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wdpar: Interface to the World Database on Protected Areas

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Software

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Summary

The `wdpar` `R` package provides an interface to data available on Protected Planet (https://www.protectedplanet.net). It can be used to access the World Database on Protected Areas (WDPA) and the World Database on Other Effective Area-Based Conservation Measures (WDOECM). Additionally, it provides data cleaning procedures to prepare these databases for analysis. These data cleaning procedures are essential for ensuring correct results when using the databases. As a software package for the `R` statistical computing environment, it can easily be integrated into workflows and spatial analyses. The package has applications for conservation research. It has been used to assess performance of existing protected areas and account for such areas when identifying priority areas for conservation efforts.

Statement of need

Area-based conservation measures are crucial for safeguarding biodiversity (Dudley et al., 2018; Watson et al., 2014). Examples of such measures include protected areas, marine reserves, and other effective area-based conservation measures (OECMs). Protected Planet is a key resource for area-based conservation measures, providing the World Database on Protected Areas (WDPA) and the World Database on Other Effective Area-Based Conservation Measures (WDOECM) (UNEP-WCMC & IUCN, 2022). These publicly available databases contain standardized data for over 270,000 protected areas and over 800 OECMs worldwide (UNEP-WCMC & IUCN, 2022). By detailing the designation, establishment, management, and spatial boundaries of area-based conservation measures (UNEP-WCMC, 2019), these databases play a vital role in monitoring and prioritizing conservation efforts (Bingham et al., 2019; Butchart et al., 2015).

The WDPA and WDOECM require data cleaning procedures to prepare them for analysis (Butchart et al., 2015; Protected Planet, 2021). These procedures include excluding areas that have yet to be fully implemented, areas that are no longer designated, and UNESCO Biosphere Reserves (Coetzer et al., 2014). They also include geoprocessing procedures, such as repairing invalid geometries in spatial boundaries, buffering areas represented by point localities (Visconti et al., 2013), and removing spatial overlaps (Deguignet et al., 2017). Specifically, overlapping geometries are erased such that areas associated with more effective management categories are retained (Runge et al., 2015) and – in cases where geometries with the same management category overlap – areas associated with historical precedence are retained. These procedures are critical to ensure accuracy in assessments of area-based conservation measures (Coetzer et al., 2014; Deguignet et al., 2017). Yet, despite their importance, these procedures can be challenging to implement.

The `wdpar` `R` package provides automated methods to obtain and clean the WDPA and WDOECM. The data cleaning procedures implemented in the package follow best practices (Butchart et al., 2015; Protected Planet, 2021) and can be performed without specialized

knowledge, customized to particular use cases, and applied to the global scale. By providing this functionality, the package aims to increase accessibility to the WDPA and WDOECM.

Applications

The `wdpar` R package is designed to provide a reproducible tool for downloading and cleaning the WDPA and WDOECM. Although the default settings for the data cleaning procedures are well-suited for national scale reporting of protected area coverage, they can be customized for other applications. For example, the precision of spatial data processing procedures can be increased so that they are suitable for local scale analyses. This is especially important because the default precision may remove smooth edges at fine scales. Additionally, the data cleaning procedures can be customized to retain protected areas regardless of their status which, in turn, could be useful for monitoring and evaluation of protected area effectiveness.

The `wdpar` R package has several applications for conservation research. For example, it has been used to assess the performance of existing protected areas in Colombia, Greece, and South Asia (Chowdhury et al., 2021; Gonzalez et al., 2022; Kougioumoutzis et al., 2021; Panitsa et al., 2021). It has also been used to examine the potential implications of climate change on conservation efforts (Kougioumoutzis et al., 2022; Mothes et al., 2020). Additionally, it has been used to account for existing protected areas when identifying priority areas for biodiversity conservation (J. O. Hanson et al., 2020). Furthermore, it has been used to help understand how protected area management by Indigenous Peoples can reduce deforestation (Sze et al., 2022).

