Land Use Land Cover Change Analysis
of Maverick County Texas
along the US Mexico Border

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Abstract

A Land Use Land Cover analysis (LULC) was conducted for Maverick County, TX. Determination of land cover change was sought for demographic correlation. The data set used was downloaded from the USGS Land Cover Institute website. The USGS LULC product is provided as an image file and was processed using ArcMAP and ENVI as well as Excel. The period of LULC analysis covered roughly a ten year time frame from 1992 to 2001. As expected, the results showed an increase in urbanization while decreasing in agriculture. The implications of a shift away from an agricultural community toward an urban community can now be discussed in the light of land use and land cover change data. The use of satellite imagery has become one of the strongest tools for analyzing and interpreting the complex systems of the earth and the anthropogenic influences that continue to pressure the planets limited resources.
Introduction

Demographic studies using combinations of census data and spatially referenced data has been actively investigated in the US for many decades. Aerial photos from the 1930’s and 40’s were used by Francis Marschner to compile a map of major land uses in the United States. The introduction of satellite imaging systems presses a new paradigm to the forefront of spatial demography. Satellite data can now be used along with more traditional demographic techniques providing an even better tool for evaluating population dynamics.

Analyzing spatially referenced data, where quantitative observations can be associated with spatial data, allows for a much stronger correlation and understanding of population dynamics at a macro scale. It may even be argued that it will lead to an interpretation of human population motivation on a micro scale. This of course must be taken in the context of inherent data errors, and all other problems and assumptions associated with extrapolation from one scale to another.

Traditional statistical methods of analyzing spatial distribution have been enhanced with the addition of satellite imagery data sets. Using satellite imagery data, this paper evaluates the land use land cover changes and attempts to correlate them to demographic census population data for the years 1990 and 2000.

Changes are ubiquitous across all landscapes over any given period of time. They may take place across the landscape gradually, seasonally, or episodically. Some of these changes are naturally occurring such as the greening of forests and flowering of meadows in spring or after a soaking rain. Other natural changes in landscape include episodic blackening of fire scorched areas due to lighting strikes. When seen from space by earth orbiting satellites, these changes can be recognized and often distinguished from anthropogenic landscape alterations.

Human alterations of landscape occur from many types of human activity. Some changes are by design, such as new housing developments, new roads or new farms. Other anthropogenic changes occur by accident or other means, such as excessive erosion induced by vehicle traffic
on thin soils or human caused grass fires. With appropriate spatial, temporal, and spectral resolution, most changes of the earth’s surface can be detected with remote sensing.

New shopping centers, housing developments, even the conversion of native grasslands into cornfields or other agricultural activities can be distinguished using remote sensing, and satellite imagery. This paper presents some of the changes that occurred between 1992 and 2001 in the Maverick County area of South Texas and along the US and Mexico border.
Objectives, Scientific Questions and Hypothesis

Objectives:
The objectives of this paper are to show that satellite data is valuable to the study of demography; and further, that the information derived from the satellite data has a correlation to quantitative demographic census data.

Scientific Questions:
Can changes be detected in two satellite images collected at different times, and is this change detection accurate and valid?

Hypothesis:
Satellite data collected at a ten year temporal interval can have an accurate change analysis conducted and the subsequent change data can be correlated to quantitative demographic data.

Anthropogenic alteration of landscape may be correlated to economic activity or conditions. As a community increases in population, it could be expected to show a corresponding change in land use and land cover. New schools, hospitals, churches, and government buildings are likely to be seen as populations grow and community service demands increase.

Infrastructure projects will also be seen in various stages of development as a community grows. New roads, power distribution lines, sewer and water systems can all be traced and tracked using remotely sensed satellite imagery. These anthropogenic alterations may have a correlation to demographic population dynamics. The question raised by this paper is; can a correlation be drawn between the land change detection and the census track data?
Methodology

Data:

Satellite Images and Products
National Land Cover Data (NLCD), 1992 Land Cover and NLCD 2001 Land Cover were processed by USGS to create the NLCD Retrofit Change Product used in this paper.

Shape files
Shape files for US States, Counties, and municipalities were used for isolating areas of interest that correspond with quantitative demographic data.

Quantitative Demographics
Statistical Census data was retrieved from US Census Bureau for Maverick County

Programs:

ESRI, ArcMap

Image shows ArcMap 9.2; used for processing rasters and vectors
The Land Cover Change Product was imported into ArcMap where the data for Maverick County was selected from the attribute table. This data was then exported to Excel.

