

## Release Statement

### Gridded population estimates for Ukraine using UN COD-PS estimates 2020, version 1.0

14 March 2022

These data were produced by the WorldPop Research Group at the University of Southampton. These data include gridded estimates of population at approximately 100m and 1km resolution for 2020, along with estimates of the number of people belonging to individual age-sex groups. These results were produced using Subnational Population Statistics 2020 for Ukraine provided in the Common Operational Dataset on Population Statistics ([COD-PS](#)) and ORNL LandScan HD for Ukraine 2022 [settlement layer](#). The datasets are produced using the "[top-down](#)" method, with both the [unconstrained and constrained](#) top-down disaggregation methods used to produce two different datasets. The modelling work and geospatial data processing was led by Bondarenko M., Sorichetta A. and Leasure DR. Oversight was provided by Andrew J. Tatem. Attila N. Lazar and Édith Darin provided internal WorldPop peer reviews that helped to improve the results and documentation.

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*The authors followed rigorous procedures designed to ensure that the used data, the applied method and thus the results are appropriate and of reasonable quality. If users encounter apparent errors or misstatements, they should contact WorldPop at [release@worldpop.org](mailto:release@worldpop.org).*

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## CITATION

Bondarenko M., Sorichetta A., Leasure DR. and Tatem AJ. 2022 *Gridded population estimates for Ukraine using UN COD-PS estimates 2020, version 1.0*. WorldPop, University of Southampton. doi:10.5258/SOTON/WP00734.

## MAIN DATA SOURCES

- ORNL LandScan HD for Ukraine 2022 settlement layer [1].
- Subnational Population Statistics for Ukraine provided in the Common Operational Dataset on Population Statistics (COD-PS) [2]. The subnational population statistics were estimated using baseline information from the 2001 Population Census of Ukraine and annual birth and death registration data since the last census.
- Subnational Administrative Boundaries for Ukraine provided by OCHA [3].
- Geospatial covariate layers available at WorldPop [4].

## RELEASE CONTENT

1. ukr\_pop\_2020\_100m\_unconstrained\_v1\_0.tif
2. ukr\_pop\_2020\_100m\_constrained\_v1\_0.tif
3. ukr\_pop\_2020\_1km\_unconstrained\_v1\_0.tif
4. ukr\_pop\_2020\_1km\_constrained\_v1\_0.tif

5. ukr\_agesex\_2020\_100m\_unconstrained\_v1\_0.zip
6. ukr\_agesex\_2020\_100m\_constrained\_v1\_0.zip
7. ukr\_agesex\_2020\_1km\_unconstrained\_v1\_0.zip
8. ukr\_agesex\_2020\_1km\_constrained\_v1\_0.zip
9. ukr\_agesex\_0\_18\_2020\_1km\_unconstrained\_v1\_0.zip
10. ukr\_agesex\_0\_18\_2020\_1km\_constrained\_v1\_0.zip

## FILE DESCRIPTIONS

The projection for all GIS files is the geographic coordinate system WGS84 (World Geodetic System 1984).

### **ukr\_pop\_2020\_100m\_unconstrained\_v1\_0.tif**

This geotiff raster, at a spatial resolution of 3 arc-seconds (approximately 100m at the equator), contains estimates of total population size per grid cell across Ukraine. NA values represent areas that were mapped as water. These data are stored as floating-point numbers rather than integers to avoid rounding errors in aggregated populations for larger areas.

### **ukr\_pop\_2020\_100m\_constrained\_v1\_0.tif**

This geotiff raster, at a spatial resolution of 3 arc-seconds (approximately 100m at the equator), contains estimates of total population size per grid cell across Ukraine. NA values represent areas that were mapped as unsettled based on ORNL LandScan HD for Ukraine [1]. These data are stored as floating-point numbers rather than integers to avoid rounding errors in aggregated populations for larger areas.

