Measuring City Sustainability: Project Houston

A Shell Center for Sustainability White Paper

Jim Blackburn

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RICE UNIVERSITY
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Credits

This paper was written by Jim Blackburn, based upon a class (SOSC 325/ CEVE 325) taught by Blackburn in association with Dr. Steven Klineberg. Jesse Gill and Raleigh Ricart provided excellent research and technological support for the class. GIS work and associated graphics were completed by Bryan Carlile of Beck Geodetix and Matt Neuman of Houston Wilderness as noted in the text. Supplemental class lectures were provided by Karl Pepple, Brian Yeoman, Dr. Barton Smith, David Crossley, Juan Parras, Dr. Diana Strassman, Miki Milovanovic and Dr. Melissa Marschall. Students in the class contributing to the development of the matrix of indicators as well as evaluating the application of such indicators to the Houston region included Lindsay Asbury, Nicholas Basch, Drew Berger, Britney Blodgett, Richard Campbell, Rowan Canter, Christopher Chan, Roni Dietz, Janhvi Doshi, Austin Edwards, Ryan Gravolet, Rory Hatch, Frances Kellerman, Kurt Kienast, Timothy Kinney, Noah Levine, Cassie Lopez, Tatyana Luttenschlager, William Mansfield, Ellory Matzner, John McWilliams, Margaret Murphy, Alayne Potter, Jane Puthaaroon, Savannah Ritter, Aaron Robson, Jeffrey Rudnick, Joshua Rutenberg, Kyle Saari, Rebecca Sagestequi, Roque Sanchez, Carlos Solis, Emilia Stepinski, Citali Tapia, Christopher Thomas, Carter Wang, Daniel Willis, Willie Xu and Jaclyn Youngblood. Thanks also to student Marilu Corona for data from paper prepared for CEVE 302. The teaching of this class was supported by a grant from the Shell Center for Sustainability at Rice University.

Review

Special acknowledgment goes to Meredith Dang of the Houston-Galveston Area Council, for her review and suggestions to improve this document.

Foreword

What is urban sustainability? The Shell Center for Sustainability (SCS) in partnership with Jim Blackburn and Dr. Stephen Klineberg sought to answer that exact question.

Measuring City Sustainability: Project Houston is an important effort to measure sustainability by first creating sustainable development indicators. The next phases will define a sustainable development baseline and then measure progress in the Houston region.

Students from Rice University assisted the effort, resulting in 25 proposed measures to view sustainable development through an economic, environmental and social lens. These metrics include education, land use, air quality, crime, local food, open space, public transportation and job creation, among others.

These diverse indicators are critical to understanding Houston's sustainability profile, and improvement. In the past, Houston's sustainability has been looked at through only a few lenses, such as air and water quality. These indicators are important, but a full picture of Houston's sustainability landscape needs to be measured to understand how multiple issues overlap and intertwine, and work together. A complete and balanced understanding of what determines sustainability for a region is also critical to implementing initiatives, prioritizing actions, creating partnerships and making policy changes that improve sustainability.

This report clearly outlines and describes recommended sustainability metrics. In the next phase, SCS will proceed by initiating measurements to define Houston's baseline, and to continue to collect information that will present a picture of Houston's evolving condition. This work will be carried out by a dedicated SCS fellow who will develop the long-term and ongoing plan for this effort. The SCS fellow will work with faculty advisors close to the project in the areas of environmental policy, social, economic, and environmental impact.

This future work will be critical to our understanding of sustainability and will help guide us to make necessary changes to continue our progress to becoming an economic, ecological and social leader in the region and the US.

Laura Spanjian

Laura Spanjian is the Sustainability Director for Houston Mayor Annise Parker. She leads the Green Houston Office of Sustainability.

Executive Summary

During the Spring semester, 2010, a course was conducted that was funded by the Shell Center for Sustainability titled Measuring Sustainability: Project Houston. In this class, students worked as teams under the guidance of Jim Blackburn and Dr. Stephen Klineberg to determine a group of indicators to measure sustainability and then to gather data regarding those indicators. Other sustainability metric projects from around the United States and Canada were used as initial guides to determining appropriate sustainability metrics, which were compiled in a spread sheet to determine the consensus indicators from the studies consulted. The remainder of the class was devoted to the finding data to describe the performance of the City of Houston and/or the Houston metropolitan area relative to these indicators. The list of indicators developed by the class and refined or further developed by Jim Blackburn are shown in the Summary of Recommende Metrics below.

Summary of Recommended Metrics:

1. Education –High school drop-out rate Harris County 2009
   - Overall – 35%
   - Anglo – 13%
   - African American – 39%
   - Hispanic – 46%

2. Poverty – Per Cent Population Below Poverty 2009
   - City of Houston – 20.6%
   - Harris County – 20.5%

3. Land Use – Density (persons per square mile) 2010
   - City of Houston - 2.26 million persons/640 sq. miles = 3,482 persons/sq. mile
   - City of Houston ETJ – 1,347,697 persons/1815 sq. miles = 743 persons/sq. mile

4. Air Quality - 2009
   - Eight Hour Ozone – Compliance status - severe non-attainment area
     - 2009 Eight hour high – 97 ug/m3 (std – 75)
   - PM 2.5 – Compliance status - attainment
     - Clinton Drive Yearly Average 2009 – 14.4 ug/m3 (std. – 15.0)
   - Benzene - Highest Monitor
     - Pasadena North – 1.39 ppb (suggested long term level - 1.4 ppb)

5. Crime –yearly average for City of Houston based on 6/2009 – 3/2010 and 2.2 million population
   - Murder – 120
   - Rape – 408
   - Burglary – 14,520
   - Auto Theft – 7,080

6. Local Food
   - % City of Houston Low Income in Food Desert – 61% (91,965 acres)
   - Number of Community Gardens in Houston/Sugarland area - 125

7. Energy Efficiency - Gross Area Product/Energy Use Per Capita
   - 8.9 x 10E-04

8. Ecology – PerCent Coverage (loss) of Ecosystems at Regional Level 2005
   - Big Thicket – 25%
   - Coastal Marsh – 14%
   - Columbia Bottomlands – 21%
   - Piney Woods – 31%
   - Post Oak Savannah – 16%
   - Coastal Prairie – 40%
   - Trinity Bottomlands – 11%
   - Total Bird Species Houston Region – 295

9. Cost of Living/Housing Cost
   - ACCRA cost of living index – 8% below national average
   - Avg % income spent on housing – 22%
   - % population spending >30% on housing – 34%
   - Cost of gasoline 5/2011 - $3.99 per gallon

10. Flood Damages
   - Flood Damages as % of GDP for Houston area – 3%
   - Increase in flood plain area Harris County 1996-2007 – 34,125 acres
   - Acres of Flooded Housing Purchased and Removed By Watershed
     - White Oak Bayou – 158 acres
     - Greens Bayou – 198 acres
     - Halls Bayou - 60 acres
     - Brays Bayou – 16 acres

11. Environmental Justice
   - % population below poverty level living near designated hazardous waste sites – 57%

12. Water Quality
   - Number of Harris County Stream Segments Violating Water Quality Standards – 48

13. Drinking Water Quality
   - Number Wastewater Plants Discharging Into Lake Houston – 274

14. Public Transportation
   - Per Cent of Population and Jobs Within ¼ mile of public transportation stops – 75.1%
   - Per Cent of Population and Jobs within ¼ mile of rail stops – 5.4%
   - Miles of Rail – 7.5

15. Open Space
   - Per Cent of City Area within ½ mile of park or open space – 66%
   - Per Cent of Population within ½ mile – 65%

16. Freshwater Inflows to Galveston Bay
   - Number of Acre Feet Dedicated to Galveston Bay – 300,000 as of 2011

17. Water Usage
   - Data on Water Use for landscaping in City of Houston needs to be collected
   - Default Assumption – 52% used on landscaping

18. Job Creation
   - Workforce As of 9/2010 – approx. 1 million workers

19. Obesity and Outdoor Recreation
   - % of population with obesity issues
     - Anglo – 26%
     - African American – 28%
     - Hispanic – 27%
   - Miles of Bayou Greenway Trails Completed – 15.5 + 3.6 under construction

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20. Economic Diversity
    # of sectors > 20% of economic activity in region = 1

21. Debt Structure
    No acceptable metric determined – ideally debt per capita but not sure about debt reporting

22. Green Jobs
    No acceptable metric determined – ideally measure the recruitment of unemployed local workers into workforce

23. Community Involvement
    % of Harris county residents voting in most recent election – 57%

24. Recycling
    % waste diverted for recycling in City of Houston – 4%

25. Climate Change
    Harris County metric tons of CO_2 emissions – 18.625 million tons (Project Vulcan 2002 data) – better data forthcoming based on industrial reporting initiated in 2010
    ≠Acres of land dedicated to carbon sequestration - 1000

Sustainable development is a fascinating concept. It considers whether human settlements and institutions can be maintained into the future as first set forth in the 1987 report of the World Commission on Environment and Development titled "Our Common Future". In this report, sustainable development was defined as "development that meets the needs of the present without compromising the ability of the future generations to meet their own needs." A sustainable system is one that has a stable economic base, equitably provides for the needs of its citizens and exists within ecological limits. Sustainable practices minimize the use of materials and energy while taking care of the needs of the people and the natural system. As such, it represents a departure from past development practices and human settlement patterns. There also seems to be a relationship between areas that are desired locations for corporate relocations and headquarters development and sustainability. Sustainable cities make business sense as well as social and environmental sense.

To better understand the relationship of the concept of sustainable development to the Houston area, the Shell Center for Sustainability awarded a grant to research this issue and to teach a course on Measuring Urban Sustainability. The course was taught in the spring, 2010 as SOSC 325/CEVE 325 by Jim Blackburn and Steve Klineberg. During the course, students evaluated how other parts of the United States have approached urban sustainability and then developed their own criteria and metrics for the Houston area. Here we present the combined results of the class work and the research effort.

