared to LC. We rasterized each species’ distribution range using the same extent and resolution we used for infrastructure density information (10 km x 10 km), and assigned the species was the corresponding median score of its IUCN category. We summed all species’ layers to obtain a Conservation Value layer, which represents how the different species are globally distributed, weighted by their conservation status score. We then overlaid this layer with information on infrastructure density, which we used to create a bivariate map that reflects the co-occurrence of the Conservation Value and Infrastructure density information. From this map we selected areas with both high Conservation Value and high Infrastructure Density and named these Priority Mitigation Areas. We named areas with both high Conservation Value and low Infrastructure Density, Priority Preservation Areas. We based low thresholds on the 20% percentiles and high thresholds on 80 % percentiles of the

intersected layers. For example, Priority Mitigation Areas have both a conservation value and an infrastructure density greater than the 80% percentile of their respective layer.

Finally, for each country, we summed all of the 10 km x10 km cells classified as either Priority Mitigation Areas or Priority Preservation Areas. This allowed us to rank each country according to the amount of priority areas for conservation management. We compared this ranking with the one obtained from expert knowledge from Q4 (“in which countries it is more urgent to improve primate conservation regarding the threats due to linear infrastructures?”). We gave each expert a score of 1, which we divided by the number of countries named in the reply. The rationale was that experts naming only one country were likely to perceive that country as the top management priority, whereas experts naming two or more countries would disperse management actions across those countries.

Specific risk to transportation infrastructures’ impacts

We considered that the species-specific risk of being impacted by infrastructures results from the interaction between the species’ vulnerability to infrastructures and their exposure to infrastructures within their distribution range (e.g. Visintin et al. 2016, D’Amico et al. 2019). As limited data exist on species’ vulnerability, we used the replies from experts to our online survey, specifically to question Q3 (“which species/taxa are more vulnerable to [infrastructure] impacts?”). As before, we assigned one point for each expert, divided by all species mentioned in her/his reply. For example, if the answer was “apes”, we divided 1 by all species of the families Hylobatidae and Hominidae. To avoid overrepresentation of experts for a given region, we bootstrapped the replies, sampling 85% of replies in each replicate (total = 100 replicates). To obtain the vulnerability score per species, we used the median and the 20% and 80% percentiles as confidence intervals from the replicates. To obtain the exposure value, we calculated the median of infrastructure density inside the distributional range of each species. By overlaying the two information sources, we derived the potential risk from infrastructures for each species, in a manner identical to the way we calculated the spatial biplot. This

enabled us to identify those taxa that simultaneously showed high/low exposure and high/low vulnerability to infrastructures.

Results

Literature review

Of the total number of publications retained for analyses (n=74), most focused on fragmentation impacts (42, 57%), followed by behavioural impacts (28, 36%), indirect mortality (21, 28%) and direct mortality (14, 19%). One third of studies (n = 26) focused on more than one of the main impacts, while pollution was not treated in any publication. As for the number of species mentioned in the publications, from a total of 96 species studied, about half studied the impact of fragmentation (59, 61%) and indirect mortality (52, 54%), followed by changes in behaviour (40, 42%) and direct mortality (18, 19%). These studies were conducted in 26 countries (28% of countries known to host primates), of which 12 studies were conducted in Brazil, 6 in Madagascar and 6 in Gabon (Supplementary material S1).

Questionnaire to primatologists

We obtained 112 validated replies from primatologists (i.e., responders work or had worked with primates) from across the world. Respondents ranked habitat loss and fragmentation highest, with a median rank of 5 (20-80% percentiles: 4-5), followed by indirect mortality, direct mortality and behavioural change, all with a median rank of 3 (2-4), and pollution with a median rank of 1 (1-3).

Respondents generally agreed that species with categories of greatest conservation concern (IUCN) should be prioritized in conservation actions to minimize the impacts of linear infrastructures. Median values were 7 for CR (20-80% percentiles 3-10), 7 for EN (2-9), 5 for VU (2-8), 4 for NT (1-7), 4 for DD (1-7) and 3 for NE (1-7). These scores resulted in a Conservation Value map that highlights Central America, the Amazon basin and Atlantic forest (Neotropics), the Guinean Forests of West Africa and the Congo basin (mainland Africa), coastal areas of Madagascar, southwestern

India, Sri Lanka, and the region between south China and Indonesia (Asia), as hotspots of conservation concern (Fig. 1A).

Fig.1 – Prioritizing management areas with regard to the impacts of linear infrastructures in primates. A map of Primate Conservation Value (A) overlayed with one of infrastructure density (B), resulting in a map relating the two layers of information (C). Priority areas for mitigation are shown in redder colours, areas where new infrastructures should be avoided in greener colours, and areas that already have a high density of infrastructures in the primate global distribution are in yellower colours. In the legend, values of the Conservation Value and Infrastructure density layers are each divided into demi-deciles, yielding 25 unique colour combinations.

Researchers ranked countries known to host high primate species richness such as Brazil, Indonesia, the Democratic Republic of the Congo and Madagascar as experiencing the greatest threats from linear infrastructures. India, Malaysia, Mexico, and the Republic of the Congo were also considered at high risk due to linear infrastructures (Fig. 2).

Fig.2 – Country prioritization (top 25) to improve primate conservation based on threats due to linear infrastructures. Prioritization was based on expert knowledge and perceptions (left side, brown bars); and by summing areas classified as Priority areas for Mitigation (red bars) and Priority areas for Preservation (green bars) per country (right side green/red bars), corresponding to the red and green areas shown in the inset map.

Priority areas for management

Overlaying Conservation Value and Infrastructure density (Fig.1B), resulted in the Assessment map (Fig.1C). From this Assessment map we derived Priority Areas for Mitigation (redder colours) and Priority Areas for Preservation (greener colours) (Fig.2, Supplementary material S2). Ranking countries based on the amount of area occupied by each Priority category provided a slightly different order of countries. Brazil again appeared as the top priority country, both in terms of a larger area to address Mitigation actions, and a larger amount of land devoid of infrastructures (Fig. 2). However, Thailand emerged as the second highest priority country in terms of mitigating existing infrastructures, followed by Indonesia and China. The Democratic Republic of the Congo, and to a lesser extent, Colombia and Indonesia emerged as priority countries for the Preservation of their vast

areas with a minimal density of infrastructure and with high conservation value for primates (Fig. 1C).

Specific risk of the impact of transportation infrastructures

The expert-based score of species' Vulnerability to infrastructures ranked all species of the families Hominidae (great apes) and Hylobatidae (gibbons) in the top semi-decile, as well a high proportion (25%) of cercopithecoid species (Fig. 3, Supplementary material S3). Thirty-one other species from the families Atelidae (howler, spider, woolly and woolly spider monkeys), Callitrichidae (marmosets, callimicos, and tamarins), Cebidae (capuchin and squirrel monkeys) and Galagidae (galagos) were also classified in the top semi-decile of Vulnerability (Fig. 3, rightmost dots in each panel). The Bornean orangutan (*P. pygmaeus*), Tapanuli orangutan (*P. tapanuliensis*), and Sumatran orangutan (*Pongo abelii*), were the top ranked species, with highest Vulnerability (Fig S3.1). We identified 32 species classified as highly Vulnerable to infrastructure effects inhabiting areas of high Exposure to infrastructures (i.e., the infrastructure density inside their range area is in the top semi-decile; Fig. 3, top-right dots in each panel). Half of these species are from the Cercopithecidae (n=14 species), followed by Callitrichidae (n=9), Hylobatidae (n=5), Atelidae (n=2), Cebidae (n=1) and Hominidae (n=1). Species in these families should be considered top priority for research on how to mitigate the effects of infrastructures on species survivorship.

Five species of Atelidae, including the Juruá red howler (*Alouatta juara*), Guianan red howler (*Alouatta macconnelli*), Amazon black howler (*Alouatta nigerrima*), Purús red howler (*Alouatta puruensis*) and black spider monkey (*Ateles chamek*) were classified as being highly vulnerable to infrastructures, while inhabiting low infrastructure density areas, i.e., in the 1st semi-decile of Exposure (Fig.3 Atelidae panel, bottom-right dots). Ten other species were classified in the top semi-decile of Vulnerability and in the 2nd semi-decile of Exposure, i.e., despite their recognized high Vulnerability, they inhabit areas characterized by a relatively low density of infrastructures. This latter group comprises Eastern gorillas (*Gorilla beringei*), Western gorillas (*G. gorilla*), Eastern hoolock gibbons (*Hoolock leuconedy*), Kloss's gibbons (*Hylobates klossii*), Superagüi lion tamarins

(*Leontopithecus caissara*), Pagai Island macaques (*Macaca pagensis*), Siberut macaques (*M. siberu*), Spix's howlers (*Alouatta discolor*), bonobos (*Pan paniscus*) and Myanmar snub-nosed monkeys (*Rhinopithecus strykeri*) (Supplementary material S3). Together with the five Atelidae, these taxa should be considered as species for preservation. A high number of Cheirogaleidae (dwarf, mouse and fork-marked lemurs) were classified as having lower Vulnerability to infrastructure impacts (90% of the species in this family; Supplementary material S3), the majority of which inhabit areas that contain a high density of infrastructures in the southern coastal areas of Madagascar, such as the Critically Endangered Nosy Be mouse lemur (*Microcebus manitatra*).

Fig.3 – The position and colour of each point represents a combination of semi-deciles of species' Vulnerability (x-axis) and Exposure to linear infrastructure density (y-axis). Vulnerability values are the medians after bootstrapping responses to a questionnaire (100 replicates). Redder colours are species currently facing high Vulnerability and Exposure to linear infrastructures. Greener colours represent species with high Vulnerability, but lower Exposure to linear infrastructures. The size of each dot represents the richness of species of each family in that combination of Vulnerability/Exposure. Shaded areas show the risk 'space' occupied by each taxon of a given family. For example, all seven Hominidae were classified as highly Vulnerable to infrastructure impacts, one of which (Tapanuli orangutan *Pongo tapanuliensis*) inhabits a region classified in the top semi-decile of infrastructure density (top-right red dot in Hominidae panel).