**Microsoft Office Excel**

Image shows Excel 2003; used for processing database files and statistical analysis

Excel was used for statistical analysis of data and for the preparation of graphs.

**ENVI Geospatial Image Processing software**

ENVI 4.4; used for processing satellite image files
ENVI was used to view satellite images of the Maverick County area and spot check Classification Codes with on the ground images. Photos of selected areas are included in the appendix.
**Classification:**

Understanding the application of land cover classification by the USGS for this Change Product is important to understanding the accuracy of the data. Both the classification scheme for the product and the accuracy table have been included in their entirety directly from the USGS data server. A discussion on classification development and application is included below.

The excerpt below is from the classification methods presented in U.S. Geological Survey Circular 671 by James Anderson.

*Concepts concerning land cover and land use activity are closely related and in many cases have been used interchangeably. The purposes for which lands are being used commonly have associated types of cover, whether they be forest, agricultural, residential, or industrial. Remote sensing image-forming devices do not record activity directly. The remote sensor acquires a response which is based on many characteristics of the land surface, including natural or artificial cover. The interpreter uses patterns, tones, textures, shapes, and site associations to derive information about land use activities from what is basically information about land cover. Some activities of man, however, cannot be directly related to the type of land cover. Extensive recreational activities covering large tracts of land are not particularly amenable to interpretation from remote sensor data. For example, hunting is a very common and pervasive recreational use of land, but hunting usually occurs on land that would be classified as some type of forest, range, or agricultural land either during ground survey or image interpretation. Consequently, supplemental information is needed to identify lands used for hunting. Supplemental information such as land ownership maps also is necessary to determine the use of lands such as parks, game refuges, or water conservation districts, which may have land uses coincident with administrative boundaries not usually discernable by inventory using remote sensor data. For these reasons, types of land use and land cover identifiable primarily from remote sensor data are used as the basis for organizing this classification system.*

*The definition of Urban or Built-up Land, for example, includes those uses similarly classified (Wooten and Anderson, 1957) by the U.S. Department of Agriculture, plus the built-up portions*
of major recreational sites, public installations, and other similar facilities. Agricultural land has been defined to include Cropland and Pasture; Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas; and Confined Feeding Operations as the principal components. Certain land uses such as pasture, however, cannot be separated consistently and accurately by using the remote sensor data sources appropriate to the more generalized levels of the classification.

The principal concept by which certain types of cover are included in the Rangeland category, and which separates rangeland from pasture land, is that rangeland has a natural climax plant cover of native grasses, forbs, and shrubs which is potentially useful as a grazing or forage resource (U.S. Congress, 1936; U.S. Department of Agriculture, 1962, 1971). Although these rangelands usually are not seeded, fertilized, drained, irrigated, or cultivated, if the forage cover is improved, it is managed primarily like native vegetation, and the forage resource is regulated by varying the intensity and seasonality of grazing (Stoddard and Smith, 1955). Since the typical cropland practices mentioned just above are characteristics of some pasture lands, these pasture lands are similar in image signature to cropland types.
Results

From the original USGS Change product download site, each of the four sections of south west United States is was opened in ArcMap and clipped to each of the twenty three US Counties, from four States that share the border with Mexico. These twenty three counties can be seen outlined in magenta in the image below, with Maverick County highlighted in green. With a combination vector data available for these counties as well as the USGS raster change product, it is possible to analyze each of the counties for demographic correlation.

Maverick County was isolated from the data set and used as an example of demographic correlation. Population information on Maverick County was acquired from the US Census Department. A change in County population from the 1990 census to the 2000 census was determined to be thirty percent. This growth has been reported as fifteen percent over that past seven to eight years since the 2000 census. The current estimated County population is 51,656. The area land use is estimated at 88% urban, 12% rural according to the Maverick County website. (http://www.city-data.com/county/Maverick_County-TX.html). It is uncertain how their land use classification was done, but illustrates the inconsistency of methodology and consequently repeatable results since the USGS model doesn’t use a rural category. The USGS classification model includes an “Urban” class, so this class was compared against all other
classes. The result of that for the 1992 – 2001 change product suggested that 6% of Maverick County was "Urban" with the remaining 94% of land use was fell into the other categories.

The town of Eagle Pass sits on the border, directly across from its Mexican counterpart of Piedras Negras. Eagle Pass is the largest urban area within Maverick County and has an estimated population of 26,285. The rate of population change since 2000 is reported as 15.2%.

