LandScan Locating People is What Matters

Most natural and manmade disasters strike very unexpectedly placing a large number of people at risk. The lack of efficient advanced warning systems compels emergency responders to quickly assess how far and in what direction will a contaminant release disperse. They also need to assess how many people are at risk. Geographic information is essential for fast, effective response to these disasters and is the common thread in all planning, response, and recovery activities. Emergency response by many national and international organizations requires simulation of disasters, and population data is undoubtedly one of the critical elements in such analyses.

By Budhendra Bhaduri, Edward Bright, Phillip Coleman, and Jerome Dobson

Since the late 1990s, the United States Department of Energy's (USDOE) Oak Ridge National Laboratory (ORNL) has been committed to the ORNL Global Population Project. Using an innovative approach with Geographic Information System and Remote Sensing, researchers at ORNL have been the pioneer in developing, refining, and updating a global population database known as LandScan, which is the finest global population data (< 1 km resolution) ever produced and is several orders of magnitude more spatially refined than some of the previously available global population datasets. Initially developed and distributed in 1999 (LandScan 1998), LandScan is continuously updated and subsequently an updated version has been released in early 2001 (LandScan 2000).

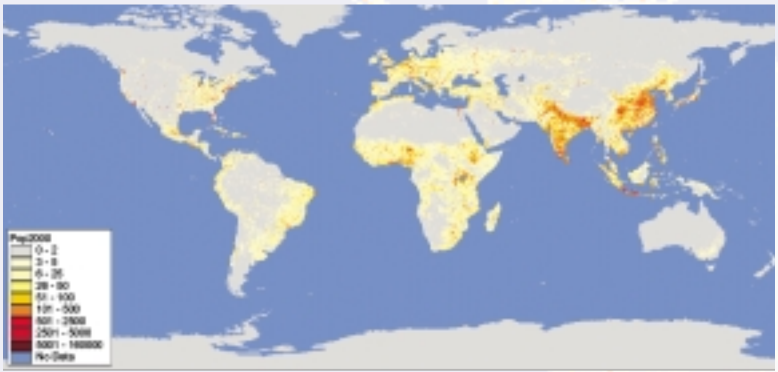

Figure 1: LandScan 2000 global population distribution at 30 arc second (approximately 1 km) resolution.

LandScan

LandScan population distribution model involves collection of the best available census counts (usually at sub-province level) for each country and four primary geospatial input datasets, namely land cover, roads, slope, and night time lights, that are key indicators of population distribution. Relationships between any of these datasets and population distribution are not globally uniform. Roads play a critical role in human settlements independent of other forms of transport. However, residential population density in proximity to major roads varies significantly across the world. For example, residential population is much higher to primary roads in southeast Asian countries, which is quite contrary to the same in the United States. Similarly, preference for people to reside on steeper versus gentler (or flat) slopes is generally a function of the abundance of available areas with gentler slope. Based on this variability in cultural and settlement geography, the world is divided into several different regions and each region is considered to have unique settlement characteristics. For each region, the population distribution model calculates a "likelihood" coefficient for each LandScan cell, and applies the coefficients to the census counts, which are employed as control totals for appropriate areas. For example, in the USA, census tracts serve as the polygonal unit or control population. Census tracts are divided into finer grid cells (1 km) and then each cell is evaluated for the likelihood of being populated based on the four geospatial characteristics. The total population for that tract is then allocated to each cell weighted to the calculated likelihood (population coefficient) of being populated. Large volumes of satellite derived spatial data including land cover and nighttime lights are used in developing LandScan databases and verification and validation (V&V) of the population model.