### **ukr\_pop\_2020\_1km\_unconstrained\_v1\_0.tif**

This geotiff raster, at a spatial resolution of 30 arc-seconds (approximately 1km at the equator), contains estimates of total population size per grid cell across Ukraine. NA values represent areas that were mapped as water. The dataset was produced by aggregating *ukr\_pop\_2020\_100m\_unconstrained\_v1\_0.tif* dataset to 1km.

### **ukr\_pop\_2020\_1km\_constrained\_v1\_0.tif**

This geotiff raster, at a spatial resolution of 30 arc-seconds (approximately 1km at the equator), contains estimates of total population size per grid cell across Ukraine. NA values represent areas that were mapped as unsettled based on ORNL LandScan HD for Ukraine [1]. The dataset was produced by aggregating *ukr\_pop\_2020\_100m\_constrained\_v1\_0.tif* dataset to 1km.

### **ukr\_agesex\_2020\_100m\_unconstrained\_v1\_0.zip**

This zip file contains 34 rasters in geotiff format at a spatial resolution of 3 arc-seconds (approximately 100m at the equator). Each raster provides gridded population estimates for an age-sex group across Ukraine (NA represent surface waters). Files are labelled with either an "M" (male) or an "F" (female) followed by the age-range of the group (five year bins). For instance, "F\_00\_04" and "M\_05\_09" are population counts of under 5 year olds for females and between 5 and 9 years old for males, respectively. Eighty year olds and over are represented in the groups "F\_80Plus" and "M\_80Plus". These data were produced using age-sex national proportions from COD-PS [2]. The age-sex proportions were applied to the gridded population estimates (*ukr\_pop\_2020\_100m\_unconstrained\_v1\_0*) to allocate the population to the different age-sex classes. While this data represents population counts, values contain decimals, i.e. fractions of people. This is because we do not estimate which grid cell each individual in a given age group occupies. For this reason, it is advised to aggregate the rasters at a coarser scale. For example, if four grid cells next to each other have values of 0.25 this indicates that there is 1 person of that age group somewhere in those four grid cells.

### **ukr\_agesex\_2020\_100m\_constrained\_v1\_0.zip**

This zip file contains 34 raster files in geotiff format at a spatial resolution of 3 arc-seconds (approximately 100m at the equator). Each raster provides gridded population estimates for an age-sex group of settled areas (NA represent unsettled areas). Files are labelled with either an "M" (male) or an "F" (female) followed

by the age-range of the group (five year bins). For instance, “F\_00\_04” and “M\_05\_09” are population counts of under 5 year olds for females and between 5 and 9 years old for males, respectively. Eighty year olds and over are represented in the groups “F\_80Plus” and “M\_80Plus”. These data were produced using age-sex national proportions from COD-PS [2]. The age-sex proportions were applied to the gridded population estimates (*ukr\_pop\_2020\_100m\_constrained\_v1\_0*) to allocate the population to the different age-sex classes. While this data represents population counts, values contain decimals, i.e. fractions of people. This is because we do not estimate which grid cell each individual in a given age group occupies. For this reason, it is advised to aggregate the rasters at a coarser scale. For example, if four grid cells next to each other have values of 0.25 this indicates that there is 1 person of that age group somewhere in those four grid cells.

#### **ukr\_agesex\_2020\_1km\_unconstrained\_v1\_0.zip**

This zip file contains 34 raster files in geotiff format at a spatial resolution of 30 arc-seconds (approximately 1km at the equator). Each raster provides gridded population estimates for an age-sex group across Ukraine (NA represent surface waters). These datasets were produced by aggregating *ukr\_agesex\_2020\_100m\_unconstrained\_v1\_0* datasets respectively to 1km.

