

## Read me

The code here is an example of one of the 4946 species of terrestrial mammals, amphibians and birds analysed in Zeng et al. (in review). Briefly, we first calculate the area of habitat. Next, for each of these species, we calculate the percent coverage of protected areas affected and unaffected by the various downgrading, downsizing, or degazettement events. Last, we similarly calculate the percent coverage of protected areas affected by future projected expansion of cropland and urban based on the Land-Use Harmonization (LUH2) project.

### *Area of habitat*

We created maps of the available area of habitat following Brooks et al. (1). For each species, we extract habitat from IUCN following the habitat classification scheme (Version 3.1) using the Level 2 habitat classification (e.g. 1.5 Subtropical/tropical dry forest; 3.6 Subtropical/tropical moist shrubland) (2).

Importantly, using the Level 2 habitat classification allows us to match a species quantified range to the areas of suitable habitats within its range boundaries (2-4).

The range boundaries (polygons) of each species was also obtained from IUCN (mammals and amphibians) and BirdLife International (2, 3). These polygon, which we limited to extant and native ranges, were used to mask the 2015 map of habitat types characterized by Jung et al. (4). The 2015 map of habitat types is optimized to the Level 2 habitat classification of terrestrial systems (4). Additionally, we also limited a species' area of habitat to its suitable elevational range, based on quantified values from IUCN and a recent elevation map (2, 5). Last, we updated the area of habitat of each species to 2019 by excluding any expansion of anthropogenic land cover (i.e., cropland and built-up areas) between the 2015 to 2019 (6).

### *Protected area coverage and downgrading, downsizing, or degazettement events*

Next, we classified current protected area coverage based on spatially explicit data from the World Database of Protected Areas (7). This includes all areas recognized as protected areas (in all categories) as well as other effective area-based conservation measures, according to the standards of the United Nations Environment Programme and International Union for Conservation of Nature, and represents the most comprehensive database of terrestrial protected areas available on a global level (7). It is important to note that this dataset does not necessarily match up with national-level inventories, and might also miss out other conservation governance systems (e.g. community managed forests, indigenous lands) that are known to provide biodiversity conservation benefits.

We then cross-referenced these protected areas identities to parks that have affected by downgrading, downsizing or degazettement events (often referred to as PADDD events) recorded in PADDDtracker.org (Version 2.1) (8). Location and extents of degazettement events were obtained from PADDDtracker.org when degazettement led to removal from the protected area database. Specifically, parks can be affected by a single downgrading, downsizing or degazettement events, or multiple events (same or combination of event types). Parks can also experience *enacted* or *proposed* PADDD events, and some parks also experience PADDD reversals (9).

Using these two sources of data, we calculated the proportion of each species area of suitable habitat that occurs (1) within protected areas and (2) within protected areas previously affected by PADDD events. We further classify this into the proportion of each species area of suitable

habitat that occurs parks affected by (2a) downgrading, (2b) downsizing or (2c) degazettement events alone, or (2d) the combination of multiple type of events, as well as (2e) parks that have experienced reversals. This includes parks that experience multiple events within its boundaries. To account for potential time lags, we also assume that *proposed* PADDD events would carry the same degree of risk to species vulnerability as *enacted* PADDD events and assess the combined risk of both in this study.

#### *Future expansion of human activities into protected areas*

We estimated the potential for future human activities, namely cropland and urban expansion, to encroach into existing protected areas by using data from the Land-Use Harmonization (LUH2) project (10). Here, we focused on four specific Shared Socio-Economic Pathways (SSPs) that reflect different scenarios of future global socio-economic development and the degree of associated land-use change. Briefly, we considered: SSP1, which represents a sustainability narrative, where there is a strong degree of land-use change regulation; SSP2: which represents a middle-of-the-road narrative, with a medium degree of land-use change regulation; SSP3: regional-rivalry and rocky-road narrative, with limited degree of land-use change regulation; and SSP5: fossil-fueled-based narrative, where there remains a medium level of land-use change regulation (10). We utilized the summed total of cropland and urban expansion predicted to 2050 as an indicator the degree of increased human pressures likely to be faced within each protected area. While not directly indicative of downgrading, downsizing, or degazettement events, it nevertheless allows us to estimate the relative increase in human pressures that would threaten species that depend on these protected areas for the maintenance of natural habitats.

#### *Results reporting*

With these modeled results, we were able to calculate: (1) the area of suitable habitat available to each species, (2) the proportion of species habitat currently occurring in protected areas, (3) the proportion of species habitat currently in protected areas affected by PADDD events collectively, and (4) the proportion of species habitat that could be affected by expanding human pressures in the future. These data were cross-referenced to the threat status within IUCN red list, and the criteria that was used. Final results are included as a .csv file in this dataset.

Note that we do not own the source data, but the sources can be requested from the individual respective providers. Species assessments and range maps can be accessed and requested from the IUCN Red List of Threatened Species ([www.iucnredlist.org/](http://www.iucnredlist.org/)). Protected area maps can be requested from the World Database on Protected Areas ([www.protectedplanet.net](http://www.protectedplanet.net)). Records of protected area downgrading, downsizing or degazettement events were obtained from PADDDtracker ([www.PADDDtracker.org](http://www.PADDDtracker.org)) Version 2.1. Also note that all calculations were done in 2021, and any updates to the source datasets could result in discrepancies in the final reporting values.

For any questions about the methodology and calculations, please contact the lead author Zeng Yiwen ([zengyiwen@nus.edu.sg](mailto:zengyiwen@nus.edu.sg)).

## References

1. T. M. Brooks *et al.*, Measuring Terrestrial Area of Habitat (AOH) and Its Utility for the IUCN Red List. *Trends in Ecology & Evolution* **34**, 977-986 (2019).
2. IUCN, "The IUCN Red List of Threatened Species. Version 2021-1.," (2021).
3. BirdLife International. (BirdLife International, 2021).
4. M. Jung *et al.*, A global map of terrestrial habitat types. *Scientific Data* **7**, 256 (2020).
5. S. E. Fick, R. J. Hijmans, WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. *International journal of climatology* **37**, 4302-4315 (2017).
6. M. Buchhorn *et al.*, Copernicus global land cover layers—collection 2. *Remote Sensing* **12**, 1044 (2020).
7. WDPA, The world database on protected areas (WDPA). (2021).
8. Conservation International and World Wildlife Fund, W. W. F. Conservation International, Ed. (Arlington, VA: Conservation International. Washington, DC: World Wildlife Fund. , 2021), vol. 2022.
9. R. E. G. Kroner *et al.*, The uncertain future of protected lands and waters. *Science* **364**, 881-886 (2019).
10. A. Popp *et al.*, Land-use futures in the shared socio-economic pathways. *Global Environmental Change* **42**, 331-345 (2017).