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Various Geodata Sources

LandScan uses the National Imagery and Mapping Agency's (NIMA) Vector Map (VMAP) series data and Digital Terrain Elevation Data (DTED) for global coverage of roads and slope respectively. Land cover data is obtained from the United States Geological Survey's (USGS) Global Land Cover Characteristics (GLCC) database that is derived from Advanced Very High Resolution Radiometry (AVHRR) satellite imagery. The source for the night time lights dataset is the Night time Lights of the World data processed

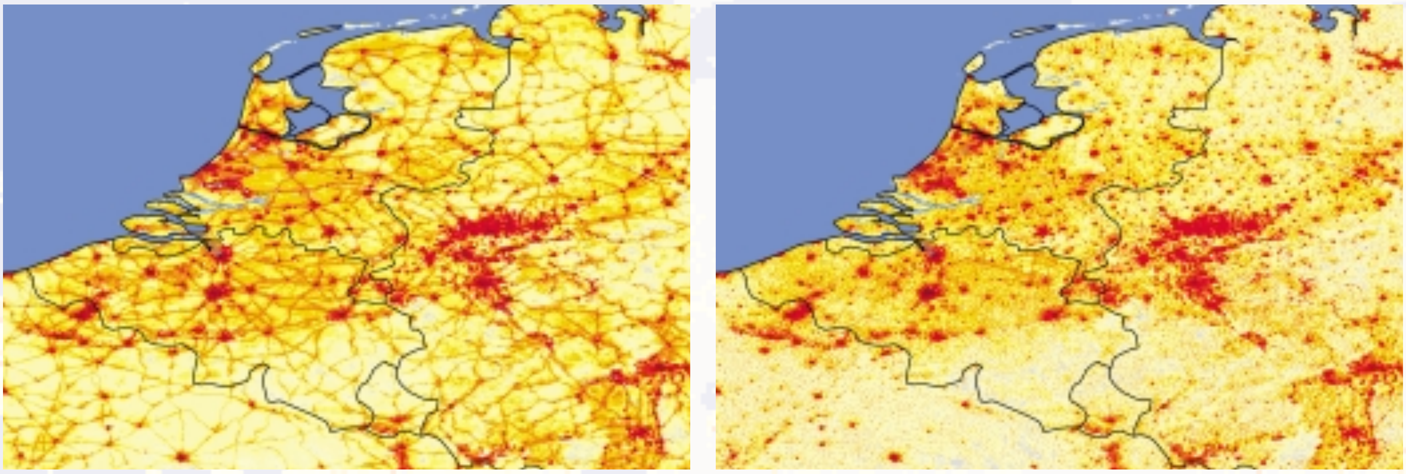

Figure 2: Improvement in LandScan 2001 population data (compared to LandScan 2000) for the Netherlands, primarily because of spatially refined roads data.

and distributed by the National Oceanic and Atmospheric Administration's (NOAA) National Geophysical Data Center (NGDC). LandScan (global) data have a grid cell size of 30 arc seconds (approximately 1 km x 1 km at the equator) and represents an ambient or average population distribution over a 24-hour period. Although the spatial resolution of both LandScan 1998 and 2000 datasets is 30 arc seconds, significant refinement of the population data itself has been achieved via utilization of higher resolution input data in the population distribution model. For example, in LandScan 1998 VMAP-Level 0 (1:1 000 000 scale) data was used for roads and DTED-Level 0 (30 arc second resolution) data was used for slope. In the 2000 and later reversions, LandScan uses VMAP Level 1 (1:250 000 scale) data for roads and DTED Level 1 (3 arc second resolution) data for slope as they become available for different regions of the world. Night time light frequency data was being used in LandScan 1998 that has since been upgraded to light intensity data from three different gain settings. The resultant population data from higher resolution input data is significantly refined (Figure 2).

Variable Spatial Resolution

Experience of developing global LandScan led to two important realizations:

1) given that the granularity of population distribution data is directly proportional to the resolution of the input data, it is possible to develop even higher (spatial) resolution data for the parts of the world where higher resolution input data is available, and
2) given that disasters do not routinely strike at night, it is critical to modify and refine the night time or residential population data to develop daytime population distribution.