#### **ukr\_agesex\_2020\_1km\_constrained\_v1\_0.zip**

This zip file contains 34 rasters in geotiff format at a spatial resolution of 30 arc-seconds (approximately 1km at the equator). Each raster provides gridded population estimates for an age-sex group of settled areas (NA represent unsettled areas). These datasets were produced by aggregating *ukr\_agesex\_2020\_100m\_constrained\_v1\_0* datasets respectively to 1km.

#### **ukr\_agesex\_0\_18\_2020\_1km\_unconstrained\_v1\_0.zip**

This zip file contains 3 rasters in geotiff format at a spatial resolution of 30 arc-seconds (approximately 1km at the equator). Each raster provides gridded population estimates for children-age (0 to 18 years old) across Ukraine (NA represent surface waters). Files are labelled with either an “M” (male) or an “F” (female) or “F\_M” for both male and female. These data were created by applying the Sprague multipliers [5] to “*ukr\_agesex\_2020\_1km\_unconstrained*” raster data. The Sprague multiplier is used to interpolate five-year binned data and obtain population estimates by single years that are then aggregated to 0 to 18 years of age.

#### **ukr\_agesex\_0\_18\_2020\_1km\_constrained\_v1\_0.zip**

This zip file contains 3 rasters in geotiff format at a spatial resolution of 30 arc-seconds (approximately 1km at the equator). Each raster provides gridded population estimates for children-age (0 to 18 years old) of settled areas (NA represent unsettled areas). Files are labelled with either an “M” (male) or an “F” (female) or “F\_M” for both male and female. These data were created by applying the Sprague multipliers to “*ukr\_agesex\_2020\_1km\_constrained*” raster data. The Sprague multipliers is used to interpolate data and obtain population estimates by single years of age and that are then aggregated to 0 to 18 years of age.

## **METHODS**

**Pre-processing:** Subnational Administrative Boundaries provided by OCHA were nibbled (i.e. cells with no data are replaced with the values of the nearest neighbors.) to match WorldPop mastergrid and avoid mismatch with the WorldPop covariates.

**Modelling:** Following the Random Forest (RF)-based dasymetric mapping approach (Stevens et al., 2015 [7]), the popRF ‘R’ package [6] based on Breiman (2001) [8] algorithm was used to produce a population weighting surface as a combination of the geospatial covariates (APPENDIX 2) and 2020 Ukraine population totals for level 3 administrative units (WorldPop [9]). The model could explained 90.1% of the population input variance. Then the population weighting layer from the RF modelling was used as a weight to disaggregate COD-PS [2] population counts for each approximately 100m grid cell (0.0008333 decimal degrees grid or 3 arc seconds) or 1km grid cell (0.008333 decimal degrees grid or 30 arc seconds) (APPENDIX 1). The gridded population estimates were then combined with the COD-PS [2] age/sex

pyramid table for Ukraine to produce gridded population estimates for each sex group (female and male) at regular age intervals.

## WORK CITED

1. ORNL LandScan High Definition (HD) Data for Ukraine <https://landscan.ornl.gov/ukraine-landscan-hd-data>
2. UNFPA Ukraine - Subnational Population Statistics <https://data.humdata.org/dataset/cod-ps-ukr>
3. OCHA Ukraine - Subnational Administrative Boundaries <https://data.humdata.org/dataset/cod-ab-ukr>
4. WorldPop (www.worldpop.org - School of Geography and Environmental Science, University of Southampton; Department of Geography and Geosciences, University of Louisville; Departement de Geographie, Universite de Namur) and Center for International Earth Science Information Network (CIESIN), Columbia University (2018). Global High Resolution Population Denominators Project - Funded by the Bill and Melinda Gates Foundation (OPP1134076). <https://dx.doi.org/10.5258/SOTON/WP00644>
5. G. Calot and J.-P. Sardon. Methodology for the calculation of Eurostat's demographic indicators. Detailed report by the European Demographic Observatory. Brussels: European Commission (Population and Social Conditions 3/2003/F/no 26).
6. Bondarenko M., Nieves J.J., Forrest R.S., Andrea E.G., Jochem C., Kerr D., and Sorichetta A. (2021): popRF: Random Forest-informed Population Disaggregation R package, [\\_Comprehensive R Archive Network \(CRAN\)\\_url:https://cran.rproject.org/package=popRF](https://cran.rproject.org/package=popRF).
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## APPENDIX 1