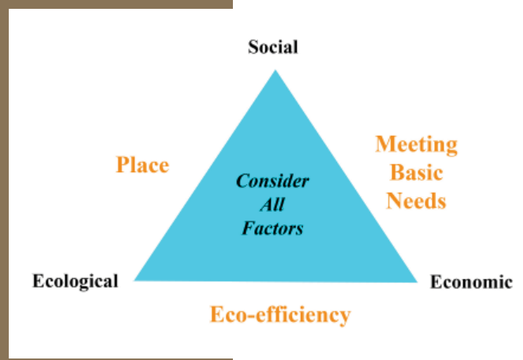


Figure 1: Sustainability Triangle

The key to sustainable development is consideration of social, economic and ecologic factors together. The triangle image shown in figure 1 is useful both in reminding us that there are three factors that must be considered and for amplifying the connections between these factors. Meeting basic needs involves the integration of economic and social considerations. Eco-efficiency results when economic and ecological factors are considered together and the concept of place emerges from the combination of social and ecological factors. In the class and in the research, this modified triangle proved to be a useful conceptual device. However, the most important point is that sustainability requires these factors to be balanced.

As part of this research, working definitions were developed for each of these areas of inquiry. The economic inquiry was concerned with the production, distribution, and consumption of goods and services in a

way that meets the needs of today without compromising the needs of future generations. The ecological issue was concerned with the physical state of water quality, air quality, biodiversity and ecological health. The social issue was focused on aspects of the equity of distribution of benefits, wealth and impacts in the Houston area. To amplify and better understand the intersect of these issues, meeting basic needs was defined as access to and ability to attain primary and secondary basic needs in order to maintain a reasonable quality of life, eco-efficiency was considered to be the efficiency of the movement and utilization of materials, energy and people within the Houston region and place was viewed as the characteristics of the surrounding environment and the choices made, actions taken or decisions informed by those characteristics that help define Houston. Together, these concepts guided our analysis of urban sustainability.

The first task was to identify various indicators of urban sustainability. To this end, there are many papers and reports that have been produced on urban sustainability from other areas of the United States as well as a national report by SustainLane. The class was divided into nineteen two-student groups that were charged with identifying and classifying indicators and entering them onto an excel spreadsheet that was maintained on the class web site. The goal here was to identify which indicators were used in multiple studies from different regions in an attempt to identify the range and type of variables considered as indicators of urban sustainability. The cities that were studied were based upon availability of suitable materials and included Baltimore, Maryland; Bay Area Alliance; Boston Indicator Project; Calgary Canada; Calvert and Henderson; Chicago, Illinois: Cincinnati, Ohio; Fraser Basin, Canada; Forum For the Future British Cities; Hamilton, Ontario; Issaquah, Washington; Minneapolis, Minnesota; Missoula Montana; NRDC Smarter Cities; Ontario, Canada; Pasadena, California and Tucson, Arizona.

Categories	SustainLane	Calgary	Issaquah	Santa Monica	Chicago	Missoula	Calvert-Henderson	Cincinnati	Baltimore	Pasadena	NRDC - Smarter Cities	Fraser Basin	Bay Area Alliance	Tucson	Seattle	Hamilton	Minneapolis	Ontario	Boston	FOF - British Cities	Total
Educational Achievement & Performance		X	X	X	X	X	X	X	X			X	X	X	X		X	X	X	X	16
Community Engagement		X	X	X	X		X	X	X		X	X	X	X	X	X	X		X		15
Employment/Unemployment		X	X		X		X		X	X		X	X	X	X	X	X	X	X	X	15
Land Use			X	X	X	X	X	X	X	X		X	X	X	X	X		X	X		15
Water Conservation	X	X	X	X			X		X	X	X	X	X	X	X	X	X		X		15
Affordable Housing	X	X	X	X	X	X			X				X	X	X	X	X	X	X	X	14
Crime		X	X		X	X	X	X	X			X	X	X	X	X	X		X		14
Air Quality - PM	X			X		X	X			X	X	X	X	X	X	X		X	X		13
Cost of Living		X	X	X	X	X	X	X	X		X		X	X			X		X		13
Health Care: Access		X	X	X	X	X	X	X	X			X	X	X	X				X		13
Homelessness/Poverty		X	X	X	X	X	X		X	X	X	X	X				X		X		13
Waste Production	X	X	X	X			X	X		X	X	X	X		X	X				X	13
Commuting	X	X	X	X		X				X	X		X	X	X			X		X	12
Ecological Footprint		X	X	X			X			X	X	X		X	X		X		X	X	12
Income Distribution		X			X	X	X	X				X	X	X	X	X		X	X		12
Public Transportation	X		X	X	X	X		X	X	X		X	X	X					X		12
Air Quality - Ozone	X			X	X	X			X	X	X		X	X		X			X		11
Ecological Health		X	X	X		X	X					X		X	X		X		X	X	11
Green Space			X			X			X	X	X	X	X	X	X				X	X	11
Recreation Area	X		X	X		X			X	X		X		X		X			X	X	11
Air Quality - Toxics				X	X	X	X			X			X		X	X			X	X	10
Bicycling/Walking	X		X	X		X				X		X		X			X	X	X		10
Childhood Health		X		X	X	X	X					X		X	X		X		X		10
Demographics		X		X	X	X	X		X			X	X		X				X		10
Economic Diversification		X	X		X		X		X				X	X	X			X	X		10
Health Care: Affordability			X	X		X	X	X				X	X	X	X				X		10
Obesity/Weight			X	X		X	X	X		X						X	X	X	X		10
Educational Accessibility		X			X		X		X			X	X		X	X			X		9
Entrepreneurship & Innovation				X	X			X	X	X	X		X	X					X		9
Public Health - Asthma, HIV, etc.				X	X	X	X	X		X		X					X		X		9
Recycling	X		X	X						X	X	X		X					X	X	9
Traffic Congestion	X		X	X	X				X	X		X	X			X					9
Water Supply			X	X	X		X			X		X		X		X			X		9
Access to Food	X	X	X	X						X			X	X					X		8
Alternative Energy	X		X	X						X	X	X					X		X		8
Population		X				X			X			X			X	X		X	X		8
Resource Conservation			X	X		X						X	X	X	X				X		8
Safety			X	X		X	X			X		X			X				X		8
Climate Change	X		X	X						X		X	X						X		7
Green Building	X		X	X			X			X	X								X		7
Green Economy	X			X			X			X		X	X						X		7
Historic & Cultural Resources									X				X	X	X	X		X	X		7
Labor Force				X	X		X		X	X			X	X							7
Local Food		X	X	X						X	X			X	X						7

Figure 2: Urban Indicators Matrix

Figure 2 shows 44 indicators (as classified by the students) that were included on seven or more of the city sustainability reports. This list was used as a starting point for identifying candidate issues because these had been considered important to other urban areas in defining sustainability. As indicated by this list, there is no escaping the breadth of the urban sustainability issue. Education and air quality must be considered alongside issues such as water usage, housing cost and local food availability. There must be an economic engine to maintain this urban area over time, and the food, water and shelter must be affordable to residents. It is a formidable and humbling task to develop metrics for these various and varied indicators.

The second goal of this project was to develop metrics associated with these indicators. Regarding metrics, it is important to consider both the scope and availability of data. There is a difference between the physical agglomeration of people and businesses that we collectively refer to as Houston or the Houston area and the municipal corporation that is the City of Houston with its corporate boundaries. Certain indicators refer to the agglomeration but the primary data may only be available within city boundaries. Some indicators may involve other institutions such as the Houston Independent School District or Houston-Galveston Area Council. Additionally, there are many ways to measure these various and varied subject areas, with data being more easily available for some approaches than others. In short, there is both variability and variety of data and the coverage of the region. In the following paragraphs, the indicators selected for measuring urban sustainability in the Houston area are set out along with our best efforts to begin to describe the Houston situation relative to these indicators.

1. Education Success

Education success was the number one consensus indicator from our survey of sustainability studies; neither Texas nor Houston distinguished themselves in this regard. The State of Texas ranks 49 out of the 50 states in terms of high school

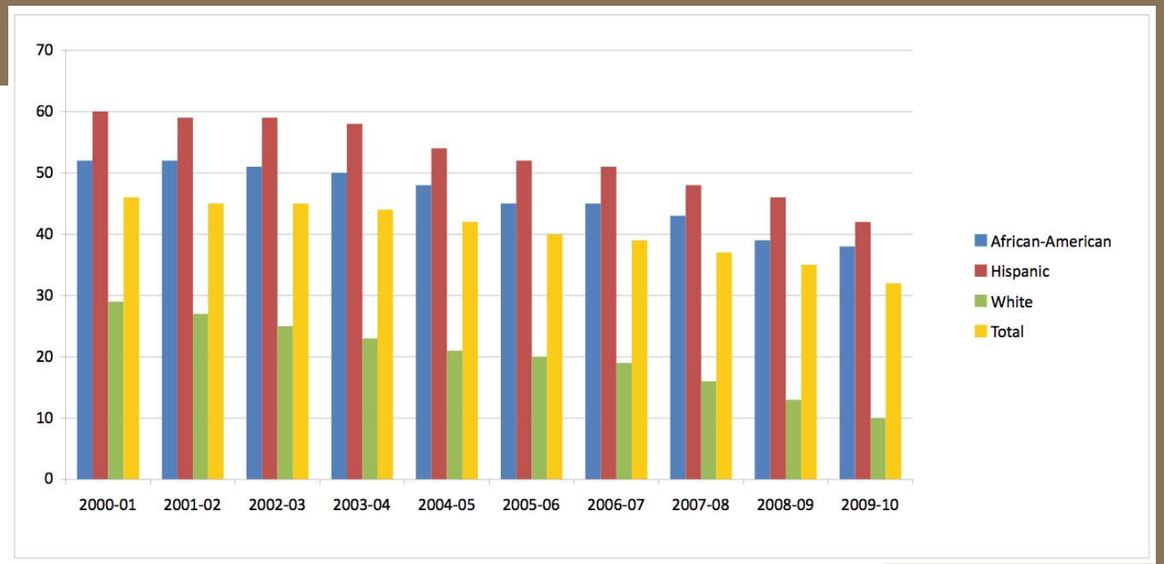


Figure 3: Harris County attrition rate
Source: Interculturual Development Research Association, 2008-2009

