

# Data and Code for: "Private Management of African Protected Areas Improves Wildlife and Tourism Outcomes but with Security Concerns in Conflict Regions"

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## Data Availability Statement

### Boundaries of protected areas

The paper uses public World Database on Protected Areas (WDPA) data. The data were downloaded on January 19, 2023 from <https://www.protectedplanet.net/en/thematic-areas/wdpa?tab=WDPA>. These data can't be redistributed in the reproducibility package. Users must download the data file to be able to reproduce the paper results.

N	Location	Files
1	Data/WPA/File0	All files in WDPA_Jun2023_Public_shp_0.zip
2	Data/WPA/File1	All files in WDPA_Jun2023_Public_shp_1.zip
3	Data/WPA/File2	All files in WDPA_Jun2023_Public_shp_2.zip

A few protected area boundaries do not appear in the WDPA data, so we obtained the following:

- Chinko shapefile from Reece Thornley by email on February 2, 2023 and saved in data/chinko folder;
- Siniaka Minia shapefile from Mathias D'haen by email on September 27, 2023 and saved in data/Siniaka\_Minia\_Reserve folder;
- Ennedi boundary downloaded on September 19, 2023 from <https://whc.unesco.org/en/documents/143294> and saved in data/ennedi;
- Luengue and Mavinga boundaries drawn from <https://www.tandfonline.com/doi/epdf/10.2989/10220119.2023.2208626?needAccess=true> on October 20, 2023 and saved in data/Luengue-shapefile and data/mavinga-shapefile folders, respectively.

In addition, the files ap\_df.csv, anchor\_protected\_areas.xlsx, and PA-management.xlsx are public files created by the authors following the processes and for the purposes described in Section 4 of the paper (Methods).

### MIKE data

The paper uses public data from the Monitoring the Illegal Killing of Elephants (MIKE) program. We downloaded the annual poaching data on January 16, 2023 from <https://cites.org/eng/prog/mike/index.php/portal#Access%20to%20MIKE%20Data>. The file url was [https://cites.org/sites/default/files/MIKE/data/Numbers\\_Carcasses\\_eachMIKESite\\_year\\_2022-03-31.xlsx](https://cites.org/sites/default/files/MIKE/data/Numbers_Carcasses_eachMIKESite_year_2022-03-31.xlsx).

We saved the data in data/Numbers\_Carcasses\_eachMIKESite\_year\_2022-03-31.xlsx. We received MIKE site boundaries by email from a MIKE employee on February 11, 2022 and saved the file in data/2021\_10\_29\_Mike\_Boundary/2021\_10\_29\_MIKE\_Boundary\_shp\_wgs6.shp.

### eBird

The paper uses public data from eBird. We downloaded the eBird basic data from the eBird website country by country on April 10, 2023. Downloading the data requires making a free account: <https://science.ebird.org/en/use-ebird-data/download-ebird-data-products>. We saved the data in data/ebird folder and data/other\_ebird folder. Each country's raw data is its own .txt file in that folder. These data can't be redistributed in the reproducibility package. Users must download each data file to be able to reproduce the paper results.