Table of *ADM1\_PCODE* Subnational Administrative Boundaries for Ukraine provided by OCHA. Source <https://data.humdata.org/dataset/cod-ps-ukr>

<b>ISO3</b>	<b>ADM1_NAME</b>	<b>ADM1_COD_AB_EN</b>	<b>ADM1_PCODE</b>
UKR	Cherkasy oblast	Cherkaska	UA71
UKR	Chernihiv oblast	Chernihivska	UA74
UKR	Chernivtsi oblast	Chernivetska	UA73
UKR	Dnipropetrovsk oblast	Dnipropetrovska	UA12

UKR	Donetsk oblast	Donetska	UA14
UKR	Ivano-Frankivsk oblast	Ivano-Frankivska	UA26
UKR	Kharkiv oblast	Kharkivska	UA63
UKR	Kherson oblast	Khersonska	UA65
UKR	Khmelnyskiy oblast	Khmelnyska	UA68
UKR	Kirovohrad oblast	Kirovohradska	UA35
UKR	Kyiv city	Kyivska	UA80
UKR	Kyiv oblast	Kyivska	UA32
UKR	Luhansk oblast	Luhanska	UA44
UKR	Lviv oblast	Lvivska	UA46
UKR	Mykolayiv oblast	Mykolaivska	UA48
UKR	Odesa oblast	Odeska	UA51
UKR	Poltava oblast	Poltavska	UA53
UKR	Rivne oblast	Rivnenska	UA56
UKR	Sumy oblast	Sumska	UA59
UKR	Ternopil oblast	Ternopilska	UA61
UKR	Vinnytsya oblast	Vinnytska	UA05
UKR	Volyn oblast	Volynska	UA07
UKR	Zakarpattia oblast	Zakarpatska	UA21
UKR	Zaporizhzhya oblast	Zaporizka	UA23
UKR	Zhytomyr oblast	Zhytomyrska	UA18
UKR	Autonomous Republic Crimea	Avtonomna Respublika Krym	UA01
UKR	Sevastopol	Sevastopilska	UA85

Table of *adm4\_PCODE* Subnational Administrative Boundaries for Ukraine provided by OCHA.  
Source <https://data.humdata.org/dataset/cod-ps-ukr>

<b>ISO3</b>	<b>ADM1_NAME</b>	<b>City_Name_EN</b>	<b>adm4_PCODE</b>
UKR	Cherkasy oblast Cherkasy city	Cherkasy	UA7108049001
UKR	Chernihiv oblast Chernihiv city	Chernihiv	UA7410039001
UKR	Chernivtsi oblast Chernivtsi city	Chernivtsi	UA7306061001
UKR	Dnipropetrovsk oblast Kamianske city	Kamianske	UA1204015001
UKR	Dnipropetrovsk oblast Kryvyi Rih city	Kryvyi Rih	UA1206017001
UKR	Dnipropetrovsk oblast Nikopol city	Nikopol	UA1208005001
UKR	Dnipropetrovsk oblast Pavlohrad city	Pavlohrad	UA1212007001
UKR	Dnipropetrovsk oblast Dnipro	Dnipro	UA1202001001
UKR	Ivano-Frankivsk oblast	Ivano-Frankivsk	UA2604019001
UKR	Kharkiv oblast Kharkiv city	Kharkiv	UA6312027001
UKR	Kherson oblast Kherson city	Kherson	UA6510015001
UKR	Khmelnyskiy oblast Khmelnytskiy city	Khmelnyskiy	UA6804047001
UKR	Kirovohrad oblast Kropyvnytskyi city	Kropyvnytskyi	UA3504021001
UKR	Kyiv oblast Bila Tserkva city	Bila Tserkva	UA3202001001
UKR	Kyiv oblast Brovary city	Brovary	UA3206005001