Comparison with other software packages

The `wdpar` R package provides superior functionality for processing Protected Planet data compared with other software packages. Although the `rwdpa` R package, `worldpa` R package, and the `pywdpa` Python package provide interfaces for downloading data from Protected Planet (Casajus, 2021; Chamberlain, 2017; Vieilledent, 2021), none of these software packages provide functionality for data cleaning. Additionally, the `rwdpa` R package has been archived. A command line tool was also developed to download and clean Protected Planet data (J. O. Hanson, 2017). However, because the command line tool was implemented as a collection of Python scripts and configuration files, it is difficult to install and customize.

Case study

Here I provide a short case study to showcase usage of the `wdpar` R package. This case study examines the protected area system of Malta. It involves (i) loading the package, (ii) downloading data from Protected Planet (UNEP-WCMC & IUCN, 2022), (iii) cleaning the protected area data following best practices (Butchart et al., 2015; Protected Planet, 2021), and (iv) calculating the number of protected areas associated with each IUCN management category, and (v) producing a map of the protected area system (Figures 1 and 2). Analyses were performed using the R statistical computing environment (version 4.2.1) and the `sf` and `wdpar` R packages (Pebesma, 2018; R Core Team, 2022).

```r
# (i) load package
library(wdpar)
#> Loading required package: sf
#> Linking to GEOS 3.10.2, GDAL 3.4.1, PROJ 8.2.1; sf_use_s2() is TRUE

# (ii) download data
d <- wdpa_fetch("Malta")

# (iii) clean data
d <- wdpa_clean(d)
#> ✔ initializing [75ms]
#> ✔ retaining only areas with specified statuses [41ms]
#> ✔ removing UNESCO Biosphere Reserves [62ms]
#> ✔ removing points with no reported area [37ms]
#> ✔ wrapping dateline [425ms]
#> ✔ repairing geometry [1.1s]
#> ✔ reprojecting data [65ms]
#> ✔ repairing geometry [583ms]
#> ✔ further geometry fixes (i.e. buffering by zero) [144ms]
#> ✔ repairing geometry [506ms]
#> ✔ snapping geometry to tolerance [101ms]
#> ✔ repairing geometry [564ms]
#> ✔ formatting attribute data [31ms]
#> ✔ removing slivers [122ms]
#> ✔ calculating spatial statistics [116ms]

# (iv) report number of protected areas in each IUCN category
table(d$IUCN_CAT)
#> Ia   II   III   IV   Not Reported   V   VI
#> 2    1    6     186  69             14  1

# (v) create a map showing the protected areas
# N.B., colors denote different IUCN categories
pal <- c("#FDE725FF", "#8FD744FF", "#35B779FF", "#21908CFF",
         "#31688EFF", "#443A83FF", "#440154FF")
plot(d[, "IUCN_CAT"], main = NA, pal = pal, graticule = TRUE,
     axes = TRUE, key.pos = 1L, key.length = 0.9)
```

Figure 1: Case study for the wdpar R package. Text denotes R programming code. Lines beginning with a # symbol denote comments, and lines beginning with #> symbols denote outputs from executing the code.

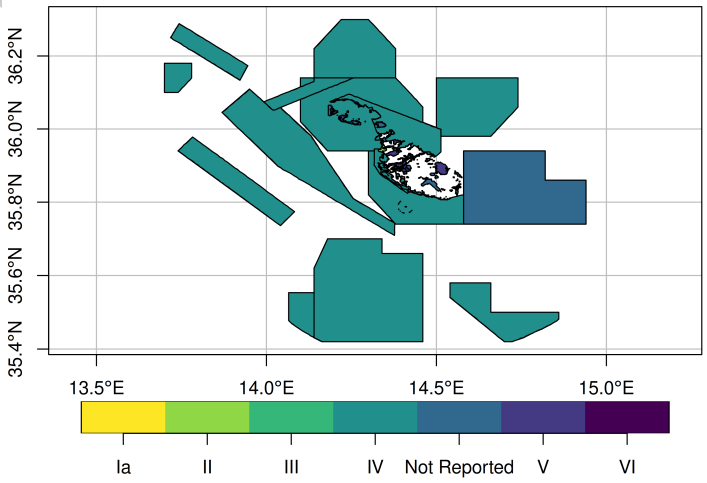

Figure 2: Map of protected areas in Malta. Colors denote IUCN management categories.