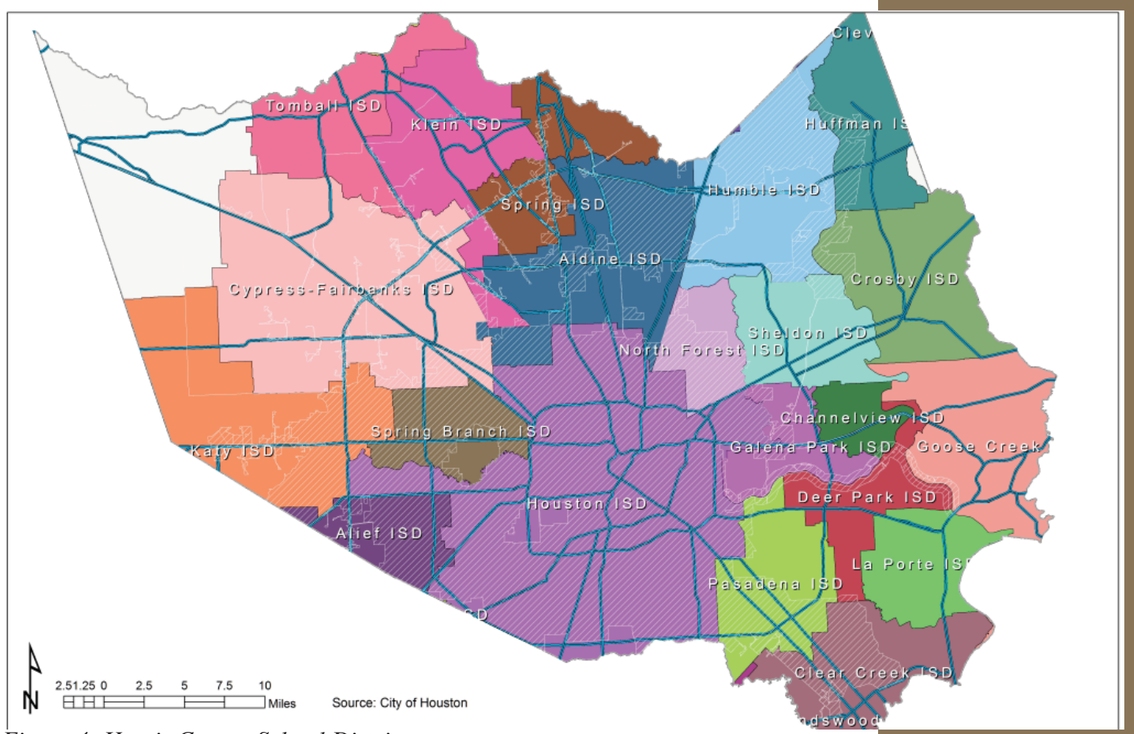


Figure 4: Harris County School Districts
Source: Bryan Carlile, Beck Geodetix and City of Houston

dropout rate. This problem also exists at the Harris County level, with the results being different for various ethnic groups as can be seen on Figure 3. As shown, the dropout rate for Hispanics is higher than for any other group. This result is particularly troubling in that Houston's Hispanic population is expected to rise in the future, further increasing the necessity for addressing this problem if all of us are to be sustainable in the future. The various school districts are shown in Figure 4. Over time, the data should be disaggregated to the various districts to allow better comparisons of success.

Recommended Indicator: Education - High School drop-out rate Harris County 2009.
Overall -39%; Anglo -13%; African American -30%; Hispanic - 45%

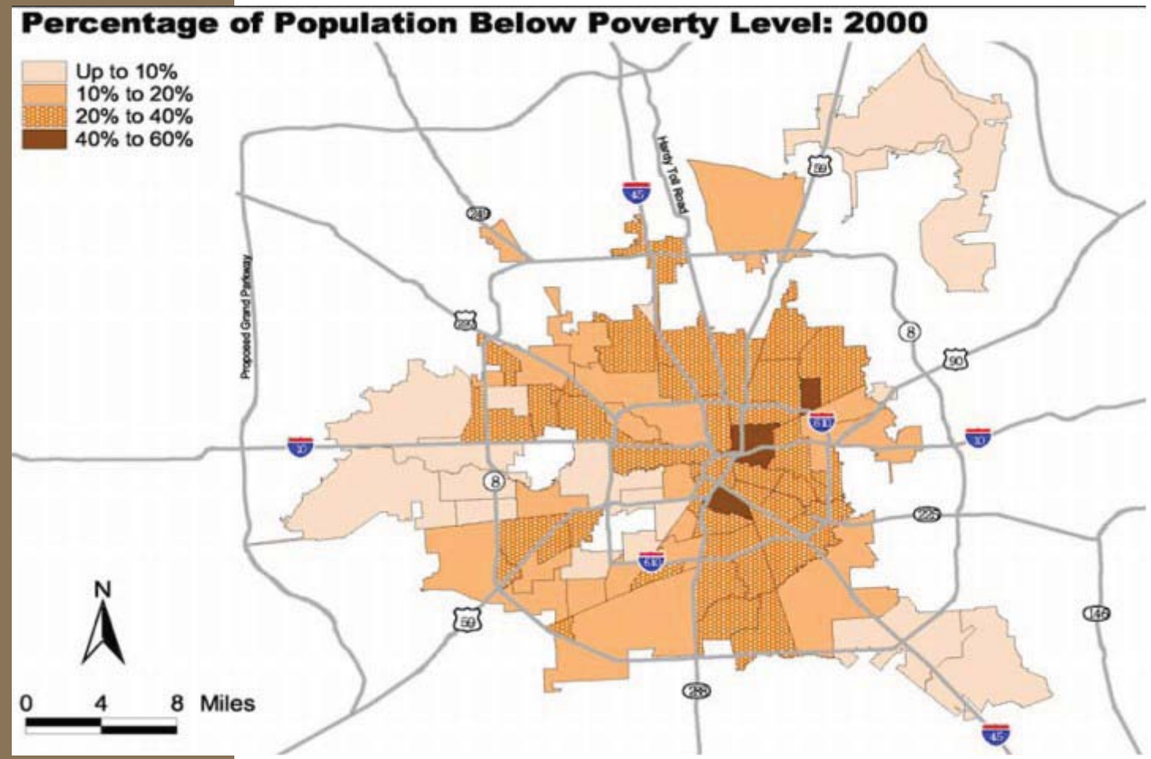


Figure 5: Percentage of Population Below Poverty Level: 2000
Source: United States Census of the Population, 2000

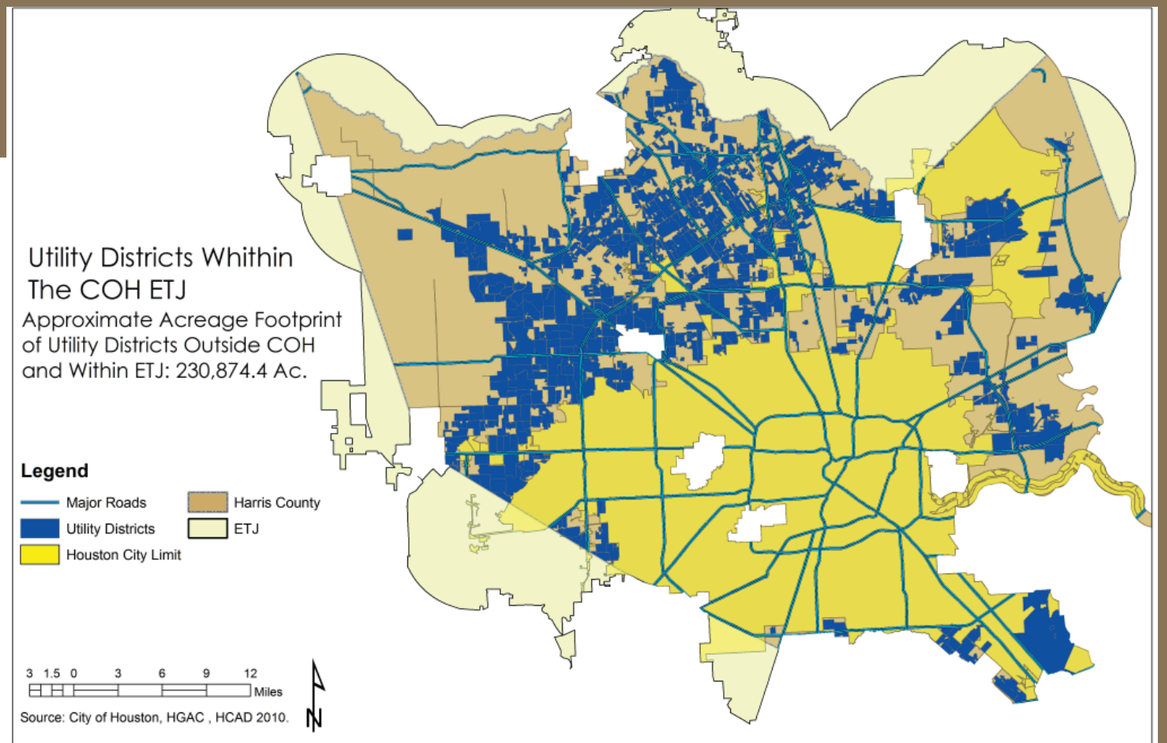


Figure 6: City of Houston Municipal Boundaries and Surrounding Utility Districts
Source: Bryan Carlile, Beck Geodetix, City of Houston, HGAC

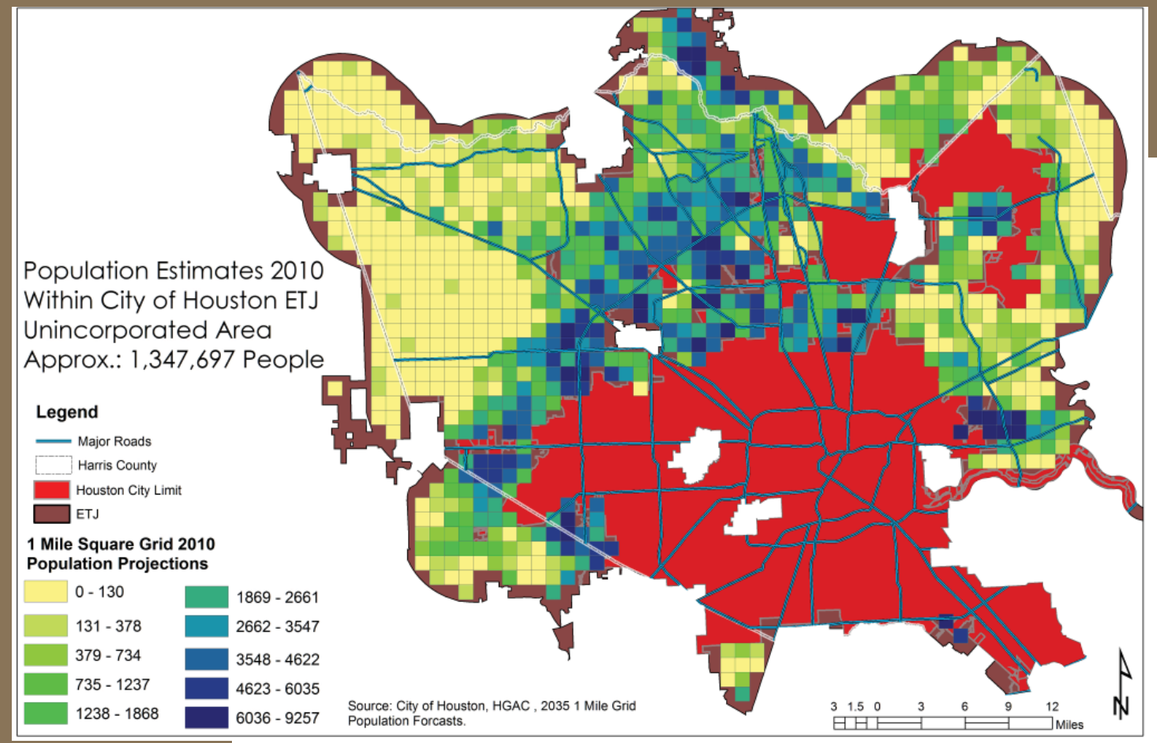


Figure 7: Population Estimates in City of Houston ETJ
Source: Bryan Carlile, Beck Geodetix, City of Houston, HGAC

