Project 3: Acquiring Geographic Data

Topic A: LandScan Global Ambient Population

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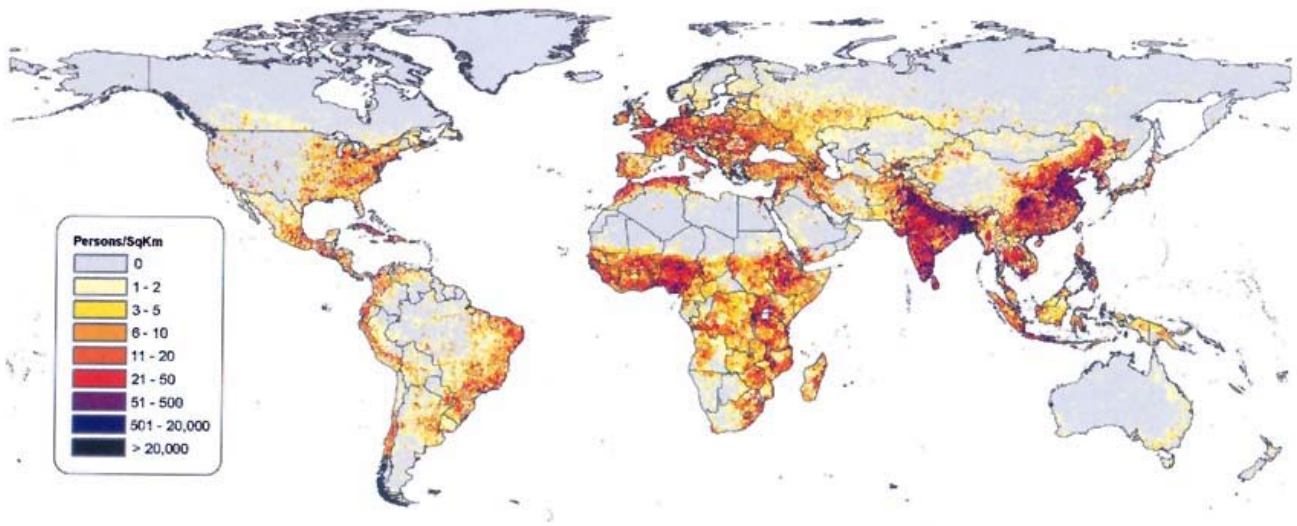

Figure 1. LandScan Global Population Database, adjusted to UN figure year 2000, in Persons per Square Kilometer
Source: Oak Ridge National Laboratories (ORNL), Tennessee, USA (Salvatore, 2004)

INTRODUCTION

Geographic Information Systems and Remote Sensing have lent themselves to increasing refined datasets and models of the real world. LandScan is the highest resolution up-to-date global population database available for rapid risk assessment of populations threatened by disasters to optimize emergency responses, including humanitarian aid. Over 200 organizations, including the United Nations and the World Health Organization, have used LandScan's free online data up through November 2004 (Bhaduri, 2004).

DESCRIPTION

LandScan is a global population database developed in 1998 at the U.S. Department of Energy's Oak Ridge National Laboratory under the director of Dr. Jerome Dobson. This U.S. Department of Defense-funded database is a disaster preparedness tool that can estimate global population density at the subnational level. With annual updates (except between 1998 and 1999), LandScan remains the first choice for governments and organizations needing to determine populations at risk from natural and manmade disasters. (Dobson, 2002) The method for spatially distributing a population, which is the goal of the LandScan Global Dataset, has been patented (US Patent # 7247024) as of July 2007.

