Data included in the decision support tool

The protected area data

The potential sites currently included in the decision support tool are all registered sites under either one or more of the following criteria:

- a protected area from the global world database in protected areas [1] that is listed by the International Union for Conservation of Nature (IUCN) in either category I or II,
- a natural World Heritage Site (WHS),
- a Key Biodiversity Area (KBA).

The shapefiles for the IUCN protected areas as well as the World Heritage Sites were derived from protected planet[1]. The Shapefiles for the KBAs were derived from BirdLife International [2].

The conservation objectives data

The six different conservation objectives which are included in the decision support tool are biodiversity, ecosystem integrity, climatic stability, land-use stability, climate protection and size. Each of these objectives consists of one or several underlying macro-ecological variables. See below for a detailed description of the variables included within each of the six conservation objectives and how these variables are derived (*Shorter and simpler explanations can be found under the tab "**How to use**"*).

Biodiversity

The biodiversity objective includes three different variables, the total number, the degree of endemism and the evolutionary diversity of the species occurring in the region the site is located in.

<u>Species richness</u>

The species richness, for four taxa of vertebrates, is derived from range maps for virtually all species of the four terrestrial vertebrate taxa: from the BirdLife International for birds [3], the IUCN for mammals and amphibians [4], and from GARD for reptiles [5].

Sites with a higher species richness are allocated a higher suitability for long-term conservation than sites with a lower species richness.

<u>Endemism</u>

To capture biodiversity that is unique to the region, a measure for the prevalence of range restricted (endemic) species within the region is used. Species endemism is estimated by calculating weighted range size rarity, which is the sum of the inverted range extents of all species, divided by the number of species occurring in a protected area [6].

Sites with a higher rate of species endemism are allocated a higher suitability for long-term conservation than sites with a lower rate of species endemism.

<u>*Evolutionary diversity*</u>

Evolutionary diversity is included to have an estimate of how evolutionary unique the species within the region are. Measures of evolutionary diversity can give an idea of how much evolutionary history is stored within a set of species. A high amount of evolutionary history might imply high higher feature diversity across the species within the area and thus, arguably, make a community more resilient to disturbance. Evolutionary diversity is calculated using phylogenetic endemism (PE), which is a combined measure of evolutionary history and the uniqueness of a species community. PE identifies areas with high numbers of evolutionary isolated and geographically restricted species. Additionally to summing the shared evolutionary history of a species assemblage, PE also incorporates the spatial restriction of phylogenetic branches covered by the assemblage [7].

Sites with a higher evolutionary diversity are allocated a higher suitability for long-term conservation than sites with a lower evolutionary diversity.

Wilderness

The wilderness objective includes three different variables, the biodiversity intactness index (BII), the human footprint in and around the site and the change from biome to anthrome in the past two decades.

<u>*Biodiversity intactness index (BII)*</u>

The BII presents the modelled average abundance of present species, relative to the abundance of these species in an intact ecosystem [8]. This means the index gives an indication of how much species abundances in an area have already changed due to anthropogenic impacts e.g. land-use change. For the BII we are using the global map of the Biodiversity Intactness Index calculated by Newbold et al (2016).

Sites with a higher estimated biodiversity intactness are allocated a higher suitability for long-term conservation than sites with a lower biodiversity intactness.

<u>*Human footprint*</u>

As a measure of how pristine the evaluated candidate sites still are, a measure of the human footprint within the area is included. Estimates of the human footprint within protected areas are derived from the standardised human footprint layer by Venter et al (2016) [9], which includes data on the extent of built environments, crop land, pasture land, human population density, night-time lights, railways, roads and navigable waterways.

Sites with a lower human footprint are allocated a higher suitability for long-term conservation than sites with a higher human footprint.

Biome to anthrome shifts

To derive past changes in the land cover of the protected area we calculated the average percentage change across the site from biomes (natural vegetation cover) to anthromes (human-modified land cover such as rainfed cropland, irrigated cropland, mosaic cropland, mosaic natural vegetation and urban areas). The fraction of land cover classes time series, ranging from 1992 – 2018, was obtained from the GEOEssential project [10].

Sites with a lower percentage area that shifted from biome to anthrome are allocated a higher suitability for long-term conservation than sites with a higher percentage area that shifted from biome to anthrome.

Climatic stability

The climatic stability objective consists of two different variables: the projected stability of animal biodiversity and the projected tree cover change under future climate change.