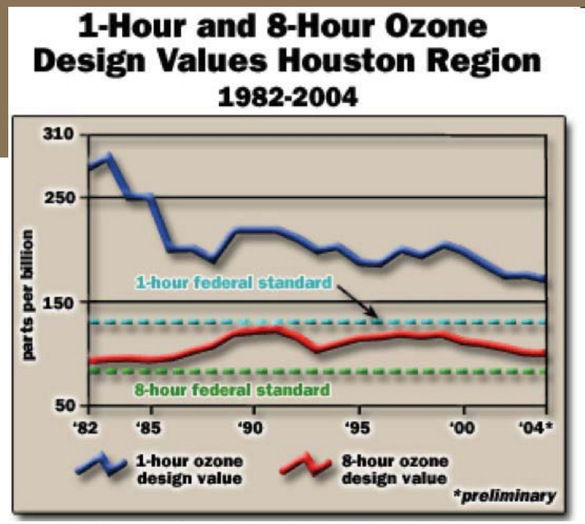
2. Poverty

It is not possible to meet basic needs if one does not have sufficient income. And while the Houston area is often viewed as a thriving and prosperous area, over 300,000 people live below the poverty line. In Figure 5, the 2000 census data shows significant portions of the City of Houston where 20% or more of the population is below poverty, with several areas showing 40% or more of the population being below poverty. More recent estimates from 2009 indicate that of an estimated City of Houston population of 2,257,926, 20.6% or 465,132 persons are currently below the poverty level. (Source: City of Houston and US Census Bureau 2009). For this same time period, it was estimated that 20.5% of the population of Harris County (including the City of Houston) were living at or below the poverty level. It will be interesting and important to compare this data with the official 2010 census data to determine the change in the relative occurrence of poverty as well as changes in the geographic location of these populations living below poverty. Here, the sustainability goal would be to decrease this percentage over time. There is no identified end point other than progress toward zero.

Recommended Indicator: Poverty - Percent Population Below Poverty 2009. City of Houston - 20.6%; Harris County - 20.5%

3. Land Use and Density

To understand the land use and density pattern of Houston, it is necessary to consider both the pattern of land use and the density within the City of Houston. The City of Houston is 640 square miles and has an estimated population of 2.26 million in 2009, resulting in a density of 3,482 persons per square mile. Another 1815 square miles has been preserved for annexation in the so-called area of extraterritorial jurisdiction or ETJ. This ETJ is predominantly in the unincorporated area of Harris County and has been developed by the use of various special governmental districts such as utility districts. In Harris County, approximately 231,000 acres are included in several hundred utility districts shown in Figure 6. These utility districts are a keky aspect of our land use policy and a driver for lower density unincorporated areas. According to the Harris County Attorney's office, collectively, the population found in the unincorporated area of Harris County is in excess of one million persons. If this area were a city, it would be the fourth largest in Texas, ranking between Dallas and Austin. However, althught approximately 1.35 million persons live in the city's ETJ, the population density drops to about 743 persons/square mile. For comparison purposes, New York City is about 27,000 per square mile, Chicago is about 12,600 per square mile, with Los Angeles being about 8,200, San Diego 1,612 and Dallas 1,427. The boundaries of the City of Houston and location of various utility districts surrounding the City are shown on Figure 6 and the population projec-



Note: The term "design value" is an indicator of pollution levels--in this case, for ozone--and is a statistic calculated from observed pollutant concentrations. For the 1-hour ozone standard, the design value is the fourth highest daily maximum 1-hour ozone concentration in a three-year period (the standard allows one exceedance a year, on average). For the 8-hour standard, the design value is the average of the fourth highest 8-hour daily maximum ozone concentration for tthee consecutive years.The design value is used to determine an areas' attainment status.

Figure 8: Ozone Pollution Levels Over Time
Source: TCEQ State Implementation Plan

tions for the unincorporated ETJ of the City of Houston is shown on Figure 7.

Recommended Indicator: Land Use - Density (persons per square mile) 2010.
City of Houston - 2.26 million persons/640 sq. miles=3,842 persons/sq. mile.
Cityof Houston ETJ - 1,347,697 persons/1,814 sq. miles=743 persons/sq. mile.

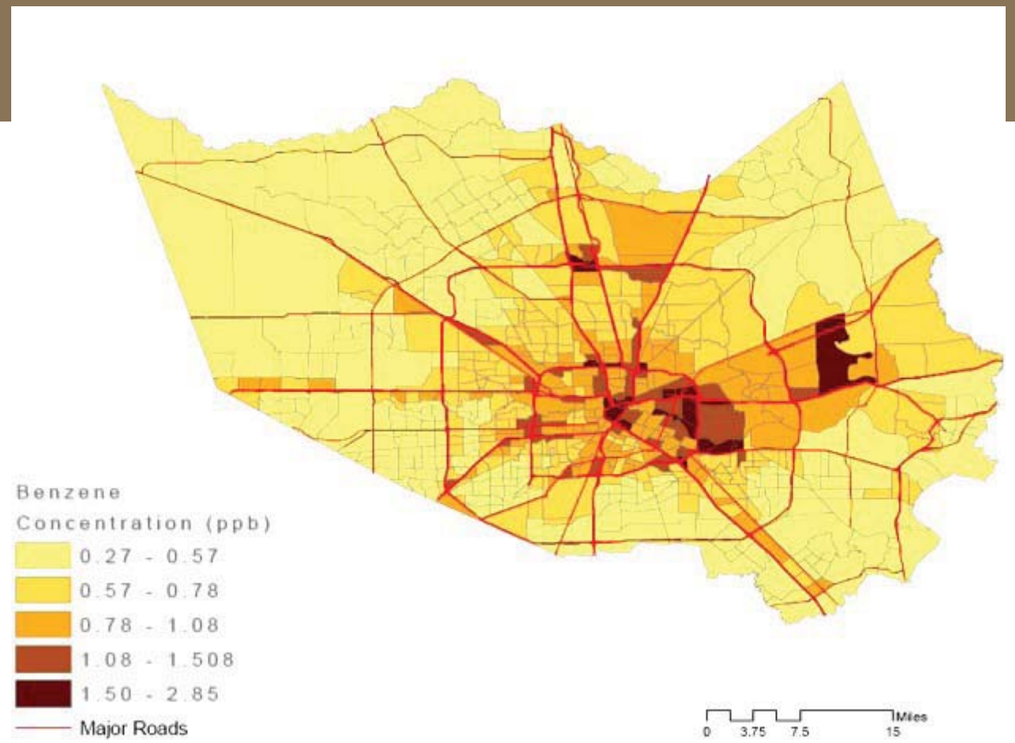


Figure 9: Projected Benzene Levels
Source: U.S. Environmental Protection Agency, Dr. Matt Fraser

Type of Crime by Division from June 2009 to March 2010

	Murder	Rape	Burglary	Auto Theft		Total for Division
Central Division	3	22	754	571		1350
Clear Lake Division	4	26	1262	732		2024
Eastside Division	8	22	726	426		1182
Fondren Division	22	58	1502	682		2264
North Division	15	27	1072	574		1688
Northeast Division	13	38	993	536		1580
Northwest Division	1	11	518	208		738
South Central Division	7	44	1048	440		1539
Southeast Division	6	22	882	517		1427
Southwest Division	7	20	1121	427		1575
Westside Division	18	54	2221	785		3078
Total	104	344	12099	5898		

Figure 10: Occurrence By Type of Crime By Police Department District
Source: City of Houston Police Department

4. Air Quality

In Houston, ozone air pollution is a major concern. The Houston region has been violating both the one hour and eight hour ozone standard since these standards were developed, although the air quality is getting better (see Figure 8). The geographic distribution of ozone air pollution is not uniform, and several areas of the region are more heavily impacted by ozone air pollution than are others. Surprisingly to some, the numbers of bad ozone days is highest in the southwest part of Houston south of Bellaire and in the northeast in the Aldine area as well as near the Houston Ship Channel. The situation with air toxics is more difficult to analyze. Data from monitoring systems in portions of Harris County are pollutant specific and the coverage is limited. Nonetheless, monitors on the east side of Houston have consistently shown problems with benzene levels that exceed the 2 ppb level set by the State of Texas as a basis for health