SPATIAL RESOLUTION

One of the strengths of LandScan is its fine spatial resolution at 30 arc seconds of latitude by 30 arc seconds of longitude. At the equator, the 30"x 30" cell is approximately one kilometer. Towards the poles and where high resolution data is available, the spatial resolution is even finer. (Dobson, 2002)

Earlier global population estimates such as the Global Population Database (GPOPD), produced by the International Programs Center of the U. S. Census Bureau in 1993, were based on 20 arc minutes of latitude by 30 arc minutes of longitude, or 2,400 square kilometers at the equator, a far coarser resolution that made identifying populations at risk difficult to increased spatial uncertainty. The Consortium for International Earth Science Information Network (CIESIN) administers the GPOPD. (IPC, 1996) Unlike the GPOPD, LandScan is updated annually. (Dobson, 2004)

The Oak Ridge National Laboratory has created LandScan USA, a 3 arc second population distribution database at 90 meter cell size, for Texas and Louisiana and a 15 arc second (i.e. 450 meters cell size) database for the continental United States. This nationwide project is supported by the US Department of Energy and the US Environmental Protection Agency (ORNL, 2004)

LANDSCAN'S DATA SOURCES

To create the global population database in 1998, the ORNL's Geographic Information Science & Technology (GIST) research group utilized aerial photography, satellite imagery, Global Land Cover Characteristics (U.S. Geological Survey), the Nighttime Lights of the World (National Oceanic and Atmospheric Administration), and aggregate census counts (IPC, US Bureau of the Census).
In 2000, the Vector Map (VMAP) and Digital Terrain Elevation Data (National Imagery and Mapping Agency) were added. Two years later, NASA's MODIS (Moderate Resolution Imaging Spectroradiometer) land cover data was incorporated into LandScan remote sensing inputs (Salvatore, 2005).

The GIST research group used a dasymetric interpolation approach developed by American Geographical Society (AGS) librarian John K. Wright for use with census data in 1936. (Wright, 1936; Dobson 2007) Wright later became director, then president of the AGS, and his influence on American geographic thought has been considerable. (Handler, 1993)

Dasymetric interpolation of best available census counts provided the LandScan ambient population density estimates. The formula for calculating the area of each LandScan cell (depending on latitude) is as follows (GICHD, 2007):

Area = R2 (sin (lat2)-sin(lat1)) * deltaLon
where:
R = Radius of the earth in Kilometers (3956.66)
lat2 = Upper Latitude in radians (radians = decimal degrees * π/180)
lat1 = Lower Latitude in radians
deltaLon = Longitudinal width of cell in radians

Then, divide each cell value by the resulting cell area to calculate the density (i.e. numerical population estimate per cell). (GICHD, 2007)

AMBIENT POPULATION

Instead of relying solely on the number of individuals counted by a national or regional census, LandScan creators posited that where people were located by the census taker (e.g. at home) or estimated to be was not necessarily where they were placed during the course of any typical day. The locations of many individuals are in flux as they travel to and from work, shopping, sports, entertainment venues, etc. On the other hand, most people do not travel a large distance from where

they were counted in the census. This notion of an "ambient" population where people are likely to be proximate to each other over a 24-hour period is another of LandScan's strengths.

INPUT VARIABLES

Salvatore et al (2005) described the process of producing the global ambient population database as follows: "Probability coefficients are assigned to every value of each input variable, and a composite probability coefficient is calculated for each LandScan cell." Originally, estimating the ambient population of each grid cells required nine input variables: census counts, roads (for road proximity), slope (categorized from elevation), populated places, coastlines (from NIMA's World Vector Shoreline (WVS) at 1:250,000 scale), land cover (including excluded areas), urban density (i.e. urban areas, developed, and undeveloped areas), and night time lighting (i.e. >90 % frequency). The last was provided by the U.S. Air Force Defense Meteorological Satellite Program (DMSP) but was dropped by 2002 as the extent and brightness of night lighting changed due to expanded economic development, (Bhaduri et al, 2002).

Each of the resulting probability coefficients is assigned a weighted value, which is independent of the census data. The composite probability coefficient per LandScan cell is used to allocate portions of actual population counts in any region of the world. (GICHD, 2007)

APPLICATIONS

Researchers primarily created LandScan's capabilities to improve emergency responses to disasters, natural or manmade; however, the database has proved itself useful for multiple uses.