Climatic stability of biodiversity

To estimate the climatic stability of a protected area we are looking at the potential impacts of climate change on the biodiversity within the site. Climate change is driving shifts in species distributions and it is well established that many taxa are shifting their ranges towards higher latitudes and altitudes. But also, idiosyncratic species responses to climate change have been observed. These heterogeneous range shifts have the potential to reshuffle species assemblages, which can have highly unpredictable impacts on species communities (e.g., changes in in prey predator balance or competition). We assume that species assemblages that are not predicted to change a lot in future or experience large species losses are under less risk from climate change than species assemblages that experience a lot of reshuffling. Therefore, we include projected turnover in species under near-future climate change as an indicator for the climatic stability of biodiversity. Projections of species ranges are derived from species distribution models (SDMs; Generalized Additive Models (GAM) and Generalized Boosted regression Models (GBM)), assuming a medium dispersal scenario (allowing dispersal across a distance equal to r/2 of the largest range polygon of a species) (see Hof et al 2018 [11] for a detailed description of the modelling). As dataset for the current climatic conditions (from 1980 – 2009) we used the meteorological forcing dataset EartH2Observe, WFDEI and ERA-Interim data, which were merged and bias-corrected for ISIMIP (EWEMBI [12]). As future climate dataset, we used bias-corrected global climate scenarios produced by ISIMIP phase 2b [13]. We selected four different global climate models (GCMs, MIROC5, GFDL-ESM2M, HadGEM2-ES and IPSL-CM5A-LR) and a medium Representative Concentration Pathway (RCP 6.0) for the analysis. For each protected area all species that are projected to occur there currently and/or in future

(2050) are extracted. The turnover is then calculated between the current and future species assemblage of a protected area, using the formula for Bray Curtis dissimilarity[14].

$$B_{ij} = \frac{2C_{ij}}{S_i + S_j}$$

Where S_i and S_j are the species counts at the two points in time, and C_{ij} the counts for each species found in both sites.
Sites with higher climatic stability (i.e., al lower projected turnover in species) are allocated a higher suitability for long-term conservation than sites with a lower climatic stability.

Forest cover change
We included the projected change in tree cover derived from the LPJ-GUESS process-based dynamic vegetation-terrestrial ecosystem model [15]. The climate input for the model was derived from the ISIMIP2b simulations., described above under climatic stability of biodiversity. The projected change of tree cover is calculated as the average percentage change projected to occur within the site.
Sites with a lower change in the projected tree cover are allocated a higher suitability for long-term conservation than sites with a higher change in projected tree cover.

Land-use stability
To assess the potential impacts projected future land-use change we used predictions of the change in pastures, croplands and biofuel croplands in the buffer zone around the sites (50 km buffer), excluding the site itself.

Projected land-use change
Projected land–use change is derived from the ISIMIP2b simulations of current and future land-use, based on global land-use change models, using the assumptions of population growth and economic development as described in Frieler et al. (2017)[13]. The land-use change models (MAgPIE and REMIND-MAgPIE model [16,17]) accounted for climate impacts (e.g., on crop yields) and were driven with the same climate input as the species distribution models used to derive climatic stability of biodiversity (see above). The ISIMIP land-use scenarios provide percentage cover of six different land-use types (urban areas, rainfed crop, irrigated crop, pastures, as well as rainfed and irrigated bioenergy crops). We averaged annual land-use data for each of two different time periods (1995 and 2050), across the four GCMs (see above under Climatic stability), and calculated a combined value of average land-use change for the buffer zone of each site.

Sites with a lower projected increase in land-use in the buffer zone are allocated a higher suitability for long-term conservation than sites with a higher projected increase in land-use in the buffer zone.

Climate protection

The climate protection objective includes three different variables, using the three dimensions of ecosystem carbon stocks as defined by Goldstein et al. (2020) [18]. These include the amount of manageable carbon stocks that currently exist but could be influenced in principle by human actions, the amount of vulnerable carbon stocks that currently exist and will be released if land-use changes and the amount of irreplaceable carbon stocks in a protected area.

<u>*Baseline (or manageable carbon)*</u>

As an indicator for the climate protection capacity, we used the estimated amount of baseline carbon as provided by Goldstein et al (2020) [18]. This layer includes the amount of carbon stored in the above and below ground as well as the soil organic carbon of an ecosystem. It excludes soil carbon below 30 cm in terrestrial and below 1m in coastal ecosystems as well as the carbon stored in tundras and desert & xeric scrublands as these carbon stocks are not directly influenced by human activities [18]. We derived the average amount of carbon in t per ha for each site.

Sites with higher baseline carbon stocks are allocated a higher suitability for long-term conservation than sites with lower baseline carbon stocks.

<u>*Vulnerable carbon*</u>

Vulnerable carbon is defined, by Goldstein et al (2020) [18] as the amount of the baseline carbon, described above, that is likely to be released through typical land conversion in an ecosystem. We derived the average amount of vulnerable carbon in t per ha for each site.

Sites with higher vulnerable carbon stocks are allocated a higher suitability for long-term conservation than sites with lower vulnerable carbon stocks.

<u>*Irreplaceable carbon*</u>

Irreplaceable carbon is defined as the amount of the vulnerable carbon, described above, that if it is lost through typical land conversion actions, cannot be recovered over the following 30 years [18]. We derived the average amount of irreplaceable carbon in t per ha for each site.

Sites with higher irreplaceable carbon stocks are allocated a higher suitability for long-term conservation than sites with lower irreplaceable carbon stocks.

Large size

For the extent of the area, we preselected sites that are larger than 2000 km^2, based on the precondition that Legacy Landscapes should have a minimum size to maintain a viable ecosystem.

<u>Extent of the site</u>

The Area in km^2 is derived from the site polygons provided by protected planet [1] or the Key Biodiversity Area (KBA) database [2].

Larger sites are allocated a higher suitability for long-term conservation than smaller sites.

More details on how the individual data layers were derived can be found in the accompanying publication (to be released soon).

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