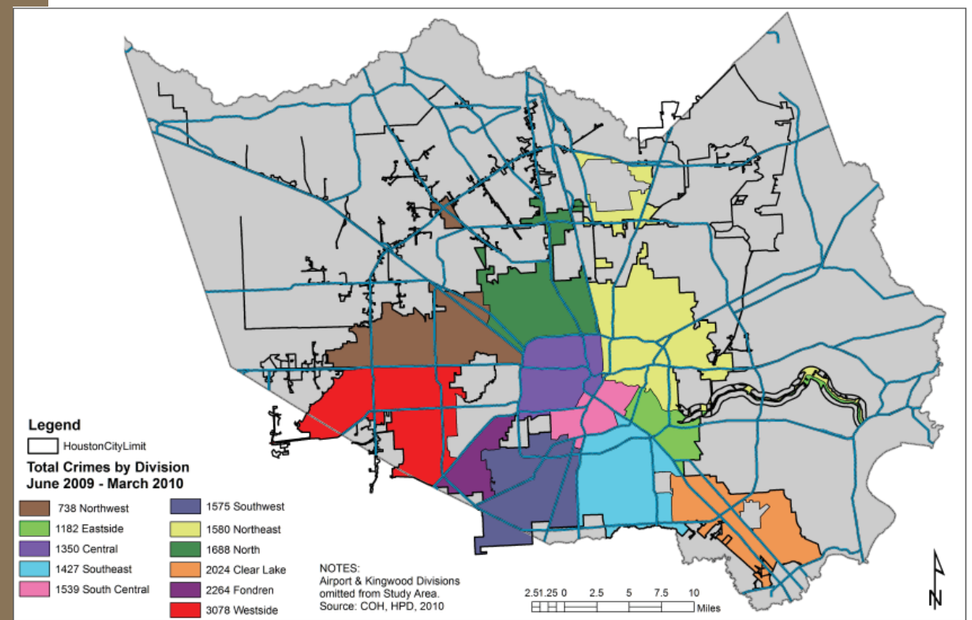


Figure 11: Houston Crime By Houston Police Department Division
Source: Bryan Carlile, Beck Geodetix and City of Houston Police Department

concern. A computerized projection of benzene levels prepared by the U.S. EPA and used by Dr. Matt Fraser in his assessment of the risks of Houston air pollution is shown in Figure 9. The projection of higher levels on the east side of Houston is noteworthy both from the public health standpoint and with respect to environmental justice concerns. To date, there have been no violations of particulate level standards in Houston, although the measurements of particulate matter 2.5 microns and smaller (PM2.5) at the Clinton Drive monitor on the east side of town are very close to violating the national standard and have demonstrated a trend of increasing concentrations over time. PM2.5 is a dangerous class of pollutants that get deep into the lungs and should be carefully monitored and maintained if not decreased over time.

Recommended Indicators: Air Quality.
-Eight Hour Ozone - Compliance status - severe non-attainment area
2009 Eight hour high = 97 ug/m3 (std - 75)
-PM 2.5 - Compliance status - attainment
Clinton Drive Yearly Average 2009 - 14.4 ug/m3 (std.-15.0)
-Benzene - High Monitor 2009
Pasadena North - 1.39 ppb (suggested long term level - 1.4 ppb)

5. Crime

Crime is an important indicator of public safety – of whether or not the fabric of society is secure. Houston crime statistics indicate that we suffer more crime than the national norm. As reported by CityRating.Com based on the 2003 FBI Report of Offenses, Houston's murder rate was three times the national average, robbery was 2.46 times the national average and all violent crimes were 1.97 times the national average. Statistics maintained by the City of Houston indicate that there are substantial differences from one part of the city to another and the Houston Police Department maintains information on a police division basis. Figure 10 presents data from these different Houston police divisions and Figure 11 shows the geographic boundaries of those divisions as well as total crimes per division.

Recommended Indicators: Crime - yearly average for City of Houston:
Murder - 120; Rape - 408; Burglary - 14,520; Auto Theft - 7,080; (based on 6/2009-3/2010 and 2.2 million population)

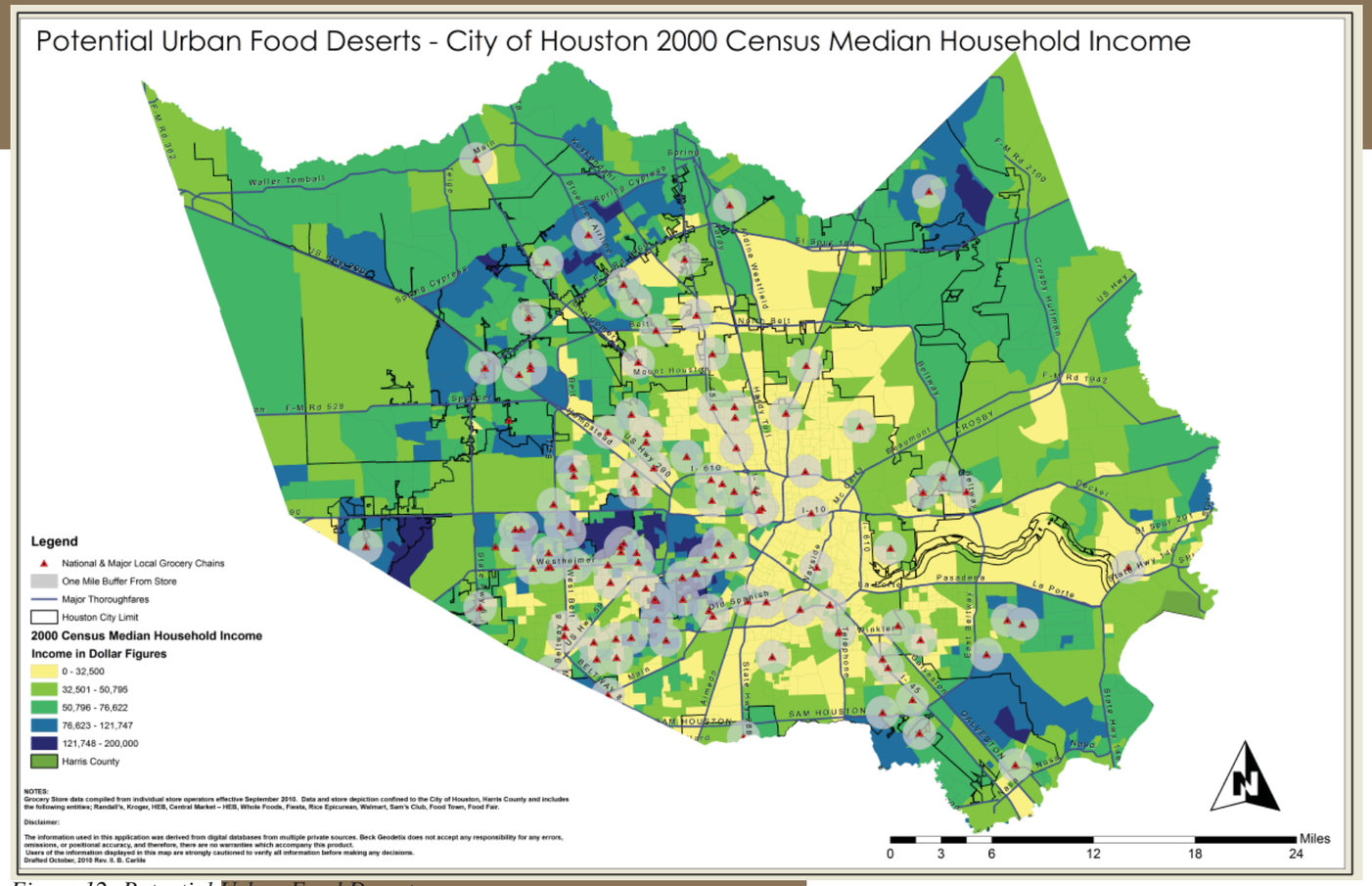


Figure 12: Potential Urban Food Deserts
Source: Bryan Carlile, Beck Geodetix from 2000 Census and Company-provided Data

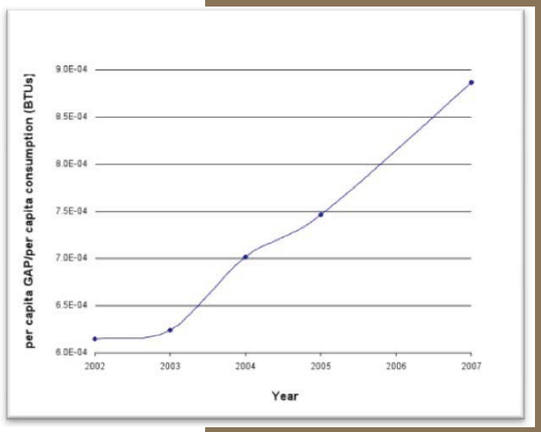


Figure 13: Houston Area Economic Energy Efficiency Index. The per capita gross area product, a measure of overall economic activity, is divided by per capita energy usage. A Postive slope to this line indicates greater energy efficiency.
Source: William Mansfield from reported energy and economic data

6. Hunger and Local Food

Food is a basic need and hunger is an indication that it is not being met. According to Dr. Bob Randall, an expert on local hunger and food issues, there are approximately 300,000 people in Houston who receive an inadequate amount of food on a daily basis. There are also areas of the city that are chronically underserved by food stores. These areas are often referred to as "food deserts". A map showing a mile radius around major food vendors overlaid upon census data showing median income is set out in Figure 12 and clearly shows a pattern of food availability in Houston that is skewed away from lower income areas, thereby making it more difficult to obtain food for those who arguably have the least resources to obtain access to food stores. In turn, various health problems including diabetes and obesity may be expected to be found in association with food deserts. On the other side of this issue are local food production and community gardens. According to Urban Harvest, a local NGO devoted to local food, there are about 125 community and school gardens in the Houston metropolitan area and the number is growing rapidly.

