Data included in the decision support tool

The protected area data
The potential sites currently included in the decision support tool belong to either IUCN category I or II, are listed as a natural World Heritage Site (WHS), or registered as 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].
To estimate the potential impacts of projected land-use change around the protected areas, 50 km buffers around the protected areas are used.

The conservation objectives data
The six different conservation objectives which are included in the decision support tool are biodiversity, wilderness, 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.

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 the BirdLife International (birds [3]), IUCN (mammals, amphibians [4]) or GARD (reptiles [5]) range polygons.
Sites with a higher species richness are allocated a higher suitability for long-term conservation than sites with a lower species richness.

<u>Endemic species</u>
To capture unique biodiversity, a measure for the number of range restricted (endemic) species within the region is used. Species endemism is estimated by calculating weighted range size rarity for each grid cell, 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.

Biodiversity intactness index (BII)

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 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.

Human footprint

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 human footprint layer by Venter et al (2016) [9]. We are using the standardised human foot print that is calculated and provided by Venter et al. and 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 (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 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). Under the assumption 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, we are including projected turnover in species as an indicator for the climatic stability of biodiversity. Projections of species ranges are derived from species distribution models (SDMs; GAM and GBM), assuming a medium dispersal scenario (allowing dispersal across a distance equal to r/2 of the largest range polygon of a species) and a medium concentration pathway (RCP 6.0) (see Hof et al 2018[11] for a detailed description of the modelling). 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[12].

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

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 a higher suitability for long-term conservation than sites with a lower climatic stability.

<u>Forest cover change</u>
We included the projected change in tree cover derived from the LPJ-GUESS process-based dynamic vegetation-terrestrial ecosystem model. The climate input for the model was derived from the ISIMIP2b simulations. The projected change of tree cover is provided as percentage per grid cell. We calculated the mean percentage change in tree cover per site based on the percentage overlap of the site polygon with the underlying grid cells.
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).

<u>Projected land-use change</u>
Projected land–use change is derived from the ISIMIP2b simulations of current and future land-use, based on the MAgPIE and REMIND-MAgPIE model (Popp et al 2014 and 2016, Stevanovic et al 2016[13,14]), using the assumptions of population growth and economic development as described in Frieler et al. (2017)[15]. Land-use change models 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 the two different time periods (1995 and 2050), across the four GCMs, and calculated a combined value of land-use change per grid cell.
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) [16]. These include the amount of manageable carbon stocks that can be influenced by human actions, the amount of vulnerable carbon stocks 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) [16]. 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 [16]. 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) [16] as the amount of (baseline) carbon 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 carbon, that if it is lost through typical land conversion actions, cannot be recovered over the following 30 years [16]. 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.

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