UKR	Lviv oblast Lviv city	Lviv	UA4606025001
UKR	Mykolayiv oblast Mykolayiv city	Mykolayiv	UA4806015001
UKR	Odesa oblast Odesa city	Odesa	UA5110027001
UKR	Poltava oblast Kremenchuk city	Kremenchuk	UA5302011001
UKR	Poltava oblast Poltava city	Poltava	UA5308037001
UKR	Rivne oblast Rivne city	Rivne	UA5606047001
UKR	Sumy oblast Sumy city	Sumy	UA5908027001
UKR	Ternopil oblast Ternopil city	Ternopil	UA6104049001
UKR	Vinnytsya oblast Vinnytsya city	Vinnytsya	UA0502003001
UKR	Volyn oblasts Lutsk city	Lutsk	UA0708017001
UKR	Zakarpattia oblast Uzhhorod city	Uzhhorod	UA2110023001
UKR	Zaporizhzhya oblast Melitopol city	Melitopol	UA2308007001
UKR	Zaporizhzhya oblast	Zaporizhzhya	UA2306007001
UKR	Zaporizhzhya oblasts Berdiansk city	Berdiansk	UA2302005001
UKR	Zhytomyr oblast Zhytomyr city	Zhytomyr	UA1804019001

## APPENDIX 2

List of covariates.

Name of the covariate	Description
ukr_grid_100m_ccilc_dst011_2015.tif	Distance to ESA-CCI-LC cultivated area edges 2015
ukr_grid_100m_ccilc_dst040_2015.tif	Distance to ESA-CCI-LC woody-tree area edges 2015
ukr_grid_100m_ccilc_dst130_2015.tif	Distance to ESA-CCI-LC shrub area edges 2015
ukr_grid_100m_ccilc_dst140_2015.tif	Distance to ESA-CCI-LC herbaceous area edges 2015
ukr_grid_100m_ccilc_dst150_2015.tif	Distance to ESA-CCI-LC sparse vegetation area edges 2015
ukr_grid_100m_ccilc_dst160_2015.tif	Distance to ESA-CCI-LC aquatic vegetation area edges 2015
ukr_grid_100m_ccilc_dst190_2015.tif	Distance to ESA-CCI-LC artificial surface edges 2015
ukr_grid_100m_ccilc_dst200_2015.tif	Distance to ESA-CCI-LC bare area edges 2015
ukr_grid_100m_cciwat_dst.tif	ESA-CCI-LC inland waterbodies 2000-2012
ukr_grid_100m_gpw4coast_dst.tif	Distance to coastline 2000-2020
ukr_grid_100m_osmint_dst.tif	Distance to OSM major road intersections
ukr_grid_100m_osmriv_dst.tif	Distance to OSM major waterways
ukr_grid_100m_osmroa_dst.tif	Distance to OSM major roads
ukr_grid_100m_px_area.tif	Grid-cell surface areas
ukr_grid_100m_slope.tif	SRTM-based slope 2000 ( SRTM is Shuttle Radar Topography Mission)
ukr_grid_100m_topo.tif	SRTM elevation 2000
ukr_grid_100m_viirs_2016.tif	VIIRS night-time lights 2016 (VIIRS is Visible Infrared Imaging Radiometer Suite )

ukr_grid_100m_wclim_prec.tif	Current average annual total precipitation
ukr_grid_100m_wclim_temp.tif	Current average annual temperature
ukr_grid_100m_wdpa_cat1_dst_2017.tif	Distance to IUCN strict nature reserve and wilderness area edges 2017
LandScanHDUkraine_dst.tif	Distance to settlement ORNL LandScan High Definition (HD) Data for Ukraine