Recommended Indicator: Local Food.
% City of Houston Low Income in Food Desert - 61% (91,965 acres)
Number of Community Gardens in Houston/Sugarland area - 125

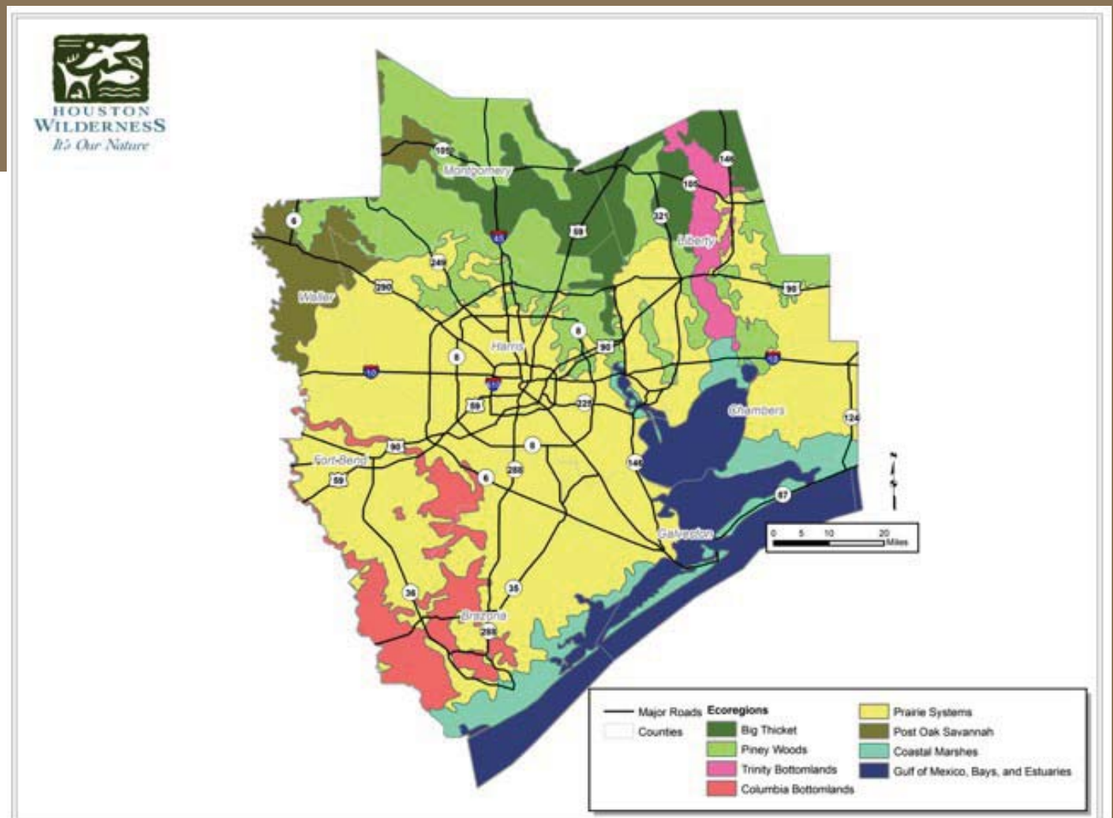


Figure 14: Ecological Capital of Houston Area
Source: Matt Neuman for Houston Wilderness

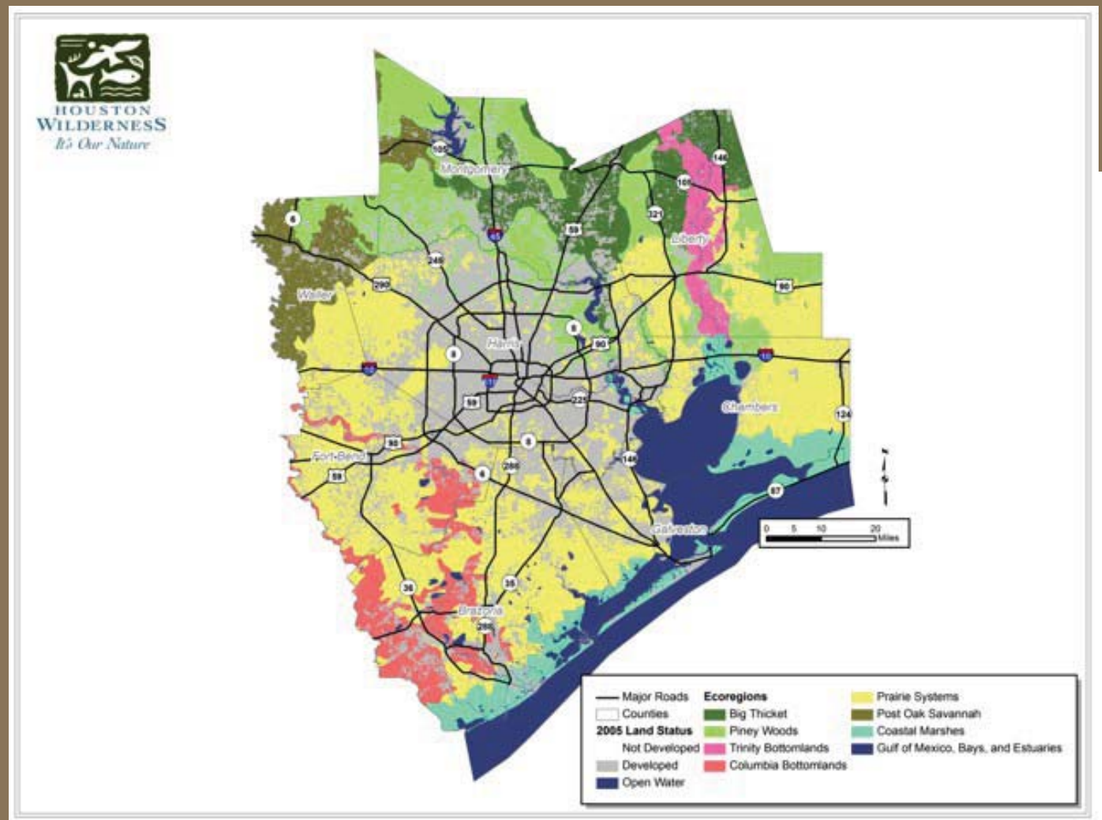


Figure 15: Houston Area Economic Energy Efficiency Index
Source: William Mansfield from reported energy and economic data

7. Energy Efficiency

There are many ways to measure energy efficiency. The City of Houston has multiple programs underway where they are bringing energy efficiency concepts to city infrastructure projects. Among these projects are utilization of LED lighting throughout the City, purchasing electricity generated by renewable sources, purchasing of a hybrid automobile fleet, requiring LEED certification for new buildings and many other important initiatives. From this perspective, one metric could be to track the electricity and gasoline usage by the City of Houston and monitor it over time. However, another approach would be to monitor energy usage within the region relative to economic activity. This approach is a much broader index that attempts to track the efficiency of our economic activity. Figure 13 shows trends in energy usage relative to economic activity over time.

Recommended Metric: Energy Efficiency - Gross Area Product/Energy Use Per Capita=8.9 x 10E-04

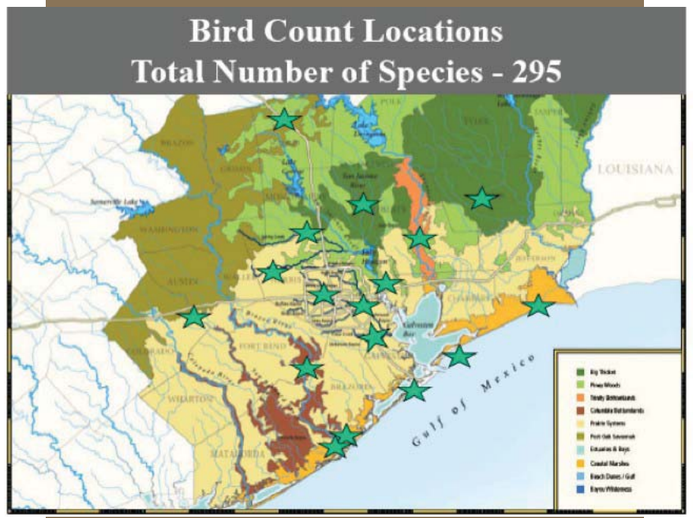


Figure 16: Christmas Bird Count Locations
Source: Houston Audubon Society

8. Ecological Footprint and Biological Diversity

Houston is rich in biological diversity and abundance; it is surrounded by approximately ten different ecological systems (see Figure 14). It is possible to track the land use change relative to these various ecosystems and determine the extent of ecosystem loss. Data compiled by Matt Neuman of Houston Wilderness, another local NGO, using Houston-Galveston Area Council data showed the amount of the region dedicated to concrete rather than ecological services can be monitored (Figure 15). The area in grey in Figure 15 shows the area covered by development of various types. With this development, the amount of the natural system remaining in 2005 is as follows: Big Thicket – 318,000, coastal marshes - 262,000, Columbia Bottomlands – 253,000, Piney woods – 652,000, Post Oak Savannah – 211,000, prairie – 1.55 million and Trinity bottomlands – 118.000. This represents, respectively, a historical loss of 25% of the Big Thicket in our area, 14% of the coastal marshes, 21% of the Columbia Bottomlands, 31% of the piney woods, 16% of the Post Oak Savannah, 40% of the coastal prairie, and 11% of the Trinity Bottomlands. This is a measurement of the land area actually converted to land development and does not include alteration by agricultural use or forestry or other types of activities that might affect the ecological system but not cover the ground.

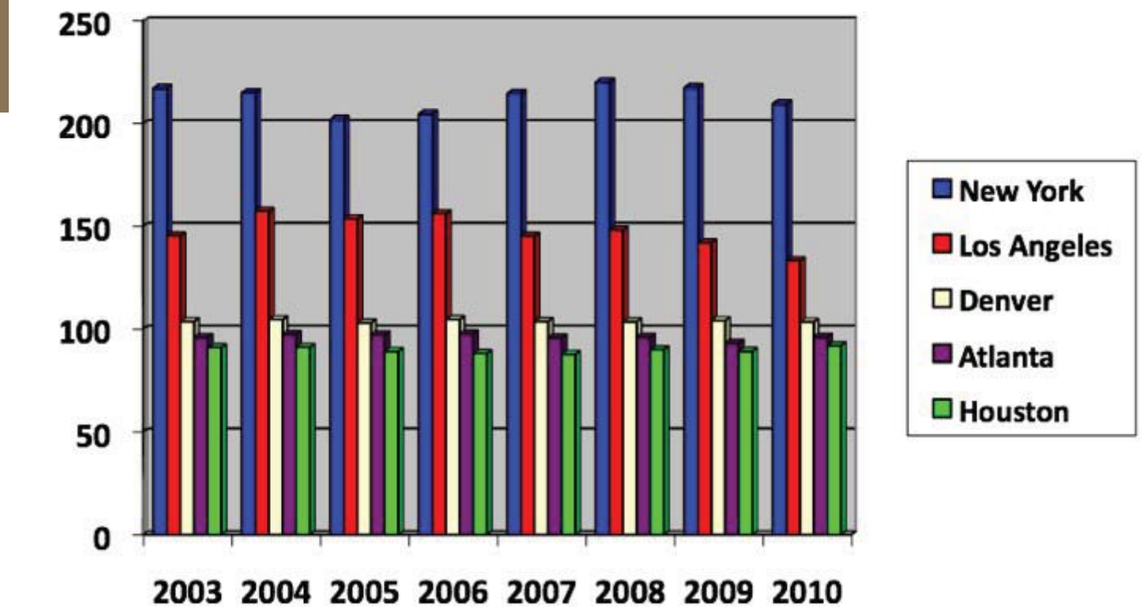


Figure 17: Cost of Living Comparison-Houston and Selected Other Metropolitan Areas. Source: ACCRA

Apart from measuring the sheer acres of land area converted to urban areas, it may be possible to identify proxy variables for biological diversity such as the number of bird species recorded in Audubon Society's Christmas Bird Counts around Houston as is shown in Figure 16.