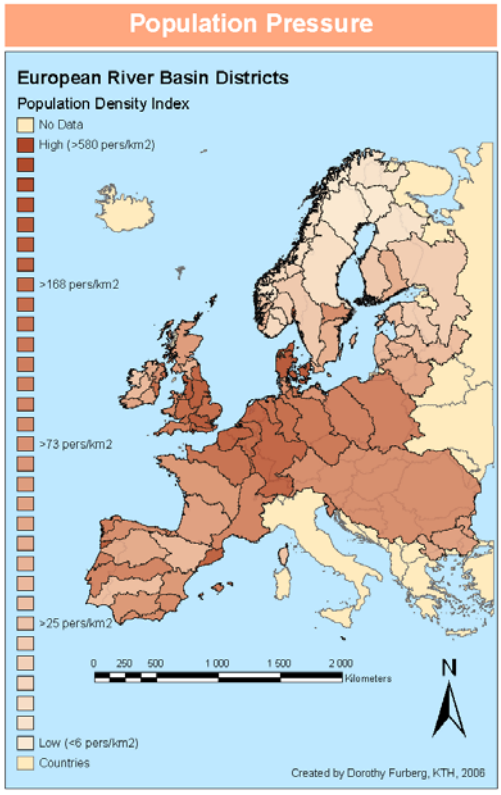

Figure 2. Population Pressure on European River Basin Districts (Furberg, 2006)

Governmental agencies, scientists, and nongovernmental organizations have used LandScan to examine the effect of population on water availability in the European Union (Figure 2 – Furberg, 2006), to study sulfur pollution in Asia (Guttikundaa et al, 2003), to establish a new indicator-based analysis of river basins districts in the European Union (Furburg, 2006), and to assess the vulnerability of our drinking water to contamination (Baranowski et al, 2006).

The dataset's robust nature is best revealed when disaster strikes. When the November 24, 2007 tsunami ravaged Thailand, the United Nations turned to 2002 LandScan Global Data Set and the most satellite imagery from the Jet Propulsion Lab's Shuttle Radar Topography Mission (SRTM) and Global Insight. In Figure 3 below, coastal areas under 20 meters of elevation that were most likely to be damaged by the tsunami are shown in hatched lines. The colored squares indicate population per square kilometer. LandScan helped emergency officials visualize where the tsunami's path likely harmed or killed individuals and damaged the island's infrastructure.