Discussion

Linear infrastructures have a major impact on habitat loss and fragmentation, and this was supported by our literature review and expert perceptions. In the past two decades, nearly 200 million ha of tropical forest have been lost in primate range regions, with Brazil, Indonesia, Democratic Republic of the Congo, China, and Malaysia accounting for half of these losses (Malhi et al. 2014, Estrada et al. 2020). Furthermore, both expert knowledge and the published literature reveal that mortality and behavioural changes associated with infrastructures severely impact primate species. This is consistent with studies showing that transportation infrastructures and related land use conversion, particularly for agriculture and cattle pastures, are a major driver of habitat destruction, particularly in tropical regions. These infrastructures are associated with increased rates of deforestation, human-induced fires, and illegal hunting and mining activities (Laurance et al. 2001, 2002, 2006, 2009, Barber et al. 2014, Kleinschroth et al. 2019). For example, roads make hitherto pristine areas accessible, increasing illegal hunting for bushmeat and the illegal trade of primates as pets and for traditional medicine (Suárez et al. 2013, Estrada et al. 2017, 2020). Likewise, many primate species avoid roads and other infrastructures, for example, the greater spot-nosed monkey (*Cercopithecus nictitans*) (Lahm et al. 1998), western gorilla (*Gorilla gorilla*) (Vanthomme et al. 2013), and Yunnan snub-nosed monkey (*Rhinopithecus bieti*) (Zhao et al. 2019), further decreasing the available habitat. Hence, infrastructures also constrain the movement of individuals between subpopulations and fragmented landscapes.

The impacts of infrastructures on species and habitats should be integrated into management and conservation planning (Arcus Foundation 2018), and it is thus essential to empirically identify areas where urgent mitigation of existing infrastructures is required, and areas where future infrastructure construction should not be permitted. Here, we provide a global assessment highlighting priority areas for management and identify the set of primate species at greatest risk of being impacted by linear infrastructures. We distinguished between Priority Mitigation Areas (areas with both high conservation value and high infrastructure density) and Priority Preservation Areas (areas with high conservation value but low infrastructures density). Our assessment highlights the priority

areas in which management and planning should be considered first. However, areas outside the priority areas also must be integrated into mitigation actions and planning programs, and not considered as areas where the expansion of infrastructure is free from environmental damage.

Priority Mitigation and Preservation Areas generally corresponded to regions known to host high primate richness, namely the basins of the Amazon and Congo rivers, together with Indonesia and Madagascar. These areas were also highlighted by experts. However, several other countries were highlighted in our assessment that did not coincide with the ranking resulting from the responses provided by primate researchers. Brazil is undoubtedly a top priority, highlighted in both procedures, containing the large priority areas for both Mitigation and Preservation. The Atlantic forest of Brazil is a critically impacted ecosystem where mitigation of infrastructures is urgently needed. This threatened biome has faced a marked decline over the past 500 years, with less than 10% of the original forest remaining (Ribeiro et al. 2009, de Lima et al. 2020). Brazil also hosts the largest Priority Preservation Areas, namely the Amazon basin (also covering Peru, Colombia, Bolivia, Venezuela and Suriname), where immediate actions to protect this rich primate community from increasing exposure to linear infrastructures are needed. The Democratic Republic of the Congo and Indonesia were highly ranked in our assessment, the former for its large amount of Priority Mitigation Areas, and the latter for hosting both Priority areas for Mitigation (Sumatra, Java and Borneo) and Preservation (principally Borneo). Our assessment also highlighted the Guinean Forests of West Africa, including Ivory Coast (although ranked 25th by the experts), Nigeria, and Guinea as top priority for Mitigation; together with the Asian countries of Thailand, Myanmar, China, Vietnam, India and Malaysia. As priority areas for Preservation, we highlight some of the regions in Gabon, Republic of the Congo, Central African Republic, Cameroon and Madagascar, in Africa, and Myanmar in Asia.

Unsurprisingly, the most threatened primate species are those inhabiting priority areas for conservation. Several species of Brazil's Atlantic Forest are in danger of extinction, many of which are threatened by transportation infrastructures. However, the infrastructure networks in this region continue to expand. For example, our assessment classified the golden lion tamarin (*Leontopithecus rosalia*), which is endemic to the Atlantic forest (Ascensão et al. 2019), as having the highest

Vulnerability to infrastructures, and inhabiting an area in the top semi-decile of infrastructure density. Likewise, orangutans from the Sundaland region are highly threatened by infrastructure expansion. The Tapanuli orangutan is a recently described species, with less than 800 animals living in a small and fragmented forest area, and therefore immediately considered to be among the most endangered great apes (Nater et al. 2017). There is great concern that the Batang Toru hydroelectric project will extirpate the last remaining population of this ape species, as the project will flood the orangutan habitat, and new infrastructure including roads and powerlines will divide the remaining forest up and increase human presence in the orangutan's territory (Sloan et al. 2018). Furthermore, the area also is home to six other primate species including the Endangered siamang (*Symphalangus syndactylus*) and the Endangered agile gibbon (*H. agilis*) (Fig.S3.1). Our assessment further identified several species from the family Cercopithecidae as being in the top semi-deciles of Vulnerability and Exposure, which should be the focus of conservation actions. Small-bodied *Cercopithecus* monkeys with restricted distributions, specialized habitat requirements, and species-specific dietary preferences are the most threatened, particularly in the Upper Guinea refugium of West Africa (Ukizintambara and Thébaud 2004).

Species currently not considered as being at immediate conservation concern by the IUCN, are currently highly exposed to infrastructures. The bonnet macaque (*Macaca radiata*) was recently reassessed by the IUCN, changing its category from Least Concern to Vulnerable given their recent dramatic population decline, with road expansion listed as one of the causes identified (Singh 2019). It is possible that other primates are currently under serious pressure from the impacts of transportation infrastructure, and therefore their conservation category should be reviewed. Species classified in the first semi-decile of Vulnerability to infrastructures (highlighted in yellow in Fig. 3) are not non-vulnerable, but are considered to have relatively lower Vulnerability. These species are still likely to face serious impacts from new infrastructures.

Our assessment has highlighted several regions that are currently facing an unprecedented and massive development of linear infrastructures under China's Belt and Road Initiative. With a projected expenditure of 1 trillion dollars, the Belt and Road Initiative will further expose biodiversity to high pressure from direct and indirect infrastructure (Laurance et al. 2015, Ascensão et al. 2018,

Farhadinia et al. 2019, Ascensão 2020, Ng et al. 2020). For example, mega-dams are being built in the world's most biodiverse river basins, the Amazon, Congo and Mekong (Winemiller et al. 2016). These dams will require additional linear infrastructures such as roads and powerlines, and temporary or permanent housing, that will further fragment each region, increasing deforestation and pressure from expanding human settlements. In Africa, infrastructure development corridors include the Lamu Port, South Sudan, Ethiopia Transport, which threatens to cut across mainland Africa from the coast of Kenya through the Congo basin; the Central African Iron Ore Corridor, which will cross the Republic of Congo, Cameroon and Gabon with road, rail and hydropower components; and the Simandou Iron Ore Project in south-eastern Guinea (Arcus Foundation 2018).

In addition to diamonds, gold, oil, and natural gas, Africa has vast unexplored deposits of minerals including uranium, iron ore, aluminium, coal, manganese (used in steel making), cobalt, coltan (used production of cell phones and tablets), copper and phosphates, among others (Taylor et al. 2009, African Natural Resources Center 2016). The Belt and Road Initiative aims to extract these mineral deposits, and is likely to represent a major threat to the environment and biodiversity in general (including primates), and to local people. As an example, the Simandou region integrates the Guinean Forests of West Africa and sits on 2bn tonnes of the highest-grade iron ore, indispensable for Chinese industrial and development ambitions. It is not just mining activities that will threaten this unique habitat. The development project is expected to result in the construction of several infrastructures, including a 650 km railway from the iron mines to a deep-water port, which will fragment and deplete intact habitats for primates.

The Belt and Road Initiative plans and programs (and those of other similar initiatives) should be carefully examined through Strategic Environmental and Social Assessments by researchers and international organizations to ensure that the potential negative impacts are avoided or mitigated, and the positive aspects are strengthened. However, a major problem with Belt and Road Initiative is the lack of open and accessible information on infrastructure planning , which makes it difficult to assess the social and ecological impacts of this initiative in an integrated and comprehensive way, instead of project by project. The availability of information on the projects, namely the corridors where future infrastructures are being planned, would allow better assessment and scrutiny of their cost and

benefits for human development and possible impacts on biodiversity. New infrastructure development plans or projects proposed for the Belt and Road Initiative or similar programs, should adopt our framework in their preliminary assessments, highlighting where the main impacts may occur, and which species may be affected. However, given the relatively coarse resolution of the data we present in our study, a local scale assessment may also be required, integrating more detailed information on species occurrence and movement, land cover and infrastructures.

For most Priority Mitigation Areas, a primary management action should be halting habitat loss and environmental degradation processes to reconnect habitat fragments. For example, canopy bridges are effective in reducing roadkill and improving landscape connectivity for arboreal primates, such as the South African samango monkey (*Cercopithecus albogularis*) (Linden et al. 2020) or the Javan slow loris (*Nycticebus javanicus*) (Birot et al. 2020). In contrast, for Priority Preservation Areas (areas with high conservation value and low infrastructure density), the primary goal is to avoid the ‘first-cut’ of the forest, as it will inevitably bring a panoply of human (legal and illegal) activities, which in most cases are detrimental to primates and their habitat (Laurance and Arrea 2017). Likewise, the creation and maintenance of ecological corridors across high quality habitat areas (often forest patches), must be an essential component of all conservation planning. There is a lack of primate behavioural and ecological studies conducted outside of protected areas, with 70% of field sites occurring inside protected areas (Bezanson and McNamara 2019). This may undermine our ability to delimit and manage ecological corridors connecting protected areas.

Maintaining the existing Preservation Areas and creating ecological corridors that link fragmented habitats and primate populations are imperative in areas where massive infrastructure development is expected. The top 25 countries with established Priority Preservation Areas are expected to expand their road networks by over 1.2 million km (predictions range 0.8-1.6 million km) (Meijer et al. 2018). Important countries for primate conservation will add 275,000-434,000 km of new roads, including an 80% increase in the Democratic Republic of the Congo and a 33% increase in Indonesia (Meijer et al. 2018).