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Availability

The wdpar R package is implemented as a software package for R statistical computing environment (R Core Team, 2022). It is available on the Comprehensive R Archive Network (CRAN) (J. O. Hanson, 2021). Developmental versions are available on an online code repository (https://github.com/prioritizr/wdpar). Documentation for the package is also available online (https://prioritizr.github.io/wdpar).

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Conflict of interest

The author declares no conflict of interest.

References

Bingham, H. C., Juffe Bignoli, D., Lewis, E., MacSharry, B., Burgess, N. D., Visconti, P., Deguignet, M., Misrachi, M., Walpole, M., Stewart, J. L., & others. (2019). Sixty years of tracking conservation progress using the World Database on Protected Areas. *Nature Ecology and Evolution*, *3*(5), 737–743. https://doi.org/10.1038/s41559-019-0869-3

Butchart, S. H. M., Clarke, M., Smith, R. J., Sykes, R. E., Scharlemann, J. P. W., Harfoot, M., Buchanan, G. M., Angulo, A., Balmford, A., Bertzky, B., Brooks, T. M., Carpenter, K. E., Comeros-Raynal, M. T., Cornell, J., Ficetola, G. F., Fishpool, L. D. C., Fuller, R. A., Geldmann, J., Harwell, H., … Burgess, N. D. (2015). Shortfalls and solutions for meeting national and global conservation area targets. *Conservation Letters*, *8*(5), 329–337. https://doi.org/10.1111/conl.12158

Casajus, N. (2021). *worldpa: An Interface to the World Database on Protected Areas (WDPA)*. R package version 2.1.0. https://github.com/frbcesab/worldpa

Chamberlain, S. (2017). *rwdpa: World Database of Protected Areas Client*. R package version 0.0.8.9713. https://github.com/ropenscilabs/rwdpa

Chowdhury, S., Alam, S., Labi, M. M., Khan, N., Rokonuzzaman, M., Biswas, D., Tahea, T., Mukul, S. A., & Fuller, R. A. (2021). Protected areas in South Asia: Status and prospects. *Science of the Total Environment*, 152316. https://doi.org/10.1016/j.scitotenv.2021.152316

Coetzer, K. L., Witkowski, E. T. F., & Erasmus, B. F. N. (2014). Reviewing biosphere reserves globally: Effective conservation action or bureaucratic label? *Biological Reviews*, *89*(1), 82–104. https://doi.org/10.1111/brv.12044

Deguignet, M., Arnell, A., Juffe-Bignoli, D., Shi, Y., Bingham, H., MacSharry, B., & Kingston, N. (2017). Measuring the extent of overlaps in protected area designations. *PloS One*, *12*(11), e0188681. https://doi.org/10.1371/journal.pone.0188681

Dudley, N., Jonas, H., Nelson, F., Parrish, J., Pyhälä, A., Stolton, S., & Watson, J. E. M. (2018). The essential role of other effective area-based conservation measures in achieving big bold conservation targets. *Global Ecology and Conservation*, *15*, e00424. https://doi.org/10.1016/j.gecco.2018.e00424

Gonzalez, B., Brook, F., & Martin, G. M. (2022). Updated distribution and conservation perspectives of marmosine opossums from Colombia. *Hystrix, the Italian Journal of Mammalogy*, *33*, 0. https://doi.org/10.4404/hystrix-00489-2021

Hanson, J. O. (2017). *Global protected areas*. Version 1.0.6. Zenodo. https://doi.org/10.5281/zenodo.256882