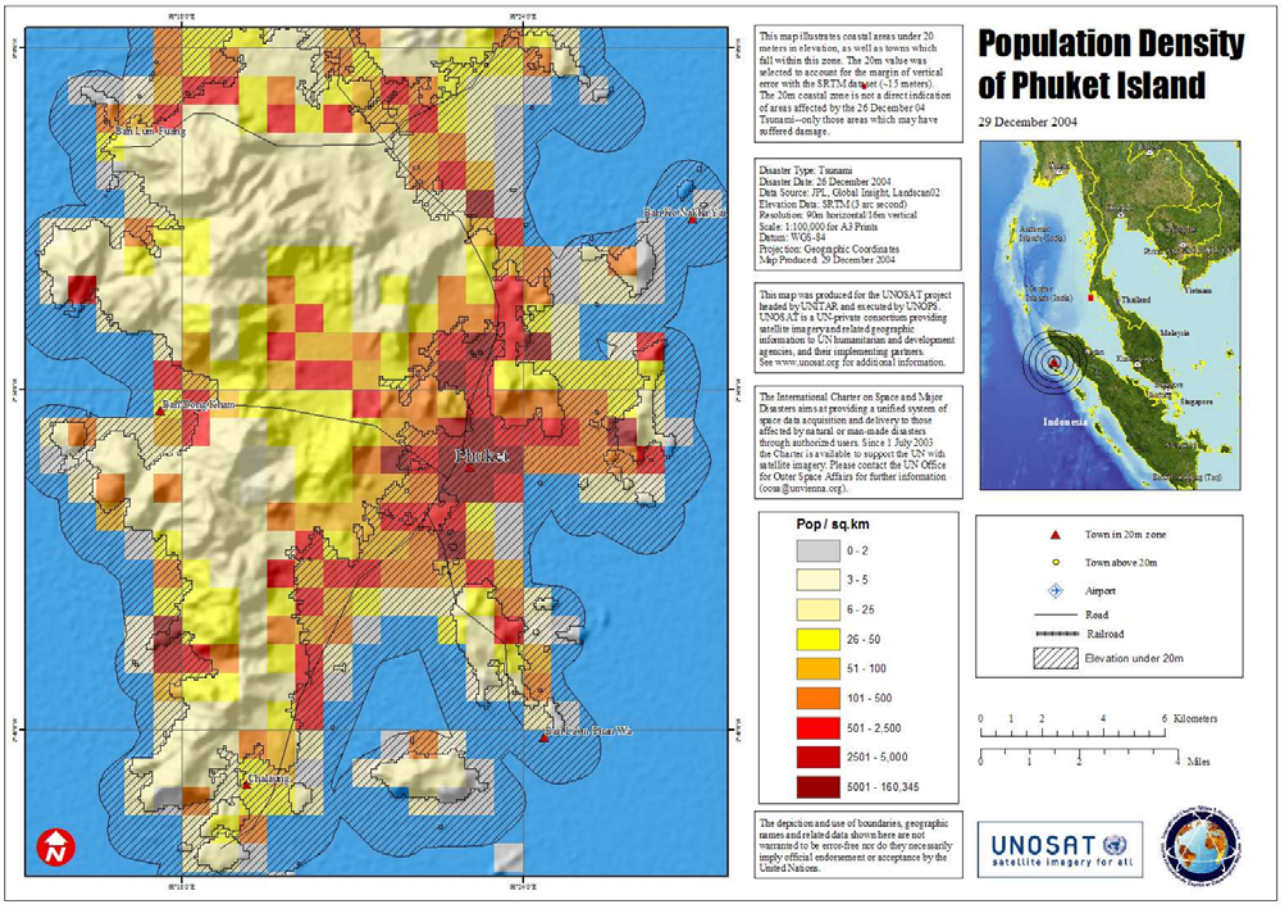

Figure 3. Population Density Map of Phuket Island, Thailand, 12/26/2004. (Reuters, 2005)

LandScan also is helping researchers to explore answers to challenges that affect the entire human race, such as which populated areas are at risk from sea rise due to climate change (Rowley et al, 2007).

LANDSCAN DATABASE AVAILABILITY

LandScan is an online database housed at http://www.ornl.gov/sci/landscan/. Prospective users must register through the website. The licenses are free for U.S. federal government agencies and

educational research. If LandScan is to be used for commercial purposes, ORNL will decide whether or not to issue a license.

The files are in ESRI grid format by continent and for the world, and in ESRI binary (raster) format for the world. The datasets are updated annually; however, not all datasets are available simultaneously. For example, the most current version is LandScan 2006, which is open to new users. LandScan 2005 is closed to new users but still accessible to existing registered users. The website contains information on which version(s) can be downloaded, general information about the LandScan project, and documentation (i.e. metadata). (ORNL, 2005)

