Annex 2: Yet another alternative method for processing LandScan data into LAEA grid cells

The methodology presented here has been suggested by EEA colleague Paul Hasenohr. The basic approach is that the original LandScan population counts in 30" WGS84 resolution are converted into population density values by using the area size values that come along in the Landscan data package. The generated population density values are then reprojected to LAEA by using bilinear resampling.

Compared to the methodology in Annex 1, this approach:

- Is faster in the processing, say: 2-3 hours of working time incl. all steps (population data and area grid preparation, data processing and consistency checks).

- Is easier to replicate in any GIS system, as standard GIS data processing methods are used (e.g. no AWK scripts are needed).

- Has a somewhat worse results in terms of keeping the original population counts: in the given area of interst (UL -35,75; LR 45,25), the original LandScan population of 967.2 million inhabitants is converted to 970.4 million people in LAEA projection. Hence more than 3 million people are "born" during resampling: an error of around 0.33%. The reason behind is that some of the resampled data values cover geographical areas which had 0 population in the source data, or were perhaps defined as NODATA areas. A test transformation using nearest neighbor resampling had a slightly higher error rate (970.5 million people after resampling).

LandScan data preparation

 # 0. Source data from ORNL (received from Oscar)

```
$ ls -l lspop2008.???
-rw-r--r-- 1 peifer mtr 3608064000 Jun 26  2009 lspop2008.flt
-rw-r--r-- 1 peifer mtr        160 Jun 26  2009 lspop2008.hdr

# Assign the missing CRS
$ gdal_translate lspop2008.flt lspop2008.vrt -a_srs epsg:4326 -of vrt

# Translate a sufficiently large area into GeoTIFF format
$ gdal_translate lspop2008.vrt lspop2008_laea_extent.tif -ot int32 \
    -projwin -35 75 45 25 -co compress=lzw -co tiled=yes
```

 # 1. Import processed source data into GRASS mapset wgs84

```
GRASS 6.4.0 (wgs84): r.in.gdal lspop2008_laea_extent.tif \
                     out=lspop2008_laea_extent
```

 # 2. Convert Landscan's area grid into AAIGrid format and import it

```
$ ls -l landscan08/ArcGis/AreaGrid/
drwxr-xr-x 2 peifer mtr 4096 Nov 24 12:10 areagrd
drwxr-xr-x 2 peifer mtr 4096 Nov 24 12:10 info
-rw-r--r-- 1 peifer mtr 5056 Jan 15  2009 areagrd.aux
-rw-r--r-- 1 peifer mtr  385 Jun 29  2009 AreaReadMe.txt
-rw-r--r-- 1 peifer mtr   39 Mar 23  2009 schema.ini
```

According to areagrd's attribute table, the area size of the 30" cells is:

VALUE	**COUNT**	**AREA**	**LAT1**	**LAT2**	
10801	43200	0.8577238096	0.000000	0.008333	# 1, see below
...					
...					
...					
18001	43200	0.4288078861	60.000000	60.008333	# 2, see below

Example cell #1 is at the equator. Its area size is 0.8577238096 km2
Example cell #2 is at 60° North. Its area size is 0.4288078861 km2

The rule is that according to simple trigonometry, the cell size changes with the cosine of its latitude. Hence cell #2 above is half the size of cell #1, as cos(60°) = 0.5

End LandScan data preparation

The actual data processing

 # 0. Calculate the LandScan population density

- Landscan population counts are integer values
- Landscan area size are single precision float values
- The calculated population density is a double precision float value representing inhabitants per km2

```
GRASS 6.4.0 (wgs84): r.mapcalc “lspop2008_density_landscan = \
                     1.0 * lspop2008_laea_extent / area_30sec_landscan”
```

It was checked that there was no rounding error introduced in the above calculation.

 # 2. Export into GeoTIFF format, reproject to LAEA projection

```
GRASS 6.4.0 (wgs84): r.out.gdal  lspop2008_density_landscan_float \
                     out=lspop2008_density_landscan_float.tif nodata=-99 \
                     createopt=compress=lzw,tiled=yes
```

The generated GeoTIFF is an intermediate product. Its GDAL data type is float64, i.e. double precision floating point values.

```
# Reproject with GDAL’s gdalwarp utility (GDAL tools, version 1.8dev)

$ gdalwarp --debug on -r bilinear -tr 1000 1000 -tap \
            -srcnodata -99 -dstnodata -99 -t_srs epsg:3035 \
            -co compress=lzw -co tiled=yes \
             lspop2008_density_landscan_float.tif \
             lspop2008_density_landscan_float_30sec_1000m.tif
```

 # 3. Import GeoTIFF into GRASS mapset in LAEA projection, for consistency checks

```
r.in.gdal input="lspop2008_density_landscan_float_30sec_1000m.tif" \
                output="lspop2008_density_landscan_float_30sec_1000m"

# Round the Float64 values:
GRASS 6.4.0 (laea): r.mapcalc lspop2008_rd = \
                    “round(lspop2008_density_landscan_float_30sec_1000m)”

# The map with rounded population values has a total of 970 422 467 inhabitants,
# Compared to the original population of 967 187 142, this is an error of 0.33%.
```

Comparison of population counts by country can be found on the next page.