N	Location	File
1	Data/ebird	ebd_AO_relFeb-2023.txt
2	Data/ebird	ebd_BF_relFeb-2023.txt
3	Data/ebird	ebd_BI_relFeb-2023.txt
4	Data/ebird	ebd_BJ_relFeb-2023.txt
5	Data/ebird	ebd_BW_relFeb-2023.txt
6	Data/ebird	ebd_CD_relFeb-2023.txt
7	Data/ebird	ebd_CF_relFeb-2023.txt
8	Data/ebird	ebd_CG_relFeb-2023.txt
9	Data/ebird	ebd_CI_relFeb-2023.txt
10	Data/ebird	ebd_CM_relFeb-2023.txt
11	Data/ebird	ebd_ER_relFeb-2023.txt
12	Data/ebird	ebd_ET_relFeb-2023.txt
13	Data/ebird	ebd_GA_relFeb-2023.txt
14	Data/ebird	ebd_GH_relFeb-2023.txt
15	Data/ebird	ebd_GN_relFeb-2023.txt
16	Data/ebird	ebd_GQ_relFeb-2023.txt
17	Data/ebird	ebd_KE_relFeb-2023.txt
18	Data/ebird	ebd_LR_relFeb-2023.txt
19	Data/ebird	ebd_LS_relFeb-2023.txt
20	Data/ebird	ebd_MG_relFeb-2023.txt
21	Data/ebird	ebd_MW_relFeb-2023.txt
22	Data/ebird	ebd_MZ_relFeb-2023.txt
23	Data/ebird	ebd_NA_relFeb-2023.txt
24	Data/ebird	ebd_NE_relFeb-2023.txt
25	Data/ebird	ebd_NG_relFeb-2023.txt
26	Data/ebird	ebd_RW_relFeb-2023.txt
27	Data/ebird	ebd_SD_relFeb-2023.txt
28	Data/ebird	ebd_SN_relFeb-2023.txt
29	Data/ebird	ebd_SS_relFeb-2023.txt
30	Data/ebird	ebd_TD_relFeb-2023.txt
31	Data/ebird	ebd_TG_relFeb-2023.txt
32	Data/ebird	ebd_TZ_relFeb-2023.txt
33	Data/ebird	ebd_UG_relFeb-2023.txt

34	Data/ebird	ebd_ZA_relFeb-2023.txt
35	Data/ebird	ebd_ZM_relFeb-2023.txt
36	Data/ebird	ebd_ZW_relFeb-2023.txt
37	Data/other_ebird	ebd_CV_199801_202212_smp_relSep-2023.txt
38	Data/other_ebird	ebd_DJ_199801_202212_smp_relSep-2023.txt
39	Data/other_ebird	ebd_DZ_199801_202212_smp_relSep-2023.txt
40	Data/other_ebird	ebd_EG_199801_202212_smp_relSep-2023.txt
41	Data/other_ebird	ebd_GM_199801_202212_smp_relSep-2023.txt
42	Data/other_ebird	ebd_GW_199801_202212_smp_relSep-2023.txt
43	Data/other_ebird	ebd_KM_199801_202212_smp_relSep-2023.txt
44	Data/other_ebird	ebd_LY_199801_202212_smp_relSep-2023.txt
45	Data/other_ebird	ebd_MA_199801_202212_smp_relSep-2023.txt
46	Data/other_ebird	ebd_ML_199801_202212_smp_relSep-2023.txt
47	Data/other_ebird	ebd_MR_199801_202212_smp_relSep-2023.txt
48	Data/other_ebird	ebd_MU_199801_202212_smp_relSep-2023.txt
49	Data/other_ebird	ebd_SC_199801_202212_smp_relSep-2023.txt
50	Data/other_ebird	ebd_SL_199801_202212_smp_relSep-2023.txt
51	Data/other_ebird	ebd_SO_199801_202212_smp_relSep-2023.txt
52	Data/other_ebird	ebd_ST_199801_202212_smp_relSep-2023.txt
53	Data/other_ebird	ebd_SZ_199801_202212_smp_relSep-2023.txt
54	Data/other_ebird	ebd_TN_199801_202212_smp_relSep-2023.txt

### **iNaturalist**

The paper uses public data from iNaturalist. The data were downloaded by running scripts/make\_data/download\_inaturalist.R between March 1 and 16, 2023. The data downloaded by this script are saved in data/iNaturalist folder. Re-running download\_inaturalist.R at later date may produce slightly different results if iNaturalist updates the underlying data in the interim (e.g., iNaturalist users upload additional historical data). To guarantee reproducibility, the script running the data wrangling (main\_make\_data.R) only runs scripts/make\_data/make\_inatdf\_and\_inat\_visits\_df.R, which loads the iNaturalist data downloaded by download\_inaturalist.R in March 2023. The script downloading iNaturalist data is provided in the reproducibility package for reference.

### **Atlas AI**

The paper uses non-public asset wealth data from Atlas AI, which were obtained on July 14, 2023. These data are only obtainable by agreement with Atlas AI. However, we are able to share derived data for the asset wealth values for each protected area and year in our study (output/data/asset\_wealth\_df.Rdata), along with the code used to derive these values from the raw data (scripts/make\_data/make\_asset\_wealth\_df.R).