Limitations of the assessment

Our assessment should be regarded as an initial evaluation of the extent, distribution, and location of priority areas for primate conservation (both Mitigation and Preservation). Limitations in our framework that should be considered in future investigations include:

- i) Only 20% of the primate species evaluated in our systematic review have been the subject of field studies. However, a recent comprehensive review (Bezanson & McNamara 2019), found that less than 50% of currently recognized primate species have been studied in the wild. Therefore, as our study is focused on the impacts of linear infrastructures, we think that we identified most studies.
- ii) Some primates are more behaviourally and ecologically resilient than others when faced with infrastructure-related impacts. Hence, some species are likely to cope with at least some of the negative impacts of roads and other linear infrastructures, and therefore the overall effect for more synanthropic species is probably lower relative to the other species (Corrêa et al. 2018, Waterman et al. 2020). However, even species highly adapted to urban environments can be impacted by linear infrastructures, as for example the black howler (*Alouatta caraya*) which is common in urban environments but also frequently affected by electrical hazards (Lokschin et al. 2007). Urban environments are unlikely to be a sustainable option for most arboreal primate species.
- iii) Infrastructure mapping in poorer countries is incomplete, and therefore Preservation Areas, such as the Congo basin, may actually have more linear infrastructures, namely roads, than those obtained through Open Street Maps. Despite an overall coverage of over 80% of all roads in the world, the Democratic Republic of Congo has less than 40% of mapping completeness (Barrington-Leigh and Millard-Ball 2017). Moreover, the road density within the Congo basin is expanding rapidly due to logging activities (Kleinschroth et al. 2019).

Conclusions

The impact of linear infrastructures on biodiversity, and in particular on threatened primates, is not yet well understood. However, given the ongoing massive expansion of roads, powerlines and other linear infrastructures, it is important to identify priority areas for conservation, for both mitigation and for preservation. Here we highlight Brazil, Thailand, Indonesia, China, the Democratic Republic of the Congo and Colombia as key countries where primate conservation and strategies to mitigate infrastructure expansion must be promoted. Similarly, we highlight the families Hominidae and Hylobatidae, as well as a high proportion of the Cercopithecidae as priority taxa, for which mitigation actions are imperative. This assessment, while having limitations, can serve as a tool to coordinate management actions and legislation around the world. This may be particularly relevant for countries involved in China's Belt and Road Initiative, where a large number of new infrastructures are being built or planned, many of which bisect important areas for primate conservation.

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Supplementary material

S1 – Publications focusing on primates and linear infrastructures

Figure S1.1 – Number of studies (total=73) retrieved from ISI WEB OF KNOWLEDGE focusing on the impact of infrastructures on primates, per country. Colour gradient indicates primate richness.

S2 – Priority areas for conservation

Overlaying Conservation Value (Fig.1A) and Infrastructure density (Fig.1B), resulted in the Assessment map in Fig.1C, where each unique colour (n=25) is a combination of the semi-deciles of the two layers. From this Assessment map we derived Priority areas for Mitigation (redder colours) and Priority areas for Preservation (greener colours) (Fig. S2.1).

Figure S2.1 – Priority areas for management: in green are priority areas for Preservation; in red are priority areas for Mitigation.

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684 Figure S3.1 – Rank of the top 40 species classified as having higher vulnerability to infrastructure
685 impacts. Bars indicate the median score after bootstrapping 85% of expert replies with 100 replicates.
686 Lines indicate the 20% and 80% percentile of the bootstrapping. The full rank in in Table S3.1.

687 Table S3.1 – Summary of Species Exposure and Vulnerability to infrastructure impacts. Median score obtained after bootstrapping 85% of expert replies with
688 100 replicates. Species sorted by score.

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Hominidae	<i>Pongo pygmaeus</i>	Asia	0.102	3.793	3.132	4.066	3	5
Hominidae	<i>Pongo abelii</i>	Asia	0.098	1.958	1.753	2.157	3	5
Hominidae	<i>Pongo tapanuliensis</i>	Asia	0.319	1.958	1.753	2.157	5	5
Hominidae	<i>Gorilla beringei</i>	Mainland Africa	0.021	1.425	1.300	1.574	2	5
Hominidae	<i>Gorilla gorilla</i>	Mainland Africa	0.035	1.423	1.301	1.575	2	5
Hominidae	<i>Pan troglodytes</i>	Mainland Africa	0.054	1.233	1.107	1.376	3	5
Cercopithecidae	<i>Macaca sylvanus</i>	Mainland Africa	0.121	1.277	1.229	1.306	4	5
Hominidae	<i>Pan paniscus</i>	Mainland Africa	0.025	1.103	0.994	1.247	2	5
Callitrichidae	<i>Saguinus bicolor</i>	Neotropics	0.131	1.195	1.150	1.209	4	5
Cebidae	<i>Sapajus flavius</i>	Neotropics	0.708	1.170	1.099	1.182	5	5
Cercopithecidae	<i>Trachypithecus phayrei</i>	Asia	0.201	1.132	1.116	1.143	4	5
Cercopithecidae	<i>Papio kindae</i>	Mainland Africa	0.07	0.539	0.419	0.569	3	5
Cercopithecidae	<i>Papio anubis</i>	Mainland Africa	0.091	0.512	0.406	0.555	3	5
Cercopithecidae	<i>Macaca thibetana</i>	Asia	0.282	0.458	0.425	0.487	5	5
Cercopithecidae	<i>Papio ursinus</i>	Mainland Africa	0.112	0.433	0.381	0.461	4	5
Cercopithecidae	<i>Macaca tonkeana</i>	Asia	0.119	0.417	0.386	0.444	4	5
Callitrichidae	<i>Leontopithecus caissara</i>	Neotropics	0.02	0.410	0.390	0.420	2	5

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Cercopithecidae	<i>Papio hamadryas</i>	Mainland Africa	0.073	0.378	0.332	0.401	3	5
Callitrichidae	<i>Leontopithecus chrysopygus</i>	Neotropics	0.65	0.383	0.366	0.395	5	5
Callitrichidae	<i>Leontopithecus rosalia</i>	Neotropics	0.569	0.383	0.366	0.395	5	5
Cercopithecidae	<i>Semnopithecus dussumieri</i>	Asia	0.422	0.352	0.305	0.380	5	5
Cercopithecidae	<i>Semnopithecus entellus</i>	Asia	0.272	0.352	0.305	0.380	5	5
Atelidae	<i>Alouatta palliata</i>	Neotropics	0.156	0.343	0.311	0.378	4	5
Callitrichidae	<i>Leontopithecus chrysomelas</i>	Neotropics	0.268	0.371	0.354	0.382	5	5
Atelidae	<i>Alouatta belzebul</i>	Neotropics	0.122	0.330	0.298	0.368	4	5
Atelidae	<i>Alouatta guariba</i>	Neotropics	0.638	0.330	0.298	0.368	5	5
Atelidae	<i>Alouatta ululata</i>	Neotropics	0.317	0.325	0.291	0.363	5	5
Atelidae	<i>Alouatta arctoidea</i>	Neotropics	0.133	0.325	0.293	0.364	4	5
Atelidae	<i>Alouatta caraya</i>	Neotropics	0.149	0.325	0.293	0.364	4	5
Atelidae	<i>Alouatta juara</i>	Neotropics	0	0.325	0.293	0.364	1	5
Atelidae	<i>Alouatta macconnelli</i>	Neotropics	0	0.325	0.293	0.364	1	5
Atelidae	<i>Alouatta puruensis</i>	Neotropics	0.005	0.325	0.293	0.364	1	5
Hylobatidae	<i>Symphalangus syndactylus</i>	Asia	0.193	0.328	0.293	0.351	4	5
Cercopithecidae	<i>Papio papio</i>	Mainland Africa	0.196	0.341	0.306	0.365	4	5
Cercopithecidae	<i>Papio cynocephalus</i>	Mainland Africa	0.098	0.342	0.308	0.365	3	5
Atelidae	<i>Alouatta discolor</i>	Neotropics	0.022	0.322	0.290	0.360	2	5
Atelidae	<i>Alouatta pigra</i>	Neotropics	0.132	0.322	0.290	0.360	4	5
Atelidae	<i>Alouatta nigerrima</i>	Neotropics	0.001	0.317	0.287	0.357	1	5
Atelidae	<i>Alouatta sara</i>	Neotropics	0.054	0.317	0.287	0.357	3	5

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Callitrichidae	<i>Callithrix jacchus</i>	Neotropics	0.287	0.332	0.281	0.356	5	5
Callitrichidae	<i>Callithrix penicillata</i>	Neotropics	0.25	0.332	0.281	0.356	5	5
Hylobatidae	<i>Nomascus hainanus</i>	Asia	0.126	0.304	0.275	0.325	4	5
Hylobatidae	<i>Nomascus nasutus</i>	Asia	0.299	0.304	0.275	0.325	5	5
Cercopithecidae	<i>Macaca mulatta</i>	Asia	0.272	0.286	0.252	0.322	5	5
Cercopithecidae	<i>Macaca radiata</i>	Asia	0.556	0.286	0.252	0.322	5	5
Hylobatidae	<i>Hylobates abbotti</i>	Asia	0.16	0.290	0.259	0.313	4	5
Hylobatidae	<i>Hylobates agilis</i>	Asia	0.252	0.290	0.259	0.313	5	5
Hylobatidae	<i>Hylobates albibarbis</i>	Asia	0.104	0.290	0.259	0.313	3	5
Hylobatidae	<i>Hylobates funereus</i>	Asia	0.072	0.290	0.259	0.313	3	5
Hylobatidae	<i>Hylobates klossii</i>	Asia	0.035	0.290	0.259	0.313	2	5
Hylobatidae	<i>Hylobates moloch</i>	Asia	0.723	0.290	0.259	0.313	5	5
Hylobatidae	<i>Hylobates muelleri</i>	Asia	0.105	0.290	0.259	0.313	3	5
Hylobatidae	<i>Hylobates pileatus</i>	Asia	0.147	0.290	0.259	0.313	4	5
Hylobatidae	<i>Hoolock hoolock</i>	Asia	0.173	0.292	0.258	0.312	4	5
Hylobatidae	<i>Hylobates lar</i>	Asia	0.245	0.292	0.258	0.312	5	5
Hylobatidae	<i>Nomascus concolor</i>	Asia	0.14	0.287	0.257	0.307	4	5
Hylobatidae	<i>Nomascus leucogenys</i>	Asia	0.18	0.287	0.257	0.307	4	5
Hylobatidae	<i>Nomascus annamensis</i>	Asia	0.147	0.280	0.251	0.301	4	5
Hylobatidae	<i>Nomascus siki</i>	Asia	0.129	0.280	0.251	0.301	4	5
Cercopithecidae	<i>Trachypithecus geei</i>	Asia	0.32	0.273	0.242	0.291	5	5
Galagidae	<i>Galagoides demidoff</i>	Mainland Africa	0.069	0.302	0.270	0.307	3	5