Recommended Metric: Ecology - PerCent Coverage (loss) of Ecosystems at Regional Level 2005.
-Big Thicket - 25%; Coastal Marsh - 14%; Columbia Bottomlands - 21%; Piney Woods - 31%; Post Oak Savannah - 16%; Coastal Prairie - 40%; Trinity -Bottomlands - 11%
Total Bird Species Houston Region - 295

9. Cost of Living and Housing Cost

Houston ranks extremely well in both cost of living and housing cost, two indicators identified by multiple cities. As can be seen from Figure 17, Houston compares very favorably to other regions of the country relative to cost of living. According to Bizjournals, 2008, Houston ranked 8th out of 50 cities regarding the amount of income spent on housing. On average, Houstonians spent 22% of their income on housing. Yet, another indicator of housing cost would be the number of Houstonians that spent over 30% of household income on housing. This number is important because spending over 30% causes difficulties in the ability of a family to put money into savings, thus creating an unsustainable financial future. This Shell Center-sponsored research showed that in the Houston area, 33% of the population

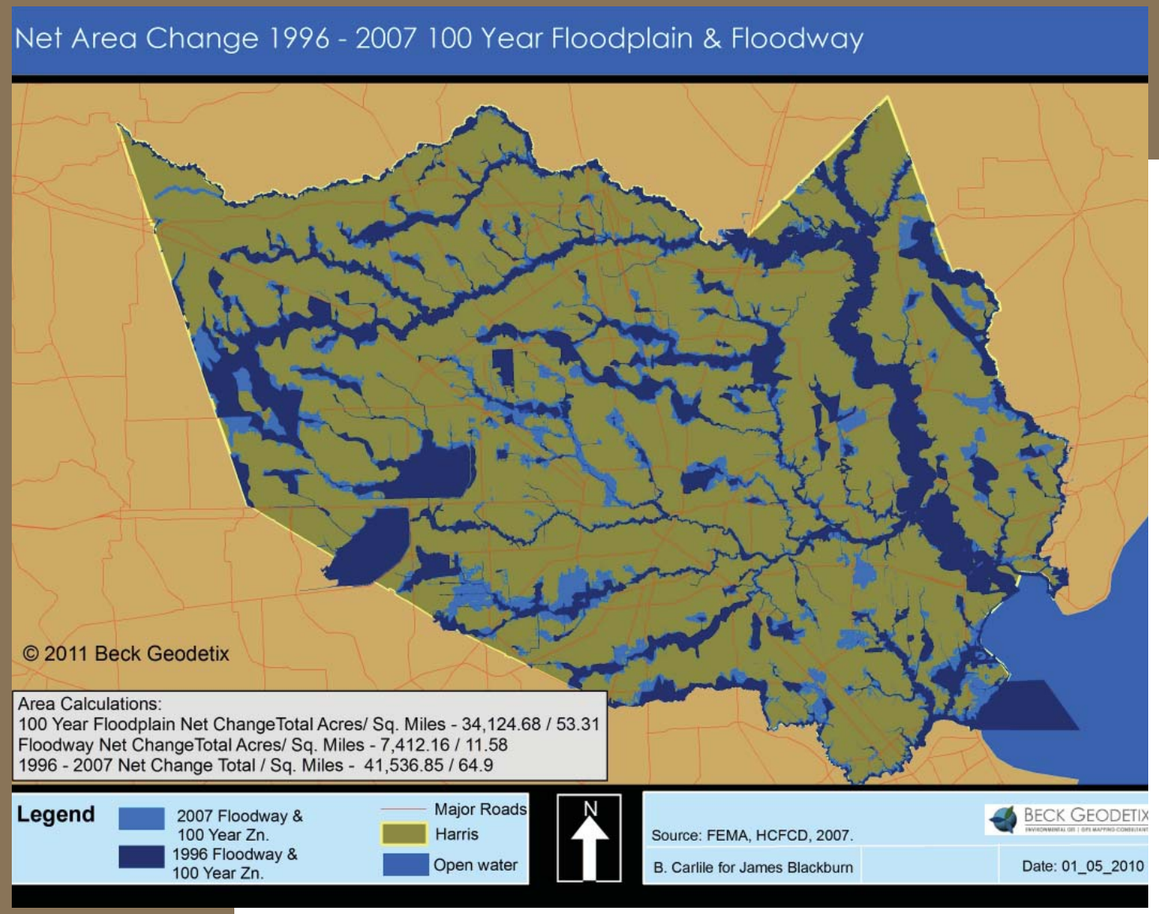


Figure 18: 1996 and 2007 100-year Flood Plain
Source: Bryan Carlile, Beck Geodetix from Federal Emergency Management Agency and Harris County Flood Control District.

spent more than thirty-percent of their income for housing in 1990 and 34% spent more than thirty-percent in 2000 according to student Ellory Matzner. On the other hand, housing cost in Houston may be offset by the cost of gasoline, as much of the housing value in Houston is related to suburban development which is supported by, and arguably subsidized by, lower cost gasoline along with the value of time spent in traffic. As the price of gasoline rises, housing patterns and costs may change.

Recommended Metric: Cot of Living/Housing Cost.
ACCRA cost of living index - 8% below national average
Avg% income spent on housing - 22%
% population spending >30% on housing -34%
Cost of gasoline 5/2011 - $3.99 per gallon

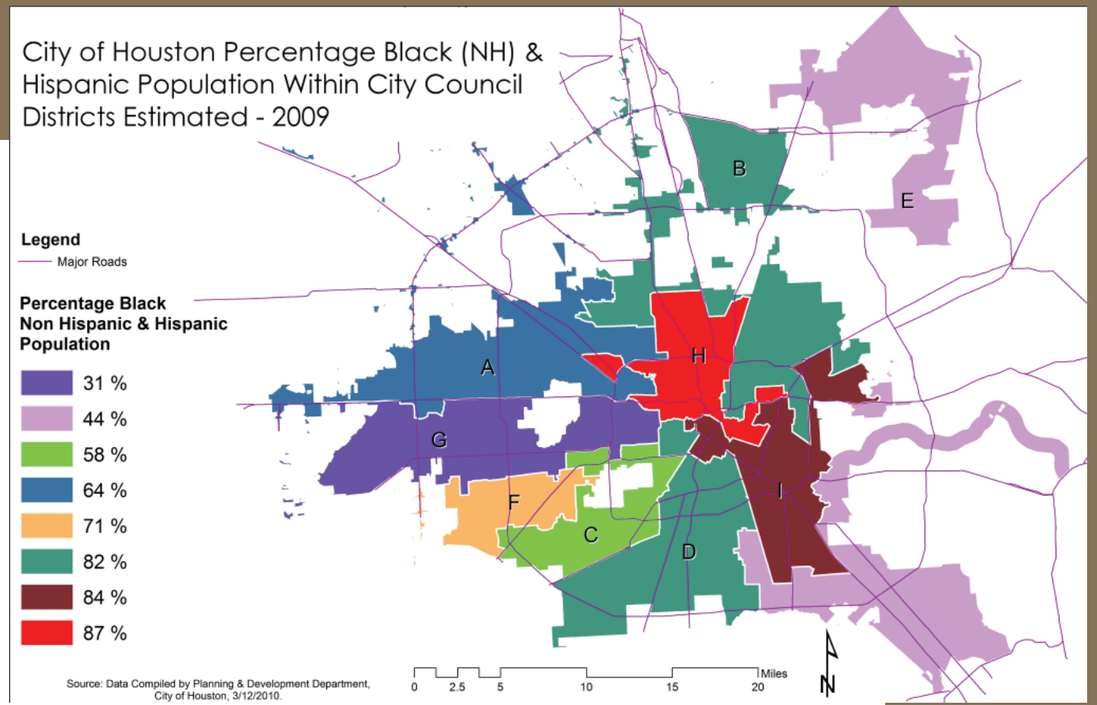


Figure 19: Percentage Black and Hispanic Population Within City of Houston Council Districts. Prepared by Maggie Murphy.
Ssource: Bryan Carlile and Beck Geodetix from City of Houston Planing and Development Department

10. Flooding Damages

Flooding is a reality of the Houston area. Approximately 25% of Harris County is in a hurricane evacuation zone as is 20% of the City of Houston. The flood plains within Harris County are quite large and have expanded over the last decade. In Figure 18, the 100-year flood plain coverage within Harris County is shown for 1996 and 2007, with the net increase being shown in light blue. During this time, the flood plains increased by approximately 65 square miles or almost 42,000 acres. Much of this new flood plain area is within existing urbanized areas. One of the flood-related metrics developed by student Drew Berger was to attempt to track flood damages as a percent of adjusted gross area product. From 2005 – 2008, the Houston area suffered $44.1 billion in damages due to natural storm disasters. During

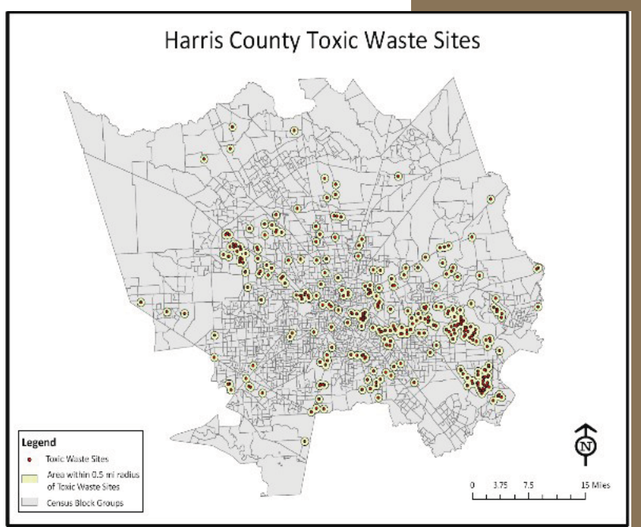


Figure 20: Location of Harris County Toxic Waste Sites. Prepared by Maggie Murphy.
Source: Census 2000 and Texas Commission on Environmental Quality