Hanson, J. O. (2021). *wdpar: Interface to the World Database on Protected Areas*. R package version 1.3.2. https://CRAN.R-project.org/package=wdpar

Hanson, J. O., Marques, A., Veríssimo, A., Camacho-Sanchez, M., Velo-Antón, G., Martínez-Solano, Í., & Carvalho, S. B. (2020). Conservation planning for adaptive and neutral evolutionary processes. *Journal of Applied Ecology*, *57*(11), 2159–2169. https://doi.org/10.1111/1365-2664.13718

Kougioumoutzis, K., Kaloveloni, A., & Petanidou, T. (2022). Assessing climate change impacts on island bees: The Aegean archipelago. *Biology*, *11*(4), 552. https://doi.org/10.3390/biology11040552

Kougioumoutzis, K., Kokkoris, I. P., Panitsa, M., Strid, A., & Dimopoulos, P. (2021). Extinction risk assessment of the Greek endemic flora. *Biology*, *10*(3), 195. https://doi.org/10.3390/biology10030195

Mothes, C. C., Howell, H. J., & Searcy, C. A. (2020). Habitat suitability models for the imperiled wood turtle (*Glyptemys insculpta*) raise concerns for the species' persistence under future climate change. *Global Ecology and Conservation*, *24*, e01247. https://doi.org/10.1016/j.gecco.2020.e01247

Panitsa, M., Kokkoris, I. P., Kougioumoutzis, K., Kontopanou, A., Bazos, I., Strid, A., & Dimopoulos, P. (2021). Linking taxonomic, phylogenetic and functional plant diversity with ecosystem services of cliffs and screes in Greece. *Plants*, *10*(5), 992. https://doi.org/10.3390/plants10050992

Pebesma, E. (2018). Simple features for R: Standardized support for spatial vector data. *The R Journal*, *10*(1), 439–446. https://doi.org/10.32614/RJ-2018-009

Protected Planet. (2021). *Calculating protected and OECM area coverage*. https://www.protectedplanet.net/en/resources/calculating-protected-area-coverage

R Core Team. (2022). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. https://www.R-project.org/

Runge, C. A., Watson, J. E. M., Butchart, S. H., Hanson, J. O., Possingham, H. P., & Fuller, R. A. (2015). Protected areas and global conservation of migratory birds. *Science*, *350*(6265), 1255–1258. https://doi.org/10.1126/science.aac9180

Sze, J. S., Carrasco, L. R., Childs, D., & Edwards, D. P. (2022). Reduced deforestation and degradation in Indigenous Lands pan-tropically. *Nature Sustainability*, *5*(2), 123–130. https://doi.org/10.1038/s41893-021-00815-2

UNEP-WCMC. (2019). *User manual for the World Database on Protected Areas and world database on other effective area-based conservation measures: 1.6*. Cambridge, UK: UNEP-WCMC. http://wcmc.io/WDPA_Manual

UNEP-WCMC, & IUCN. (2022). *Protected Planet: The World Database on Protected Areas (WDPA) and World Database on Other Effective Area-based Conservation Measures (WD-OECM) [Online]*. September 2022, Cambridge, UK: UNEP-WCMC and IUCN. www.protectedplanet.net

Vieilledent, G. (2021). *ghislainv/pywdpa: pywdpa v0.1.5 (v0.1.5)*. Zenodo. https://doi.org/10.5281/zenodo.4601607

Visconti, P., Di Marco, M., Álvarez-Romero, J. G., Januchowski-Hartley, S. R., Pressey, R. L., Weeks, R., & Rondinini, C. (2013). Effects of errors and gaps in spatial data sets on assessment of conservation progress. *Conservation Biology*, *27*(5), 1000–1010. https://doi.org/10.1111/cobi.12095

Watson, J. E. M., Dudley, N., Segan, D. B., & Hockings, M. (2014). The performance and potential of protected areas. *Nature*, *515*(7525), 67–73. https://doi.org/10.1038/nature13947