Consequently, as an expansion to global LandScan, ORNL is currently developing a very high-resolution (3 arc second or 90m cell size) population distribution data (LandScan USA) for the US detailed road network data from US Census Bureau's TIGER files and high resolution (30 m) land cover data from USGS's National Land Cover Data (NLCD) derived from Landsat Thematic Mapper (TM) satellite imagery. At this resolution population distribution data includes night time (residential) as well as daytime distributions. Worker mobility data and daytime populated features databases are integral in modeling daytime population distribution. The potential benefit of LandScan USA has been demonstrated for 29 counties covering coastal Texas and Louisiana including the Houston, Texas metropolitan area (Figure 3). ORNL has also developed an intermediate resolution LandScan USA (15 arc second or approximately 450 m cell size) for the continental United States, which is based on intermediate resolution of input data and represents an ambient or average population distribution similar to the LandScan global dataset.

Endless Possibilities of Applications

Possibilities of applications of LandScan data are endless. LandScan has significantly enhanced the utility and impact of

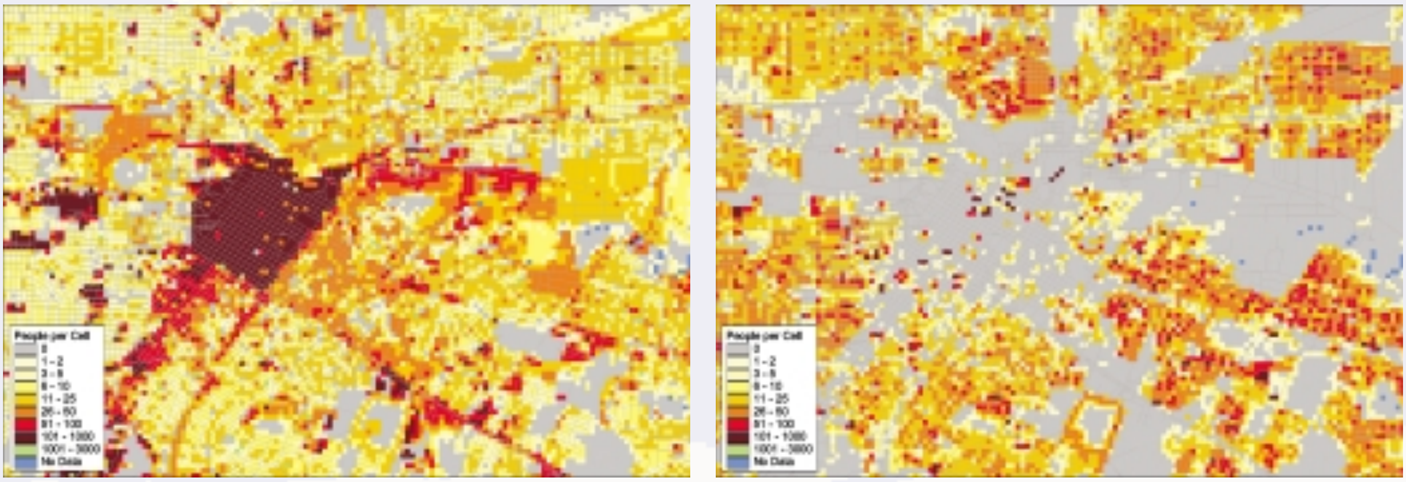

Figure 3: Preliminary LandScan USA (3 arc second resolution) data for the business district (downtown) of the city of Houston, TX. The striking difference between the night time and daytime population distribution is because of an additional 160 thousand people moving into the Census tract containing the business district, from the surrounding region.

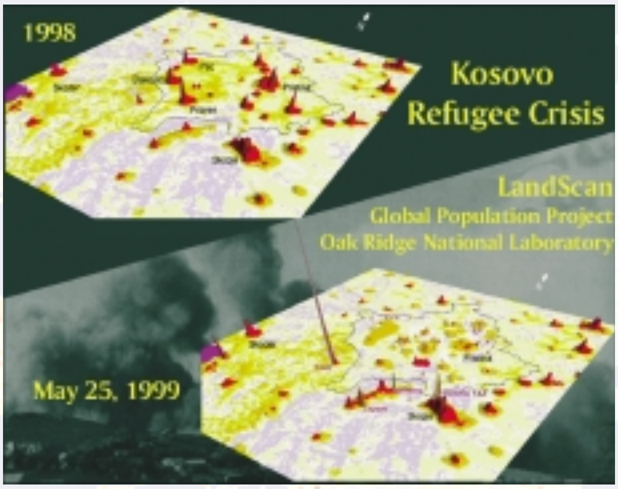

Figure 4: Population migration and change in population distribution exemplified with LandScan data during the Kosovo refugee crisis.