 # 3. Export of rounded population values into GeoTIFF format

```
GRASS 6.4.0 (laea): r.out.gdal lspop2008_rd out= lspop2008_laea.tif \
                    nodata=-99 createopt=compress=lzw,tiled=yes
```

End of the actual data processing

Results of the consistency checks by country

For all 3 country comparisons: original LandScan data (column [1]), Hermann's results (column [2]) and "méthode Paul", i.e. the generated lspop2008_laea.tif (column [3]), the same (rough) country borders have been used.

Columns [4] and [5] show the difference in the population data before and after processing, in percent. Column [4] is calculated as: 100 * ([2] - [3]) / [2], and column [5] = 100 * ([2] - [4]) / [2].

MIN_CNTRY_	[1]	[2]	[3]	[4]	[5]
Kosovo*	1792303	1792576	1806278	0.02	0.78
Jersey	70476	71711	72343	1.75	2.65
Guernsey	61979	61857	57651	-0.20	-6.98
Isle of Man	72835	71781	74119	-1.45	1.76
Andorra	82642	82833	83481	0.23	1.02
Albania	3539464	3538757	3534252	-0.02	-0.15
Austria	8195813	8198788	8259320	0.04	0.77
Bosnia & Herzegovina	4565962	4558229	4573220	-0.17	0.16
Belgium	10440492	10439628	10454579	-0.01	0.13
Bulgaria	7222584	7212686	7240187	-0.14	0.24
Belarus	9684526	9685993	9749839	0.02	0.67
Switzerland	7682877	7687633	7745307	0.06	0.81
Cyprus	762819	760843	763853	-0.26	0.14
Czech Republic	10237824	10237816	10259776	-0.00	0.21
Germany	82239677	82228161	82672972	-0.01	0.53
Denmark	5164900	5155840	5192623	-0.18	0.54
Estonia	1258368	1249004	1254846	-0.74	-0.28
Spain	39489699	39410024	39593538	-0.20	0.26
Finland	5093084	5090752	5139991	-0.05	0.92
Faroe Is.	38887	40026	40906	2.93	5.19
France	60885206	60895243	61146784	0.02	0.43
United Kingdom	59628495	59491930	59789114	-0.23	0.27
Gibraltar	29017	22853	27486	-21.24	-5.28
Greece	10203050	10156953	10186268	-0.45	-0.16
Croatia	4203406	4198573	4212153	-0.11	0.21
Hungary	9936750	9934635	9988354	-0.02	0.52
Ireland	4015034	4002474	4022876	-0.31	0.20
Iceland	261085	259442	264627	-0.63	1.36
Italy	56565609	56327302	56592642	-0.42	0.05
Liechtenstein	36410	36879	39734	1.29	9.13
Lithuania	3569629	3578549	3574834	0.25	0.15
Luxembourg	495510	496322	502716	0.16	1.45
Latvia	2190046	2183548	2205195	-0.30	0.69
Monaco	9539	22176	20741	132.48	117.43
FYR of Macedonia	2071601	2071302	2065592	-0.01	-0.29
Malta	370303	369205	376650	-0.30	1.71
Netherlands	16520676	16478071	16566427	-0.26	0.28
Norway	4098615	4087513	4110562	-0.27	0.29
Poland	38421809	38418258	38628585	-0.01	0.54
Portugal	10412683	10159938	10202190	-2.43	-2.02
Romania	22205558	22198058	22240823	-0.03	0.16
Russia	70217411	70203221	70698170	-0.02	0.68
Sweden	8439104	8424304	8458553	-0.18	0.23
Slovenia	2001854	1997541	1999043	-0.22	-0.14
Slovakia	5455670	5457332	5462479	0.03	0.12
San Marino	27823	27060	29532	-2.74	6.14
Turkey	70175681	69958907	70144042	-0.31	-0.05
Ukraine	45808482	45809961	46020751	0.00	0.46
Montenegro	640345	642871	653005	0.39	1.98
Serbia	7407755	7414359	7392497	0.09	-0.21