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Galagidae	<i>Galagoides thomasi</i>	Mainland Africa	0.075	0.302	0.270	0.307	3	5
Callitrichidae	<i>Callithrix kuhlii</i>	Neotropics	0.244	0.281	0.226	0.297	5	5
Hylobatidae	<i>Hoolock leuconedys</i>	Asia	0.035	0.273	0.236	0.294	2	5
Hylobatidae	<i>Hoolock tianxing</i>	Asia	0.19	0.273	0.236	0.294	4	5
Galagidae	<i>Galagoides kumbirensis</i>	Mainland Africa	0.128	0.295	0.262	0.299	4	5
Cercopithecidae	<i>Macaca munzala</i>	Asia	0.179	0.256	0.231	0.282	4	5
Cercopithecidae	<i>Macaca silenus</i>	Asia	0.651	0.255	0.224	0.283	5	5
Cercopithecidae	<i>Macaca nigra</i>	Asia	0.277	0.253	0.231	0.279	5	5
Cercopithecidae	<i>Macaca assamensis</i>	Asia	0.149	0.255	0.223	0.283	4	5
Hylobatidae	<i>Nomascus gabriellae</i>	Asia	0.261	0.262	0.229	0.282	5	5
Cercopithecidae	<i>Macaca arctoides</i>	Asia	0.197	0.250	0.225	0.273	4	5
Cercopithecidae	<i>Semnopithecus hector</i>	Asia	0.608	0.255	0.224	0.269	5	5
Cercopithecidae	<i>Semnopithecus hypoleucos</i>	Asia	0.498	0.255	0.224	0.269	5	5
Cercopithecidae	<i>Semnopithecus ajax</i>	Asia	0.155	0.247	0.218	0.264	4	5
Cercopithecidae	<i>Semnopithecus johnii</i>	Asia	0.847	0.247	0.218	0.264	5	5
Cercopithecidae	<i>Semnopithecus priam</i>	Asia	0.567	0.244	0.213	0.260	5	5
Cercopithecidae	<i>Semnopithecus schistaceus</i>	Asia	0.146	0.244	0.213	0.260	4	5
Cercopithecidae	<i>Macaca fascicularis</i>	Asia	0.223	0.238	0.199	0.261	4	5
Cercopithecidae	<i>Macaca pagensis</i>	Asia	0.035	0.232	0.203	0.249	2	5
Cercopithecidae	<i>Chlorocebus tantalus</i>	Mainland Africa	0.088	0.244	0.122	0.259	3	5
Cercopithecidae	<i>Erythrocebus baumstarki</i>	Mainland Africa	0.247	0.244	0.122	0.259	5	5

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Cercopithecidae	<i>Erythrocebus patas</i>	Mainland Africa	0.078	0.244	0.122	0.259	3	5
Cercopithecidae	<i>Rhinopithecus strykeri</i>	Asia	0.053	0.213	0.193	0.231	2	5
Cercopithecidae	<i>Trachypithecus pileatus</i>	Asia	0.212	0.213	0.196	0.231	4	5
Callitrichidae	<i>Callithrix flaviceps</i>	Neotropics	0.878	0.226	0.190	0.242	5	5
Cercopithecidae	<i>Rhinopithecus avunculus</i>	Asia	0.112	0.206	0.186	0.224	4	5
Callitrichidae	<i>Callithrix aurita</i>	Neotropics	0.785	0.219	0.181	0.232	5	5
Callitrichidae	<i>Callithrix geoffroyi</i>	Neotropics	0.352	0.218	0.180	0.232	5	5
Atelidae	<i>Ateles chamek</i>	Neotropics	0.007	0.212	0.187	0.233	1	5
Cercopithecidae	<i>Macaca sinica</i>	Asia	0.429	0.210	0.178	0.225	5	5
Cercopithecidae	<i>Macaca nigrescens</i>	Asia	0.176	0.207	0.175	0.222	4	5
Cercopithecidae	<i>Macaca siberu</i>	Asia	0.026	0.207	0.175	0.222	2	5
Atelidae	<i>Ateles fusciceps</i>	Neotropics	0.121	0.211	0.181	0.224	4	5
Atelidae	<i>Lagothrix flavicauda</i>	Neotropics	0.087	0.202	0.179	0.221	3	5
Cercopithecidae	<i>Mandrillus sphinx</i>	Mainland Africa	0.05	0.198	0.182	0.220	2	4
Cercopithecidae	<i>Cercopithecus mona</i>	Mainland Africa	0.293	0.214	0.084	0.221	5	4
Cercopithecidae	<i>Macaca leonina</i>	Asia	0.16	0.196	0.168	0.213	4	4
Cercopithecidae	<i>Macaca nemestrina</i>	Asia	0.155	0.196	0.168	0.213	4	4
Callitrichidae	<i>Saguinus leucopus</i>	Neotropics	0.285	0.199	0.176	0.210	5	4
Cercopithecidae	<i>Rhinopithecus bieti</i>	Asia	0.127	0.187	0.168	0.204	4	4
Cercopithecidae	<i>Rhinopithecus brelichi</i>	Asia	0.227	0.187	0.168	0.204	4	4
Cercopithecidae	<i>Rhinopithecus roxellana</i>	Asia	0.208	0.187	0.168	0.204	4	4
Cercopithecidae	<i>Macaca ochreata</i>	Asia	0.113	0.192	0.163	0.208	4	4

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Lorisidae	<i>Loris tardigradus</i>	Asia	0.788	0.197	0.145	0.205	5	4
Cercopithecidae	<i>Macaca hecki</i>	Asia	0.087	0.189	0.154	0.203	3	4
Cercopithecidae	<i>Macaca fuscata</i>	Asia	1.381	0.188	0.157	0.203	5	4
Atelidae	<i>Ateles hybridus</i>	Neotropics	0.256	0.191	0.162	0.205	5	4
Callitrichidae	<i>Saguinus geoffroyi</i>	Neotropics	0.013	0.187	0.166	0.199	1	4
Cercopithecidae	<i>Macaca maura</i>	Asia	0.493	0.179	0.149	0.196	5	4
Cercopithecidae	<i>Theropithecus gelada</i>	Mainland Africa	0.137	0.176	0.155	0.194	4	4
Lorisidae	<i>Loris lydekkerianus</i>	Asia	0.651	0.185	0.140	0.198	5	4
Cercopithecidae	<i>Cercopithecus nictitans</i>	Mainland Africa	0.063	0.197	0.063	0.202	3	4
Atelidae	<i>Ateles marginatus</i>	Neotropics	0.023	0.188	0.154	0.197	2	4
Atelidae	<i>Ateles belzebuth</i>	Neotropics	0	0.187	0.153	0.197	1	4
Atelidae	<i>Ateles geoffroyi</i>	Neotropics	0.188	0.187	0.153	0.197	4	4
Atelidae	<i>Ateles paniscus</i>	Neotropics	0	0.187	0.153	0.197	1	4
Cercopithecidae	<i>Macaca cyclopis</i>	Asia	0.492	0.179	0.146	0.194	5	4
Cercopithecidae	<i>Semnopithecus vetulus</i>	Asia	0.467	0.176	0.155	0.187	5	4
Cercopithecidae	<i>Nasalis larvatus</i>	Asia	0.103	0.167	0.152	0.184	3	4
Cebidae	<i>Sapajus xanthosternos</i>	Neotropics	0.283	0.175	0.156	0.184	5	4
Cercopithecidae	<i>Trachypithecus delacouri</i>	Asia	0.37	0.160	0.148	0.173	5	4
Cebidae	<i>Sapajus robustus</i>	Neotropics	0.349	0.168	0.154	0.177	5	4
Atelidae	<i>Lagothrix lagothricha</i>	Neotropics	0	0.167	0.136	0.176	1	4
Cercopithecidae	<i>Chlorocebus pygerythrus</i>	Mainland Africa	0.13	0.164	0.130	0.177	4	4
Callitrichidae	<i>Callimico goeldii</i>	Neotropics	0	0.158	0.142	0.169	1	4

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Cercopithecidae	<i>Simias concolor</i>	Asia	0.035	0.151	0.137	0.161	2	4
Cercopithecidae	<i>Trachypithecus leucocephalus</i>	Asia	0.252	0.149	0.136	0.160	5	4
Cercopithecidae	<i>Trachypithecus poliocephalus</i>	Asia	0.032	0.149	0.136	0.160	2	4
Cercopithecidae	<i>Rungwecebus kipunji</i>	M_Africa	0.228	0.152	0.135	0.168	4	4
Cercopithecidae	<i>Chlorocebus aethiops</i>	M_Africa	0.078	0.161	0.128	0.174	3	4
Cercopithecidae	<i>Trachypithecus cristatus</i>	Asia	0.142	0.151	0.135	0.161	4	4
Cercopithecidae	<i>Trachypithecus obscurus</i>	Asia	0.305	0.151	0.135	0.161	5	4
Callitrichidae	<i>Saguinus oedipus</i>	Neotropics	0.337	0.151	0.135	0.162	5	4
Cercopithecidae	<i>Ptilocolobus preussi</i>	M_Africa	0.077	0.152	0.138	0.162	3	4
Atelidae	<i>Brachyteles hypoxanthus</i>	Neotropics	0.75	0.154	0.128	0.166	5	4
Callitrichidae	<i>Mico melanurus</i>	Neotropics	0.057	0.153	0.137	0.164	3	4
Lorisidae	<i>Nycticebus hilleri</i>	Asia	0.137	0.155	0.135	0.163	4	4
Lorisidae	<i>Nycticebus javanicus</i>	Asia	NA	0.155	0.135	0.163	1	4
Cercopithecidae	<i>Trachypithecus auratus</i>	Asia	0.688	0.147	0.131	0.157	5	4
Cercopithecidae	<i>Trachypithecus barbei</i>	Asia	0.103	0.147	0.131	0.157	3	4
Cercopithecidae	<i>Trachypithecus germaini</i>	Asia	0.225	0.147	0.131	0.157	4	4
Cebidae	<i>Sapajus nigritus</i>	Neotropics	0.745	0.157	0.145	0.164	5	4
Callitrichidae	<i>Callibella humilis</i>	Neotropics	0	0.150	0.133	0.162	1	4
Callitrichidae	<i>Mico acariensis</i>	Neotropics	0	0.150	0.133	0.162	1	4
Callitrichidae	<i>Mico chrysoleucos</i>	Neotropics	0.009	0.150	0.133	0.162	1	4
Callitrichidae	<i>Mico humeralifer</i>	Neotropics	0.003	0.150	0.133	0.162	1	4
Callitrichidae	<i>Mico intermedius</i>	Neotropics	0.007	0.150	0.133	0.162	1	4