In the image below, you can see the USGS Classification product clipped to Maverick County with ArcMap. The legend to the right was left in the original USGS Classification Codes. The three main colors that are visible at this scale are RED, YELLOW, and TAN. Red corresponds to “URBAN”, Yellow corresponds to “Agriculture” and Tan corresponds to “Grassland/Shrub”.

Images above of Maverick County Texas showing USGS Land Cover Classification for 1992-2001 in the left image and the 2000 ETM Satellite on the right.
A closer look at the USGS Change Product Classification for the urban area of Eagle Pass reveals some of the other smaller categories. Number 1, Blue represents “Open Water”. Eagle Pass Lake can be seen in Blue, just below and off center in the image. Also showing up dark blue is the Rio Grande River that serves as the border between the US and Mexico. The lighter blue is classified as “Wetland”. The other Classification Code of note in this image is number 52 or light green. The Code 52 represents a change from 1992 of Code 5 “Grassland/Shrub” to Code 2 “Urban” in 2001. The area change from Grassland to Urban form 1992 to 2001 is calculated from the USGS Product to be less than one half square mile for the entire County of Maverick. This was done by taking the number of pixels indentified as Code 52 within Maverick County and multiplying them by the area of the pixel.

At this scale, it is easy to see several winding paths and other odd shapes in red that have been classified by the USGS as “Urban”. It is, once again, important to point out that the USGS Change Product has specific parameters to determine classification. The difficulties in matching
the two satellite images selected by the USGS, then followed by the challenges of designing and implementing a classification model that could be used for both images has proven to be only partial successful.

“Although one of the guiding principles of the NLCD 2001 design was to maintain as much compatibility with NLCD 1992 as possible, there were enough differences in the classifications to confound any direct comparison of the two datasets” (James Anderson)

The Classification Accuracy Table published by the USGS for this Change Product indicates that the accuracy ranges from 61% to 73% in the samples that were tested. The Classification Accuracy Table is included in Appendix 1. The follow definition is taken from the Classification Code definition for “Urban”:

“Urban - Includes developed open spaces with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses such as large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes. Also included are lands of low, medium, and high intensity with a mixture of constructed materials and vegetation, such as single-family housing units, multifamily housing units, and areas of retail, commercial, and industrial uses. Pixels coded to a value of 2 have not changed between 1992 and 2001.”

On a pixel by pixel basis, the change detection is summarized in the graph below. This graph was created in Excel by selecting only the USGS Classification Codes that indicated a change from the 1992 satellite image to the 2001 satellite image. These changed codes appear in the graph along the x-axis.

- **Code 1 = Open Water**
- **Code 2 = Urban**
- **Code 3 = Barren**
- **Code 4 = Forest**
- **Code 5 = Grassland/Shrub**
- **Code 6 = Agriculture**
- **Code 7 = Wetlands**
Two digit codes indicate a change from the first digit to the second digit. For example; Code 52 indicates a change in Land Cover from Code 5 (Grassland/Shrub) in 1992 to Code 2 (Urban) in 2001. So the codes in the graph below are all two digit codes which have a value in Maverick County. The value reported for each change code is the number of pixels in the County that are coded for that classification. For example; in the graph below code 52 has a value of 987. This corresponds to the number of pixels in Maverick County that have been coded by the USGS model to have changed from Grassland/Shrub to Urban. Note that the graph is logarithmic. The largest change detection is code 65 (Agriculture to Grassland/Shrub). With a spatial resolution of thirty meters, the changed area with a code of 65 is determined to be approximately 100 square kilometers or 38.8 square miles.

The three largest categories of change in Maverick County are Agriculture to Grassland/Shrub at 37%, Water to Grassland/Shrub at 21%, and Grassland/Shrub to Agriculture at 16%.
Summary:

This Land Use Land Cover analysis was conducted for Maverick County, using data downloaded from the USGS Land Cover Institute website. The USGS LULC product is provided as an image file and was processed using ArcMAP and ENVI as well as Excel. The period of LULC analysis covered roughly a ten year time frame from 1992 to 2001. As expected, the results showed an increase in urbanization while decreasing in agriculture. The implications of a shift away from an agricultural community toward an urban community can be discussed in the light of land use and land cover change data. The use of satellite imagery has become a strong tool for analyzing and interpreting earth systems and the anthropogenic influences that continue to pressure the planets limited resources.

Discussion:

Land use and land cover will continue to be tracked by governments and industries throughout time. With the additional tool of satellite remote sensing we will be able analyze changes across the planet. As changes in technology allow us to view to earth with better and better temporal, and spectral resolution, it will become easier to classify pixel changes from image to image and the resultant product will have a much higher accuracy rate.
References