various applications in counter-terrorism, homeland security, emergency planning and management, consequence analysis, epidemiology, exposure analysis, and urban sprawl detection, to name a few. LandScan is being extensively used by national and international organizations including the United Nations (UN), the World Health Organization (WHO), the Food and Agricultural Organization (FAO), and several federal agencies in the US and other countries. ORNL has distributed LandScan global population data to over 200 different organizations spread across the world. A recent survey, conducted by ORNL, of approximately 100 LandScan 1998 users indicate that environmental (38%), basic education and research (25%), and emergency management (11%) are three areas significantly benefiting from LandScan data. Other areas of significant application include defence, humanitarian relief, health, energy and social studies.

Kosovo Example

Utility of LandScan data in modelling and visualizing population migration and changes in settlement patterns was exemplified during the Kosovo refugee crisis (Figure 4). Information, from over 25 sources, about estimates of
(a) known dead,
(b) known migrants to neighbouring countries in the region,
(c) known migrants out of the region by country of origin and destination, and
(d) unaccounted

was utilized to update the LandScan population distribution for Kosovo effective May 25, 1999. This revised dataset, when compared to LandScan 1998 population distribution, reveals the dramatic depopulation of Pristina, Pec, and other cities, the appearance of large refugee camps in neighbouring Albania and Macedonia, and the growth of smaller refugee camps in central Kosovo.

Mt. Vesuvius Example

Accidental or deliberate release of contaminant plumes and natural disasters such as floods, earthquake, or volcanic eruption can put people at risk over large areas. LandScan data is being routinely used with emergency response and hazard assessment models to estimate the number of people at risk from various anticipated disasters. In a simulation to assess the impact of the catastrophic volcanic eruptions, we simulated the historic 79 AD eruption of Mt. Vesuvius using an atmospheric dispersion model developed at ORNL. Assuming volcanic ash (4 km3 over 19 hours) and SO2 gas (40,000 tons over 4 days) were released during an eruption on March 18, 1999, the dispersion of the plumes were simulated over a 7 day period using available historical weather data of the area. Interestingly, simulation results indicate that after a week, 5 cm of ash deposition is possible in as far as Bulgaria, severely crippling normal life by the failure of transportation, communication, and utility infrastructures. Surface ash deposition and SO2 dosage were analysed with LandScan 1998 data to assess the number of people at risk from the catastrophic event. This consequence analysis shows that within a week as many as 120 million people will be impacted by volcanic ash deposition and about 13 million people will be impacted by SO2 dosage.

Figure 5: Predicted volcanic ash deposition after 7 days from a simulated eruption of Mt. Vesuvius. Dispersed ash plumes can be intersected with LandScan population data to assess the number of people from risk.

Emergency Planning And Management

The terrorist attacks of September 2001 sent a clear signal of how unexpectedly deliberate attacks can paralyse our lives. With raised level of anxiety about the possibility of chemical and biological terrorism, the society requires an unprecedented level of emergency preparedness for saving innocent lives. LandScan, among its various applications, is increasing the power of emergency planning and management tools with spatially and temporally refined population distribution data. The world has devoted its finest science and technology resources to develop the best solutions for disaster prevention, response, and recovery. LandScan is constantly improving our knowledge of locating population, which has to be the first step in saving lives. Thus, locating people is what matters.

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Acknowledgements:
Financial support for LandScan Global Population Project for developing the various LandScan population distribution data is provided by several United States government agencies. LandScan global is supported by the United States Department of Defense. LandScan USA development has been supported by the United States Environmental Protection Agency and the United States Department of Energy.