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Callitrichidae	<i>Mico leucippe</i>	Neotropics	0.076	0.150	0.133	0.162	3	4
Callitrichidae	<i>Mico marcai</i>	Neotropics	0.048	0.150	0.133	0.162	2	4
Callitrichidae	<i>Mico mauesi</i>	Neotropics	0	0.150	0.133	0.162	1	4
Callitrichidae	<i>Mico munduruku</i>	Neotropics	0.028	0.150	0.133	0.162	2	4
Callitrichidae	<i>Mico nigriceps</i>	Neotropics	0.008	0.150	0.133	0.162	1	4
Callitrichidae	<i>Mico rondoni</i>	Neotropics	0.152	0.150	0.133	0.162	4	4
Callitrichidae	<i>Mico saterei</i>	Neotropics	0	0.150	0.133	0.162	1	4
Cercopithecidae	<i>Mandrillus leucophaeus</i>	Mainland Africa	0.075	0.142	0.132	0.161	3	4
Cercopithecidae	<i>Ptilocolobus oustaleti</i>	Mainland Africa	0.032	0.146	0.130	0.158	2	4
Cercopithecidae	<i>Colobus satanas</i>	Mainland Africa	0.047	0.147	0.136	0.157	2	4
Cercopithecidae	<i>Colobus angolensis</i>	Mainland Africa	0.06	0.147	0.135	0.156	3	4
Cercopithecidae	<i>Colobus polykomos</i>	Mainland Africa	0.232	0.147	0.135	0.156	5	4
Cebidae	<i>Sapajus apella</i>	Neotropics	0.003	0.153	0.140	0.161	1	4
Cebidae	<i>Sapajus cay</i>	Neotropics	0.134	0.153	0.140	0.161	4	4
Cebidae	<i>Sapajus libidinosus</i>	Neotropics	0.19	0.153	0.140	0.161	4	4
Callitrichidae	<i>Mico argentatus</i>	Neotropics	0.023	0.147	0.129	0.158	2	4
Callitrichidae	<i>Mico emiliae</i>	Neotropics	0.057	0.147	0.129	0.158	3	4
Cercopithecidae	<i>Trachypithecus francoisi</i>	Asia	0.301	0.136	0.121	0.147	5	4
Cercopithecidae	<i>Trachypithecus shortridgei</i>	Asia	0.017	0.136	0.119	0.147	2	4
Cercopithecidae	<i>Presbytis chrysomelas</i>	Asia	0.136	0.135	0.121	0.147	4	4
Callitrichidae	<i>Saguinus martinsi</i>	Neotropics	0	0.135	0.122	0.147	1	4

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Callitrichidae	<i>Saguinus niger</i>	Neotropics	0.042	0.135	0.122	0.147	2	4
Callitrichidae	<i>Saguinus inustus</i>	Neotropics	0	0.135	0.122	0.146	1	4
Lorisidae	<i>Nycticebus bengalensis</i>	Asia	0.191	0.140	0.123	0.147	4	4
Lorisidae	<i>Nycticebus pygmaeus</i>	Asia	0.184	0.140	0.123	0.147	4	4
Cercopithecidae	<i>Colobus guereza</i>	Mainland Africa	0.056	0.135	0.124	0.145	3	4
Callitrichidae	<i>Saguinus labiatus</i>	Neotropics	0.009	0.130	0.118	0.141	1	4
Callitrichidae	<i>Saguinus mystax</i>	Neotropics	0	0.130	0.118	0.141	1	4
Callitrichidae	<i>Saguinus midas</i>	Neotropics	0	0.126	0.114	0.136	1	4
Cercopithecidae	<i>Trachypithecus hatinhensis</i>	Asia	0.152	0.122	0.109	0.135	4	4
Cercopithecidae	<i>Trachypithecus laotum</i>	Asia	0.14	0.122	0.109	0.135	4	4
Cercopithecidae	<i>Presbytis canicrus</i>	Asia	0.041	0.125	0.111	0.135	2	4
Cercopithecidae	<i>Presbytis comata</i>	Asia	0.765	0.125	0.111	0.135	5	4
Cercopithecidae	<i>Presbytis frontata</i>	Asia	0.056	0.125	0.111	0.135	3	4
Cercopithecidae	<i>Presbytis hosei</i>	Asia	0.105	0.125	0.111	0.135	3	4
Pitheciidae	<i>Callicebus barbarabrownae</i>	Neotropics	0.366	0.130	0.115	0.138	5	4
Cercopithecidae	<i>Colobus vellerosus</i>	Mainland Africa	0.282	0.127	0.116	0.137	5	4
Cebidae	<i>Cebus kaapori</i>	Neotropics	0.182	0.125	0.110	0.136	4	4
Callitrichidae	<i>Saguinus imperator</i>	Neotropics	0	0.124	0.110	0.133	1	4
Atelidae	<i>Brachyteles arachnoides</i>	Neotropics	0.824	0.132	0.100	0.137	5	4
Lorisidae	<i>Nycticebus bancanus</i>	Asia	0.089	0.128	0.114	0.134	3	3
Lorisidae	<i>Nycticebus borneanus</i>	Asia	0.102	0.128	0.114	0.134	3	3
Lorisidae	<i>Nycticebus coucang</i>	Asia	0.245	0.128	0.114	0.134	5	3

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Lorisidae	<i>Nycticebus menagensis</i>	Asia	0.103	0.128	0.114	0.134	3	3
Cercopithecidae	<i>Ptilocolobus epieni</i>	Mainland Africa	0.134	0.121	0.111	0.130	4	3
Cercopithecidae	<i>Ptilocolobus waldroni</i>	Mainland Africa	0.301	0.121	0.111	0.130	5	3
Cebidae	<i>Cebus aequatorialis</i>	Neotropics	0.361	0.121	0.105	0.132	5	3
Callitrichidae	<i>Saguinus melanoleucus</i>	Neotropics	0	0.119	0.108	0.130	1	3
Lorisidae	<i>Nycticebus kayan</i>	Asia	0.063	0.124	0.110	0.130	3	3
Lorisidae	<i>Arctocebus aureus</i>	Mainland Africa	0.035	0.125	0.113	0.129	2	3
Callitrichidae	<i>Leontocebus fuscicollis</i>	Neotropics	0	0.117	0.104	0.125	1	3
Callitrichidae	<i>Leontocebus nigricollis</i>	Neotropics	0	0.116	0.104	0.125	1	3
Lorisidae	<i>Arctocebus calabarensis</i>	Mainland Africa	0.281	0.120	0.111	0.125	5	3
Pitheciidae	<i>Chiropotes satanas</i>	Neotropics	0.196	0.115	0.105	0.121	4	3
Cercopithecidae	<i>Cercocebus chrysogaster</i>	Mainland Africa	0.021	0.116	0.099	0.126	2	3
Cercopithecidae	<i>Cercocebus lunulatus</i>	Mainland Africa	0.311	0.116	0.099	0.126	5	3
Tarsiidae	<i>Tarsius tumpara</i>	Asia	NA	0.112	0.102	0.120	1	3
Pitheciidae	<i>Callicebus melanochir</i>	Neotropics	0.318	0.116	0.104	0.121	5	3
Pitheciidae	<i>Callicebus nigrifrons</i>	Neotropics	0.7	0.116	0.104	0.121	5	3
Pitheciidae	<i>Callicebus personatus</i>	Neotropics	0.482	0.116	0.104	0.121	5	3
Cercopithecidae	<i>Presbytis natunae</i>	Asia	0.103	0.109	0.099	0.119	3	3
Cercopithecidae	<i>Presbytis potenziani</i>	Asia	0.035	0.109	0.099	0.119	2	3
Cercopithecidae	<i>Presbytis rubicunda</i>	Asia	0.079	0.109	0.099	0.119	3	3
Cercopithecidae	<i>Presbytis sabana</i>	Asia	0.131	0.109	0.099	0.119	4	3

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Cercopithecidae	<i>Presbytis siamensis</i>	Asia	0.228	0.109	0.099	0.119	4	3
Cercopithecidae	<i>Presbytis sumatranus</i>	Asia	0.319	0.109	0.099	0.119	5	3
Cercopithecidae	<i>Presbytis thomasi</i>	Asia	0.137	0.109	0.099	0.119	4	3
Cercopithecidae	<i>Pygathrix cinerea</i>	Asia	0.257	0.111	0.099	0.119	5	3
Lemuridae	<i>Eulemur cinereiceps</i>	Madagascar	0.046	0.110	0.099	0.117	2	3
Lemuridae	<i>Varecia rubra</i>	Madagascar	0.03	0.110	0.099	0.117	2	3
Lemuridae	<i>Varecia variegata</i>	Madagascar	0.077	0.110	0.099	0.117	3	3
Callitrichidae	<i>Leontocebus tripartitus</i>	Neotropics	0	0.108	0.096	0.118	1	3
Cercopithecidae	<i>Presbytis femoralis</i>	Asia	0.347	0.104	0.094	0.115	5	3
Cercopithecidae	<i>Presbytis melalophos</i>	Asia	0.169	0.104	0.094	0.115	4	3
Cercopithecidae	<i>Presbytis mitrata</i>	Asia	0.342	0.104	0.094	0.115	5	3
Cercopithecidae	<i>Presbytis siberu</i>	Asia	0.026	0.104	0.094	0.115	2	3
Lemuridae	<i>Prolemur simus</i>	Madagascar	0.086	0.107	0.096	0.112	3	3
Cebidae	<i>Cebus castaneus</i>	Neotropics	0	0.108	0.092	0.114	1	3
Cebidae	<i>Saimiri boliviensis</i>	Neotropics	0.009	0.108	0.092	0.114	1	3
Cebidae	<i>Saimiri ustus</i>	Neotropics	0.016	0.108	0.092	0.114	1	3
Galagidae	<i>Sciurocheirus alleni</i>	Mainland Africa	0.258	0.108	0.100	0.112	5	3
Galagidae	<i>Euoticus elegantulus</i>	Mainland Africa	0.038	0.108	0.098	0.113	2	3
Lorisidae	<i>Perodicticus potto</i>	Mainland Africa	0.303	0.108	0.098	0.113	5	3
Galagidae	<i>Sciurocheirus gabonensis</i>	Mainland Africa	0.032	0.108	0.098	0.113	2	3
Cercopithecidae	<i>Chlorocebus cynosuros</i>	Mainland Africa	0.066	0.107	0.090	0.118	3	3