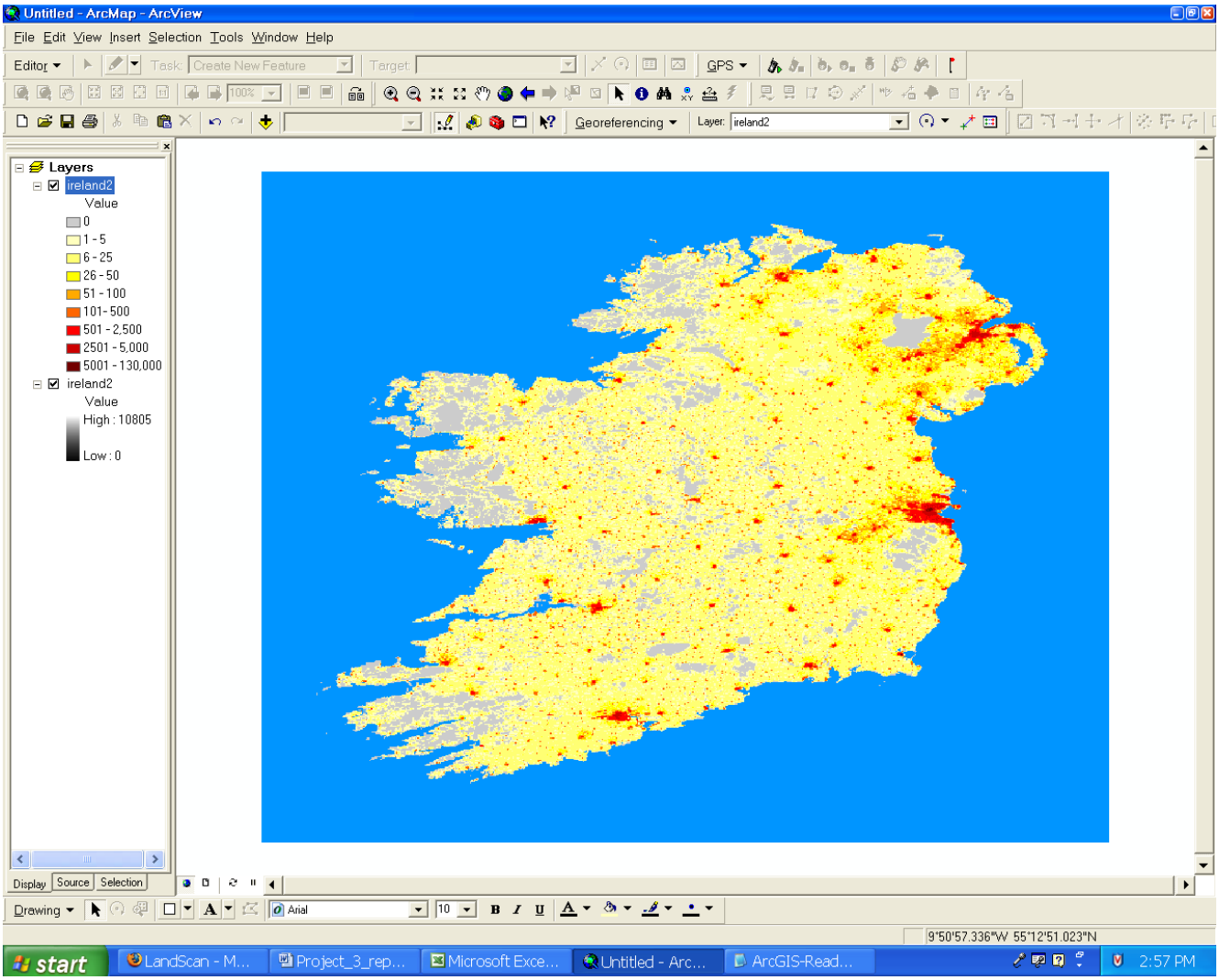

Figure 4. Screenshot of Downloaded 2005 LandScan Global Data Set of Ireland. (http://www.ornl.gov/sci/landscan)

Prospective users can sample, without registration, a dataset of Ireland derived from the LandScan dataset by downloading it into ESRI ArcGIS (Figure 4).

CONCLUSION

The LandScan Global Database is an innovative ongoing project combining advanced geographic information systems and remote sensing techniques to estimate population densities at high resolution (< 1 km). Its applications in emergency management, humanitarian relief, homeland security,

environmental modeling, resource planning, epidemiology, and other areas have benefited millions of people around the world. LandScan's motto easily could be "locating people is what matters" (Bahduri, 2002).

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