### **ACLED**

The paper uses public conflict data from ACLED. The data were downloaded and saved into a derived dataset by running scripts/make\_conflict.R on April 4, 2024. We saved the derived dataset as output/data/conflict\_panel.RData. Re-running make\_conflict.R at a later date may

produce slightly different results if ACLED updates the underlying data in the interim. To guarantee reproducibility, the code only loads "output/data/conflict\_panel.RData" and continues from there. The portion of the code that downloads the data is commented-out in the script.

### **Populated Places from Natural Earth**

The paper uses public data on Populated Places from Natural Earth. We downloaded version 5.1.2 from <https://www.naturalearthdata.com/downloads/10m-cultural-vectors/10m-populated-places/> on September 18, 2023. The file url was [https://www.naturalearthdata.com/http://www.naturalearthdata.com/download/10m/cultural/ne\\_10m\\_populated\\_places.zip](https://www.naturalearthdata.com/http://www.naturalearthdata.com/download/10m/cultural/ne_10m_populated_places.zip). We saved the data in data/ne\_10m\_populated\_places folder.

### **METT data**

The paper uses public Mechanisms and Management Effectiveness Tracking Tool (METT) data. The data were received from Jonas Geldman by email on May 1, 2023. The data are data/2023\_05\_01\_METT\_1\_3\_scores.csv and data/2023\_05\_04\_METT\_1\_3\_GEF\_assessors.xlsx

### **ERA5 weather data**

The paper uses public ERA5 weather data. The data were downloaded and processed in Google Earth Engine on May 1, 2023; the script can be found in scripts/make\_data/calculate\_dd\_precip.txt. The processed data can be found in output/data/era5 folder.

## **Computational Requirements**

### **Software and Hardware Requirements**

With one exception, we used R for everything. We used R Version 4.1.2. Other versions might produce slightly different results. The one exception is we created the weather data in Google Earth Engine. This script is included in the reproducibility package for reference but is not sourced by the main scripts. To reproduce the results, users need to install all the necessary libraries, open the RStudio project file "African-parks.Rproj" in RStudio, and run the scripts "main-make-data.R" and "main-figures-tables.R".

An optional environment file for renv is also included (renv.lock). This will allow replicators to recreate the exact programming environment in which results are verified to be reproduced. To enable the optional environment, follow these steps:

1. If you don't have RTools, install it from: <https://cran.r-project.org/bin/windows/Rtools/>
2. Open the RStudio project file "african-parks.Rproj" in RStudio
3. run the code: `renv::restore()` of line 7 of the main script "main-make-data.R". If prompted to install any package, reply Yes.

The authors used Windows 10 Enterprise. Other versions of Windows, as well as Mac and Linux, should work too. Note that OS other than Windows will need a different version of RTools than the one linked above.

The results of the paper were created in a computer with these specifications:

- CPU: We have Intel(R) Xeon(R) Gold 6132 CPU @ 2.60GHz 2.60GHz (2 processors). This equates to 16 cores.
- -Installed RAM: 256 GB

Running the script “make\_fig1.R” requires a valid Google Maps API key for line 53. Lines 41-51 of that script contain instructions on how to get one.

### **Description of programs/code**

Files in scripts/make\_data folder make the object(s) described in the title of the script. For example, “make\_park\_shapes.R” creates the object “park\_shapes.Rdata”.

Files in scripts/make\_figures\_tables create the figure(s) and/or table(s) listed in the script name. For example, “make\_fig\_3.R” creates “fig\_3.pdf”.

### **Downloading and opening the replication files**

Download the replication files as a zip file, extract them, open RStudio, click File -> Open Project, find “african-parks.Rproj” among the files on your computer, and click Open.

### **Data preparation**

Run the script in “scripts/main-make-data.R” first. Some of the scripts it sources take several hours to 1 day to run (calculate\_dd\_precip, download\_inaturalist, make\_ebirddf\_and\_ebird\_visits). The remaining scripts are fast to run (several minutes to less than 1 hour). All output files from make\_data scripts are saved in the output/data folder.

### **Analysis**

Run “scripts/main-figures-tables.R” to run the analysis. Analysis scripts are fast to run (usually no more than several minutes each).