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Cercopithecidae	<i>Chlorocebus sabaues</i>	Mainland Africa	0.246	0.107	0.090	0.118	5	3
Pitheciidae	<i>Callicebus coimbrai</i>	Neotropics	0.935	0.107	0.097	0.113	5	3
Indriidae	<i>Indri indri</i>	Madagascar	0.077	0.104	0.094	0.110	3	3
Cercopithecidae	<i>Ptilocolobus bouvieri</i>	Mainland Africa	0	0.100	0.092	0.111	1	3
Galagidae	<i>Sciurocheirus makandensis</i>	Mainland Africa	0.036	0.105	0.097	0.109	2	3
Cebidae	<i>Cebus cuscinus</i>	Neotropics	0.029	0.103	0.087	0.110	2	3
Galagidae	<i>Euoticus pallidus</i>	Mainland Africa	0.256	0.104	0.096	0.108	5	3
Cercopithecidae	<i>Cercocebus atys</i>	Mainland Africa	0.232	0.103	0.086	0.113	5	3
Galagidae	<i>Otolemur garnettii</i>	Mainland Africa	0.123	0.103	0.095	0.108	4	3
Galagidae	<i>Paragalago granti</i>	Mainland Africa	0.096	0.103	0.095	0.108	3	3
Cercopithecidae	<i>Allochrocebus preussi</i>	Mainland Africa	0.094	0.101	0.084	0.112	3	3
Lepilemuridae	<i>Lepilemur fleuretae</i>	Madagascar	0.081	0.100	0.089	0.105	3	3
Lepilemuridae	<i>Lepilemur sahamalaza</i>	Madagascar	0.023	0.100	0.089	0.105	2	3
Lepilemuridae	<i>Lepilemur septentrionalis</i>	Madagascar	0.098	0.100	0.089	0.105	3	3
Cebidae	<i>Cebus leucocephalus</i>	Neotropics	0.158	0.100	0.083	0.107	4	3
Cebidae	<i>Saimiri oerstedii</i>	Neotropics	0.181	0.100	0.083	0.107	4	3
Cebidae	<i>Saimiri vanzolinii</i>	Neotropics	0	0.100	0.083	0.107	1	3
Cercopithecidae	<i>Allochrocebus lhoesti</i>	Mainland Africa	0.024	0.099	0.081	0.110	2	3
Galagidae	<i>Galago gallarum</i>	Mainland Africa	0.08	0.101	0.091	0.105	3	3

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Galagidae	<i>Galago moholi</i>	Mainland Africa	0.074	0.101	0.091	0.105	3	3
Lemuridae	<i>Hapalemur alaotrensis</i>	Madagascar	0.121	0.096	0.085	0.102	4	3
Cercopithecidae	<i>Ptilocolobus rufomitratus</i>	Mainland Africa	0.122	0.095	0.086	0.101	4	3
Cercopithecidae	<i>Ptilocolobus tephrosceles</i>	Mainland Africa	0.05	0.095	0.086	0.101	2	3
Galagidae	<i>Galago senegalensis</i>	Mainland Africa	0.115	0.099	0.090	0.104	4	3
Galagidae	<i>Otolemur crassicaudatus</i>	Mainland Africa	0.092	0.099	0.090	0.104	3	3
Lorisidae	<i>Perodicticus edwardsi</i>	Mainland Africa	0.055	0.099	0.090	0.104	3	3
Lorisidae	<i>Perodicticus ibeanus</i>	Mainland Africa	0.055	0.099	0.090	0.104	3	3
Indriidae	<i>Propithecus perrieri</i>	Madagascar	0.072	0.095	0.086	0.102	3	3
Indriidae	<i>Propithecus tattersalli</i>	Madagascar	0.022	0.095	0.086	0.102	2	3
Cebidae	<i>Cebus albifrons</i>	Neotropics	0	0.094	0.080	0.103	1	3
Pitheciidae	<i>Cacajao calvus</i>	Neotropics	0	0.093	0.087	0.099	1	3
Galagidae	<i>Galago matschiei</i>	Mainland Africa	0.481	0.096	0.089	0.100	5	3
Galagidae	<i>Paragalago orinus</i>	Mainland Africa	0.21	0.096	0.089	0.100	4	3
Galagidae	<i>Paragalago rondoensis</i>	Mainland Africa	0.094	0.096	0.089	0.100	3	3
Galagidae	<i>Paragalago zanzibaricus</i>	Mainland Africa	0.415	0.096	0.089	0.100	5	3
Indriidae	<i>Propithecus candidus</i>	Madagascar	0.109	0.092	0.083	0.099	3	3
Indriidae	<i>Propithecus diadema</i>	Madagascar	0.086	0.092	0.083	0.099	3	3
Pitheciidae	<i>Plecturocebus caquetensis</i>	Neotropics	0.2	0.092	0.082	0.098	4	3

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Pitheciidae	<i>Plecturocebus oenanthe</i>	Neotropics	0.153	0.092	0.082	0.098	4	3
Cheirogaleidae	<i>Cheirogaleus sibreei</i>	Madagascar	0.109	0.091	0.081	0.097	3	3
Lemuridae	<i>Eulemur flavifrons</i>	Madagascar	0.023	0.091	0.081	0.097	2	3
Lemuridae	<i>Eulemur mongoz</i>	Madagascar	0.083	0.091	0.081	0.097	3	3
Lepilemuridae	<i>Lepilemur jamesorum</i>	Madagascar	0.107	0.091	0.081	0.097	3	3
Lepilemuridae	<i>Lepilemur tymerlachsoni</i>	Madagascar	0.048	0.091	0.081	0.097	2	3
Cheirogaleidae	<i>Microcebus gerpi</i>	Madagascar	0.255	0.091	0.081	0.097	5	3
Cheirogaleidae	<i>Microcebus mambiratra</i>	Madagascar	0.073	0.091	0.081	0.097	3	3
Cheirogaleidae	<i>Microcebus marohita</i>	Madagascar	0.024	0.091	0.081	0.097	2	3
Lemuridae	<i>Hapalemur aureus</i>	Madagascar	0.2	0.091	0.080	0.096	4	3
Tarsiidae	<i>Tarsius bancanus</i>	Asia	0.115	0.087	0.082	0.093	4	3
Tarsiidae	<i>Tarsius pelengensis</i>	Asia	0.062	0.087	0.082	0.093	3	3
Tarsiidae	<i>Tarsius tarsier</i>	Asia	0.163	0.087	0.082	0.093	4	3
Galagidae	<i>Paragalago cocos</i>	Mainland Africa	0.236	0.091	0.084	0.096	5	3
Pitheciidae	<i>Cacajao ayresi</i>	Neotropics	0	0.088	0.082	0.093	1	2
Pitheciidae	<i>Cacajao hosomi</i>	Neotropics	0	0.088	0.082	0.093	1	2
Pitheciidae	<i>Chiropotes chiropotes</i>	Neotropics	0	0.088	0.082	0.093	1	2
Pitheciidae	<i>Chiropotes utahickae</i>	Neotropics	0.07	0.088	0.082	0.093	3	2
Pitheciidae	<i>Pithecia aequatorialis</i>	Neotropics	0	0.088	0.082	0.093	1	2
Pitheciidae	<i>Pithecia albicans</i>	Neotropics	0	0.088	0.082	0.093	1	2
Cercopithecidae	<i>Procolobus verus</i>	Mainland Africa	0.286	0.086	0.078	0.092	5	2
Tarsiidae	<i>Tarsius dentatus</i>	Asia	0.091	0.085	0.080	0.091	3	2

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Tarsiidae	<i>Tarsius lariang</i>	Asia	0.013	0.085	0.080	0.091	1	2
Tarsiidae	<i>Tarsius pumilus</i>	Asia	0.119	0.085	0.080	0.091	4	2
Pitheciidae	<i>Cacajao melanocephalus</i>	Neotropics	0	0.087	0.082	0.094	1	2
Pitheciidae	<i>Chiropotes albinasus</i>	Neotropics	0.022	0.087	0.082	0.094	2	2
Cercopithecidae	<i>Cercopithecus dryas</i>	Mainland Africa	0.021	0.085	0.077	0.093	2	2
Pitheciidae	<i>Pithecia cazuzai</i>	Neotropics	0	0.084	0.079	0.089	1	2
Pitheciidae	<i>Pithecia hirsuta</i>	Neotropics	0	0.084	0.079	0.089	1	2
Pitheciidae	<i>Pithecia inusta</i>	Neotropics	0.01	0.084	0.079	0.089	1	2
Pitheciidae	<i>Pithecia isabela</i>	Neotropics	0.001	0.084	0.079	0.089	1	2
Pitheciidae	<i>Pithecia milleri</i>	Neotropics	0.113	0.084	0.079	0.089	4	2
Pitheciidae	<i>Pithecia mittermeieri</i>	Neotropics	0.03	0.084	0.079	0.089	2	2
Pitheciidae	<i>Pithecia napensis</i>	Neotropics	0.001	0.084	0.079	0.089	1	2
Pitheciidae	<i>Pithecia pissinattii</i>	Neotropics	0.005	0.084	0.079	0.089	1	2
Pitheciidae	<i>Pithecia rylandsi</i>	Neotropics	0.04	0.084	0.079	0.089	2	2
Pitheciidae	<i>Pithecia vanzolinii</i>	Neotropics	0	0.084	0.079	0.089	1	2
Cercopithecidae	<i>Pygathrix nemaeus</i>	Asia	0.138	0.084	0.077	0.089	4	2
Tarsiidae	<i>Tarsius syrichta</i>	Asia	0.27	0.083	0.077	0.088	5	2
Indriidae	<i>Propithecus coronatus</i>	Madagascar	0.034	0.084	0.077	0.088	2	2
Lemuridae	<i>Eulemur albifrons</i>	Madagascar	0.044	0.083	0.077	0.088	2	2
Lemuridae	<i>Eulemur collaris</i>	Madagascar	0.012	0.083	0.077	0.088	1	2
Lemuridae	<i>Eulemur macaco</i>	Madagascar	0.014	0.083	0.077	0.088	1	2
Lemuridae	<i>Eulemur rufus</i>	Madagascar	0.011	0.083	0.077	0.088	1	2
Pitheciidae	<i>Cheracebus medemi</i>	Neotropics	0.011	0.081	0.076	0.085	1	2

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Pitheciidae	<i>Cheracebus purinus</i>	Neotropics	0	0.081	0.076	0.085	1	2
Pitheciidae	<i>Cheracebus regulus</i>	Neotropics	0	0.081	0.076	0.085	1	2
Pitheciidae	<i>Cheracebus torquatus</i>	Neotropics	0	0.081	0.076	0.085	1	2
Pitheciidae	<i>Plecturocebus aureipalatii</i>	Neotropics	0.005	0.081	0.076	0.085	1	2
Pitheciidae	<i>Plecturocebus baptista</i>	Neotropics	0.001	0.081	0.076	0.085	1	2
Pitheciidae	<i>Plecturocebus bernhardi</i>	Neotropics	0.01	0.081	0.076	0.085	1	2
Pitheciidae	<i>Plecturocebus brunneus</i>	Neotropics	0.071	0.081	0.076	0.085	3	2
Pitheciidae	<i>Plecturocebus caligatus</i>	Neotropics	0.009	0.081	0.076	0.085	1	2
Pitheciidae	<i>Plecturocebus cinerascens</i>	Neotropics	0.007	0.081	0.076	0.085	1	2
Pitheciidae	<i>Plecturocebus dubius</i>	Neotropics	0.019	0.081	0.076	0.085	2	2
Pitheciidae	<i>Plecturocebus ornatus</i>	Neotropics	0.197	0.081	0.076	0.085	4	2
Pitheciidae	<i>Plecturocebus stephennashi</i>	Neotropics	0	0.081	0.076	0.085	1	2
Tarsiidae	<i>Tarsius sangirensis</i>	Asia	NA	0.079	0.074	0.084	1	2
Tarsiidae	<i>Tarsius wallacei</i>	Asia	0.097	0.079	0.074	0.084	3	2
Pitheciidae	<i>Cheracebus lugens</i>	Neotropics	0	0.081	0.075	0.086	1	2
Pitheciidae	<i>Plecturocebus cupreus</i>	Neotropics	0	0.081	0.075	0.086	1	2
Cercopithecidae	<i>Piliocolobus badius</i>	Mainland Africa	0.232	0.080	0.071	0.087	5	2
Cercopithecidae	<i>Piliocolobus foai</i>	Mainland Africa	0.016	0.080	0.071	0.087	1	2
Cercopithecidae	<i>Piliocolobus langi</i>	Mainland Africa	0.021	0.080	0.071	0.087	2	2
Cercopithecidae	<i>Piliocolobus parmentieri</i>	Mainland Africa	0.057	0.080	0.071	0.087	3	2
Cercopithecidae	<i>Piliocolobus pennantii</i>	Mainland Africa	0.011	0.080	0.071	0.087	1	2

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Cercopithecidae	<i>Ptilocolobus semlikiensis</i>	Mainland Africa	0.011	0.080	0.071	0.087	1	2
Cercopithecidae	<i>Ptilocolobus tholloni</i>	Mainland Africa	0.029	0.079	0.070	0.085	2	2
Aotidae	<i>Aotus zonalis</i>	Neotropics	0.046	0.077	0.071	0.082	2	2
Pitheciidae	<i>Pithecia chryscephala</i>	Neotropics	0.004	0.077	0.073	0.081	1	2
Aotidae	<i>Aotus trivirgatus</i>	Neotropics	0	0.078	0.070	0.082	1	2
Aotidae	<i>Aotus vociferans</i>	Neotropics	0	0.078	0.070	0.082	1	2
Lemuridae	<i>Eulemur coronatus</i>	Madagascar	0.049	0.076	0.071	0.080	2	2
Lemuridae	<i>Eulemur sanfordi</i>	Madagascar	0.049	0.076	0.071	0.080	2	2
Pitheciidae	<i>Plecturocebus moloch</i>	Neotropics	0.047	0.077	0.071	0.081	2	2
Cercopithecidae	<i>Ptilocolobus gordonorum</i>	Mainland Africa	0.169	0.075	0.067	0.082	4	2
Cercopithecidae	<i>Ptilocolobus kirkii</i>	Mainland Africa	0.153	0.075	0.067	0.082	4	2
Aotidae	<i>Aotus nancymae</i>	Neotropics	0	0.075	0.069	0.080	1	2
Aotidae	<i>Aotus nigriceps</i>	Neotropics	0.004	0.075	0.069	0.080	1	2
Cercopithecidae	<i>Cercopithecus erythrotis</i>	Mainland Africa	0.086	0.075	0.070	0.080	3	2
Cercopithecidae	<i>Cercopithecus ascanius</i>	Mainland Africa	0.059	0.075	0.069	0.079	3	2
Cercopithecidae	<i>Cercopithecus cephus</i>	Mainland Africa	0.039	0.075	0.069	0.079	2	2
Cercopithecidae	<i>Cercopithecus diana</i>	Mainland Africa	0.232	0.075	0.069	0.079	5	2
Cercopithecidae	<i>Cercopithecus mitis</i>	Mainland Africa	0.088	0.075	0.069	0.079	3	2
Indriidae	<i>Avahi betsileo</i>	Madagascar	0.195	0.072	0.067	0.076	4	1

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Indriidae	<i>Avahi cleesei</i>	Madagascar	0.006	0.072	0.067	0.076	1	1
Indriidae	<i>Avahi laniger</i>	Madagascar	0.077	0.072	0.067	0.076	3	1
Indriidae	<i>Avahi meridionalis</i>	Madagascar	0.125	0.072	0.067	0.076	4	1
Indriidae	<i>Avahi mooreorum</i>	Madagascar	0.03	0.072	0.067	0.076	2	1
Indriidae	<i>Avahi occidentalis</i>	Madagascar	0.083	0.072	0.067	0.076	3	1
Indriidae	<i>Avahi peyrierasi</i>	Madagascar	0.061	0.072	0.067	0.076	3	1
Indriidae	<i>Avahi ramanantsoavanai</i>	Madagascar	0.007	0.072	0.067	0.076	1	1
Indriidae	<i>Avahi unicolor</i>	Madagascar	0.014	0.072	0.067	0.076	1	1
Lemuridae	<i>Haplemur griseus</i>	Madagascar	0.024	0.072	0.067	0.076	2	1
Lemuridae	<i>Haplemur meridionalis</i>	Madagascar	0.012	0.072	0.067	0.076	1	1
Lepilemuridae	<i>Lepilemur aeeclis</i>	Madagascar	0.305	0.072	0.067	0.076	5	1
Lepilemuridae	<i>Lepilemur ahmansonori</i>	Madagascar	0.024	0.072	0.067	0.076	2	1
Lepilemuridae	<i>Lepilemur betsileo</i>	Madagascar	0.065	0.072	0.067	0.076	3	1
Lepilemuridae	<i>Lepilemur dorsalis</i>	Madagascar	0	0.072	0.067	0.076	1	1
Lepilemuridae	<i>Lepilemur edwardsi</i>	Madagascar	0.083	0.072	0.067	0.076	3	1
Lepilemuridae	<i>Lepilemur leucopus</i>	Madagascar	0.441	0.072	0.067	0.076	5	1
Lepilemuridae	<i>Lepilemur mittermeieri</i>	Madagascar	0.014	0.072	0.067	0.076	1	1
Lepilemuridae	<i>Lepilemur mustelinus</i>	Madagascar	0.086	0.072	0.067	0.076	3	1
Lepilemuridae	<i>Lepilemur petteri</i>	Madagascar	0.129	0.072	0.067	0.076	4	1
Lepilemuridae	<i>Lepilemur randrianasoloi</i>	Madagascar	0.006	0.072	0.067	0.076	1	1
Lepilemuridae	<i>Lepilemur ruficaudatus</i>	Madagascar	0.021	0.072	0.067	0.076	2	1
Lepilemuridae	<i>Lepilemur scottorum</i>	Madagascar	0.03	0.072	0.067	0.076	2	1
Lepilemuridae	<i>Lepilemur seali</i>	Madagascar	0.063	0.072	0.067	0.076	3	1

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Lepilemuridae	<i>Lepilemur wrightae</i>	Madagascar	0.001	0.072	0.067	0.076	1	1
Cheirogaleidae	<i>Phaner electromontis</i>	Madagascar	0.049	0.072	0.067	0.076	2	1
Cheirogaleidae	<i>Phaner pallescens</i>	Madagascar	0.012	0.072	0.067	0.076	1	1
Pitheciidae	<i>Cheracebus lucifer</i>	Neotropics	0	0.072	0.067	0.077	1	1
Pitheciidae	<i>Pithecia irrorata</i>	Neotropics	0.005	0.072	0.067	0.077	1	1
Pitheciidae	<i>Plecturocebus discolor</i>	Neotropics	0.003	0.072	0.067	0.077	1	1
Pitheciidae	<i>Plecturocebus donacophilus</i>	Neotropics	0.025	0.072	0.067	0.077	2	1
Pitheciidae	<i>Plecturocebus hoffmannsi</i>	Neotropics	0.004	0.072	0.067	0.077	1	1
Pitheciidae	<i>Plecturocebus modestus</i>	Neotropics	0.056	0.072	0.067	0.077	3	1
Pitheciidae	<i>Plecturocebus vieirai</i>	Neotropics	0	0.072	0.067	0.077	1	1
Cercopithecidae	<i>Lophocebus aterrimus</i>	Mainland Africa	0.041	0.072	0.067	0.077	2	1
Pitheciidae	<i>Pithecia monachus</i>	Neotropics	0	0.072	0.067	0.077	1	1
Pitheciidae	<i>Pithecia pithecia</i>	Neotropics	0	0.072	0.067	0.077	1	1
Cercopithecidae	<i>Lophocebus albigena</i>	Mainland Africa	0.045	0.072	0.067	0.077	2	1
Aotidae	<i>Aotus lemurinus</i>	Neotropics	0.379	0.071	0.066	0.076	5	1
Cercopithecidae	<i>Ptilocolobus lulindicus</i>	Mainland Africa	0.042	0.070	0.062	0.075	2	1
Cercopithecidae	<i>Pygathrix nigripes</i>	Asia	0.264	0.069	0.062	0.075	5	1
Indriidae	<i>Propithecus coquereli</i>	Madagascar	0.066	0.068	0.063	0.071	3	1
Indriidae	<i>Propithecus deckenii</i>	Madagascar	0.009	0.068	0.063	0.071	1	1
Aotidae	<i>Aotus azarae</i>	Neotropics	0.07	0.067	0.062	0.072	3	1
Indriidae	<i>Propithecus edwardsi</i>	Madagascar	0.231	0.065	0.060	0.069	4	1
Pitheciidae	<i>Plecturocebus olallae</i>	Neotropics	0.063	0.065	0.060	0.068	3	1

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Pitheciidae	<i>Plecturocebus pallescens</i>	Neotropics	0.046	0.065	0.060	0.068	2	1
Cheirogaleidae	<i>Allocebus trichotis</i>	Madagascar	0.03	0.063	0.059	0.067	2	1
Cheirogaleidae	<i>Cheirogaleus crossleyi</i>	Madagascar	0.112	0.063	0.059	0.067	4	1
Cheirogaleidae	<i>Cheirogaleus grovesi</i>	Madagascar	0.046	0.063	0.059	0.067	2	1
Cheirogaleidae	<i>Cheirogaleus major</i>	Madagascar	0.103	0.063	0.059	0.067	3	1
Cheirogaleidae	<i>Cheirogaleus medius</i>	Madagascar	0.021	0.063	0.059	0.067	2	1
Cheirogaleidae	<i>Cheirogaleus shethi</i>	Madagascar	0.072	0.063	0.059	0.067	3	1
Lemuridae	<i>Eulemur fulvus</i>	Madagascar	0.069	0.063	0.059	0.067	3	1
Lemuridae	<i>Eulemur rubriventer</i>	Madagascar	0.059	0.063	0.059	0.067	3	1
Lemuridae	<i>Eulemur rufifrons</i>	Madagascar	0.021	0.063	0.059	0.067	2	1
Lemuridae	<i>Hapalemur occidentalis</i>	Madagascar	0.051	0.063	0.059	0.067	2	1
Lepilemuridae	<i>Lepilemur ankaranensis</i>	Madagascar	0.037	0.063	0.059	0.067	2	1
Lepilemuridae	<i>Lepilemur grewcockorum</i>	Madagascar	0.017	0.063	0.059	0.067	2	1
Lepilemuridae	<i>Lepilemur hollandorum</i>	Madagascar	0.018	0.063	0.059	0.067	2	1
Lepilemuridae	<i>Lepilemur hubbardorum</i>	Madagascar	0.027	0.063	0.059	0.067	2	1
Lepilemuridae	<i>Lepilemur microdon</i>	Madagascar	0.046	0.063	0.059	0.067	2	1
Lepilemuridae	<i>Lepilemur milanoii</i>	Madagascar	0.072	0.063	0.059	0.067	3	1
Lepilemuridae	<i>Lepilemur otto</i>	Madagascar	0.074	0.063	0.059	0.067	3	1
Cheirogaleidae	<i>Microcebus arnholdi</i>	Madagascar	0.025	0.063	0.059	0.067	2	1
Cheirogaleidae	<i>Microcebus berthae</i>	Madagascar	0.032	0.063	0.059	0.067	2	1
Cheirogaleidae	<i>Microcebus bongolavensis</i>	Madagascar	0.074	0.063	0.059	0.067	3	1
Cheirogaleidae	<i>Microcebus boraha</i>	Madagascar	NA	0.063	0.059	0.067	1	1
Cheirogaleidae	<i>Microcebus danfossi</i>	Madagascar	0.066	0.063	0.059	0.067	3	1

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Cheirogaleidae	<i>Microcebus ganzhorni</i>	Madagascar	0.125	0.063	0.059	0.067	4	1
Cheirogaleidae	<i>Microcebus jollyae</i>	Madagascar	0.148	0.063	0.059	0.067	4	1
Cheirogaleidae	<i>Microcebus lehilahytsara</i>	Madagascar	0.175	0.063	0.059	0.067	4	1
Cheirogaleidae	<i>Microcebus macarthurii</i>	Madagascar	0.077	0.063	0.059	0.067	3	1
Cheirogaleidae	<i>Microcebus manitatra</i>	Madagascar	0.125	0.063	0.059	0.067	4	1
Cheirogaleidae	<i>Microcebus margotmarshae</i>	Madagascar	0.006	0.063	0.059	0.067	1	1
Cheirogaleidae	<i>Microcebus mittermeieri</i>	Madagascar	0.055	0.063	0.059	0.067	3	1
Cheirogaleidae	<i>Microcebus myoxinus</i>	Madagascar	0.009	0.063	0.059	0.067	1	1
Cheirogaleidae	<i>Microcebus ravelobensis</i>	Madagascar	0.083	0.063	0.059	0.067	3	1
Cheirogaleidae	<i>Microcebus rufus</i>	Madagascar	0.061	0.063	0.059	0.067	3	1
Cheirogaleidae	<i>Microcebus sambiranensis</i>	Madagascar	0	0.063	0.059	0.067	1	1
Cheirogaleidae	<i>Microcebus simmonsii</i>	Madagascar	0.028	0.063	0.059	0.067	2	1
Cheirogaleidae	<i>Microcebus tavaratra</i>	Madagascar	0.072	0.063	0.059	0.067	3	1
Cheirogaleidae	<i>Mirza coquereli</i>	Madagascar	0.021	0.063	0.059	0.067	2	1
Cheirogaleidae	<i>Mirza zaza</i>	Madagascar	0.023	0.063	0.059	0.067	2	1
Cheirogaleidae	<i>Phaner furcifer</i>	Madagascar	0.034	0.063	0.059	0.067	2	1
Cheirogaleidae	<i>Phaner parienti</i>	Madagascar	0.014	0.063	0.059	0.067	1	1
Indriidae	<i>Propithecus verreauxi</i>	Madagascar	0.095	0.063	0.059	0.068	3	1
Daubentoniidae	<i>Daubentonia madagascariensis</i>	Madagascar	0.047	0.063	0.059	0.067	2	1
Aotidae	<i>Aotus jorgehernandezii</i>	Neotropics	0.032	0.063	0.059	0.068	2	1
Aotidae	<i>Aotus miconax</i>	Neotropics	0.087	0.063	0.059	0.068	3	1
Cercopithecidae	<i>Cercocebus agilis</i>	Mainland Africa	0.031	0.063	0.056	0.070	2	1

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Cercopithecidae	<i>Cercopithecus denti</i>	Mainland Africa	0.032	0.063	0.058	0.068	2	1
Aotidae	<i>Aotus griseimembra</i>	Neotropics	0.287	0.061	0.056	0.066	5	1
Cheirogaleidae	<i>Cheirogaleus andysabini</i>	Madagascar	0.049	0.060	0.056	0.064	2	1
Cheirogaleidae	<i>Cheirogaleus lavasoensis</i>	Madagascar	0.001	0.060	0.056	0.064	1	1
Cheirogaleidae	<i>Cheirogaleus thomasi</i>	Madagascar	0.125	0.060	0.056	0.064	4	1
Cheirogaleidae	<i>Microcebus tanosi</i>	Madagascar	0.125	0.060	0.056	0.064	4	1
Cercopithecidae	<i>Cercocebus galeritus</i>	Mainland Africa	0.122	0.060	0.053	0.067	4	1
Cercopithecidae	<i>Cercocebus sanjei</i>	Mainland Africa	0.257	0.060	0.053	0.067	5	1
Cercopithecidae	<i>Cercocebus torquatus</i>	Mainland Africa	0.134	0.060	0.053	0.067	4	1
Cercopithecidae	<i>Chlorocebus djamdjamensis</i>	Mainland Africa	0.404	0.060	0.053	0.067	5	1
Cheirogaleidae	<i>Microcebus griseorufus</i>	Madagascar	0.119	0.058	0.055	0.062	4	1
Cheirogaleidae	<i>Microcebus murinus</i>	Madagascar	0.021	0.058	0.055	0.062	2	1
Aotidae	<i>Aotus brumbacki</i>	Neotropics	0.134	0.059	0.054	0.063	4	1
Cercopithecidae	<i>Cercopithecus lowei</i>	Mainland Africa	0.3	0.059	0.054	0.063	5	1
Cercopithecidae	<i>Cercopithecus sclateri</i>	Mainland Africa	0.657	0.059	0.054	0.063	5	1
Cercopithecidae	<i>Cercopithecus campbelli</i>	Mainland Africa	0.23	0.059	0.053	0.063	4	1
Cercopithecidae	<i>Cercopithecus petaurista</i>	Mainland Africa	0.277	0.059	0.053	0.063	5	1
Cercopithecidae	<i>Cercopithecus pogonias</i>	Mainland Africa	0.039	0.059	0.053	0.063	2	1
Cercopithecidae	<i>Miopithecus ogouensis</i>	Mainland Africa	0.041	0.056	0.048	0.062	2	1

Family	Species	Realm	Exposure (median infrastructure density, km/km ²)	Vulnerability (median score after bootstrapping)	20% percentile	80% percentile	Exposure semi- decile (1- 5)	Vulnerability emi-decile (1- 5)
Cercopithecidae	<i>Cercopithecus erythrogaster</i>	Mainland Africa	0.371	0.055	0.051	0.059	5	1
Cercopithecidae	<i>Cercopithecus roloway</i>	Mainland Africa	0.311	0.055	0.051	0.059	5	1
Cercopithecidae	<i>Cercopithecus wolffi</i>	Mainland Africa	0.042	0.052	0.047	0.055	2	1
Lemuridae	<i>Lemur catta</i>	Madagascar	0.056	0.051	0.043	0.054	3	1
Cercopithecidae	<i>Cercopithecus neglectus</i>	Mainland Africa	0.046	0.051	0.044	0.055	2	1
Cercopithecidae	<i>Miopithecus talapoin</i>	Mainland Africa	0.109	0.051	0.044	0.055	3	1
Cercopithecidae	<i>Allenopithecus nigroviridis</i>	Mainland Africa	0.026	0.047	0.040	0.052	2	1
Cercopithecidae	<i>Allochrocebus solatus</i>	Mainland Africa	0.032	0.046	0.038	0.050	2	1
Cercopithecidae	<i>Cercopithecus hamlyni</i>	Mainland Africa	0.022	0.046	0.038	0.050	2	1
Cercopithecidae	<i>Cercopithecus lomamiensis</i>	Mainland Africa	0.001	0.046	0.038	0.050	1	1

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Supplemental File

Primates and linear infrastructures (Responses).xlsx