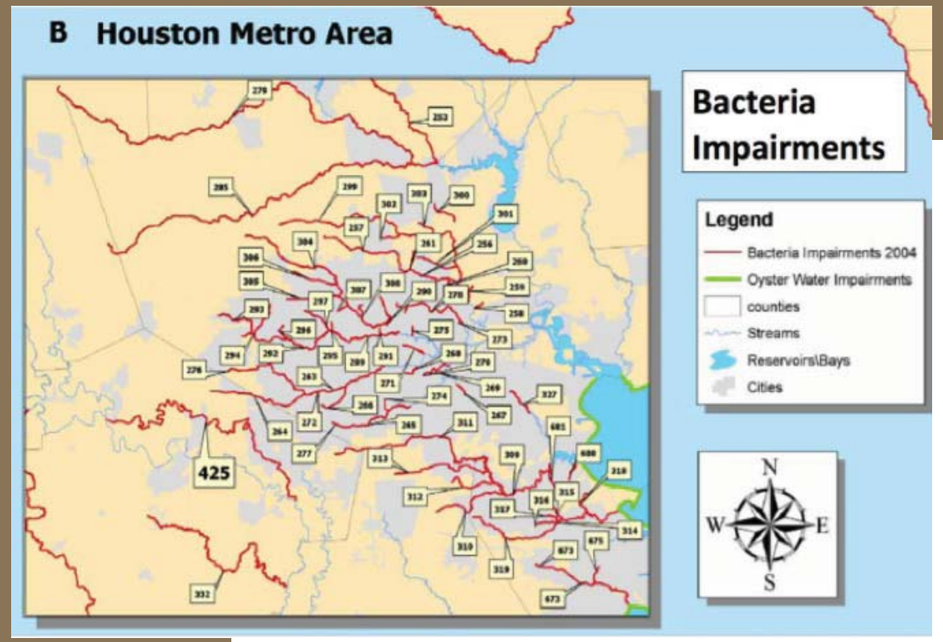


Figure 21: Bacteria Impairments
Source: Houston Galveston Area Council and Texas Commission On Environmental Quality

that same time, the adjusted gross area product was almost $1,400 billion, leading to about 3% of the gross area product being lost to flood damage during this time period. Over the last few years, significant numbers of homes have been purchased and removed from developed flood-prone areas with approximately 158 acres being purchased in the White Oak Bayou watershed. More recently, the U.S. Army Corps of Engineers has identified certain dam safety issues regarding Addicks Reservoir which protects Buffalo Bayou and downtown Houston. This dam safety concern should be closely monitored as a safe Addicks reservoir and dam is absolutely critical to the long-term safety and security of the City of Houston.

Recommended Metrics: Flood Damages.

Flood Damages as % of GDP for Houston area - 3%
Increase in floo plain area Harris County 1996-2007 - 34,125 acres
Acres of Flooded Housting Purchased and Removed By Watershed
- **White Oak Bayou - 158 acres**
- **Greens Bayou - 198 acres**
- **Halls Bayou - 60 acres**
- **Brays Bayou - 16 acres**

11. Environmental Justice

Environmental justice is concerned with the equity of the distribution of environmental impacts across ethnic and poverty lines. As can be seen in Figure 19, Houston is a majority minority community, meaning that the majority of the 2.2 million residents within the City of Houston's city limits are non-whites. This fact makes the environmental justice issue in Houston more about poverty than race. In

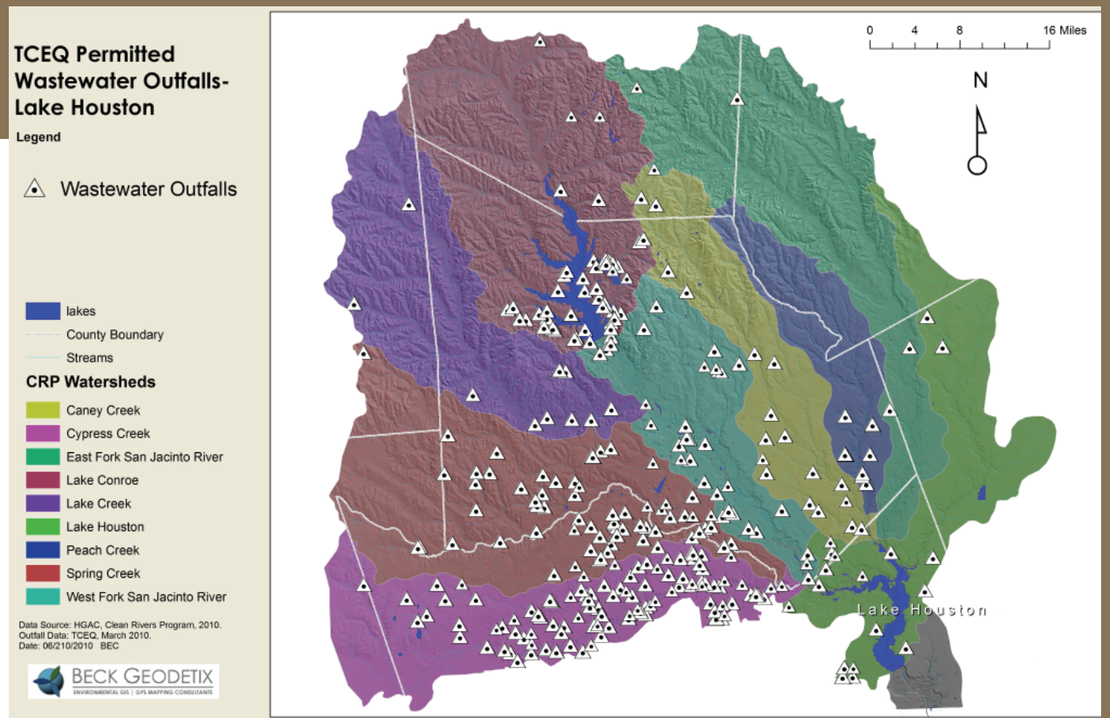


Figure 22: Permitted Wastewater Discharges into Lake Houston.
Source: Bryan Carlile, Beck Geodetix, based on TCEQ data.

the Houston area, those with less money suffer greater environmental exposures to air toxics as can be seen by comparing the poverty distribution in Figure 5 to the benzene distribution in Figure 9. As a general proposition, minority populations are also greater in those areas showing a larger percentage living below poverty. A similar pattern exists with regard to old hazardous waste sites with residual toxicity. While only 20% of the population of Harris County is below the poverty level, 57% of those living within one-half mile of these hazardous sites are below the poverty line. The distribution of these sites is shown in Figure 20 prepared by student Maggie Murphy.

Recommended Metrics: Environmental Justice.
% population below poverty level living near designated hazardous waste sites - 57%

12. Water Quality

The availability and quality of drinking water is an important sustainability indicator as is the quality of streams and bayous generally. Over the years, there has been great improvement in water quality of streams and bayous of the Houston area, particularly with regard to dissolved oxygen levels, a variable related to the survival of fish and shellfish. However, most streams and bayous are currently violating the standard for bacteria, due in part to the large number of wastewater

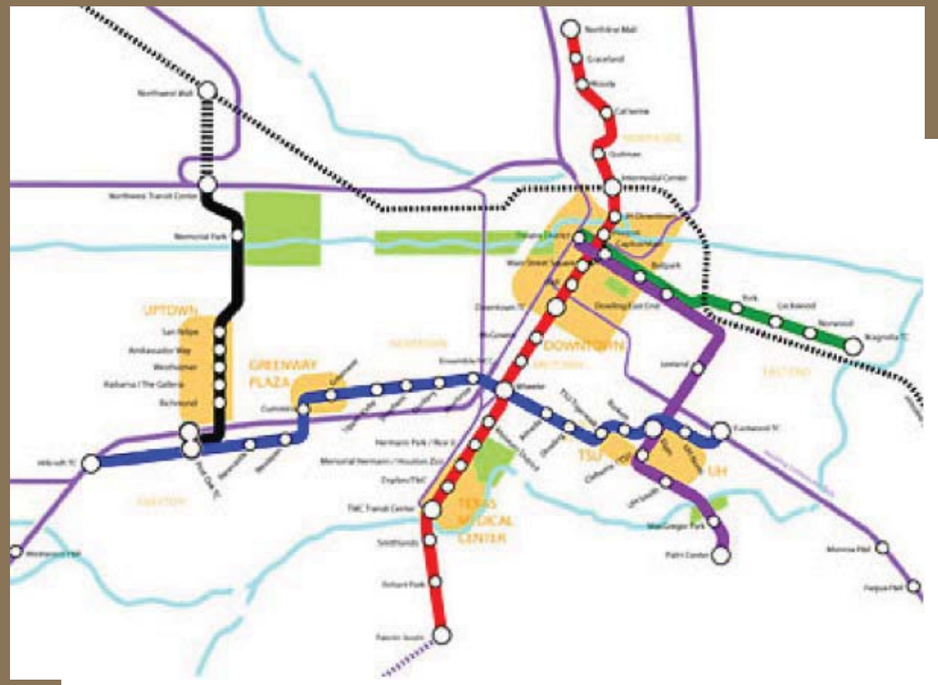


Figure 23: Proposed Rail System
Source: METRO

treatment plants that are discharging into our streams and bayous along with various leaks in the infrastructure and other factors. The streams and bayous currently violating the water quality standard for bacteria are shown in Figure 21.

Recommended Metric: Water Quality.
Number of Harris County Stream Segments Violating Water Quality Standards - 48

13. Drinking Water Quality

Over the last two decades, Houston has moved off of groundwater due to land surface subsidence and has been converting to surface water at a rapid rate. Currently, Lake Houston is a major supplier of drinking water and is likely to become more important in the future. Studies conducted over the last ten years indicate that there are several types of pollutants that are not removed from wastewater by traditional biological treatment technology, including various pharmaceuticals such as anti-depressants and estrogen-containing compounds as well as sophisticated chemicals used in soap and other products. One measure of the risk of these contaminants is the number of wastewater treatment plants or the volume of treated effluent entering our drinking water supply system. In Figure 22, the location of wastewater treatment plants discharging into Lake Houston are shown. These are used as a proxy variable for the presence of these "emerging" pollutants absent data about the levels of these contaminants in either raw water or treated drinking water from Lake Houston. There is a high likelihood that the issue of regionalization of

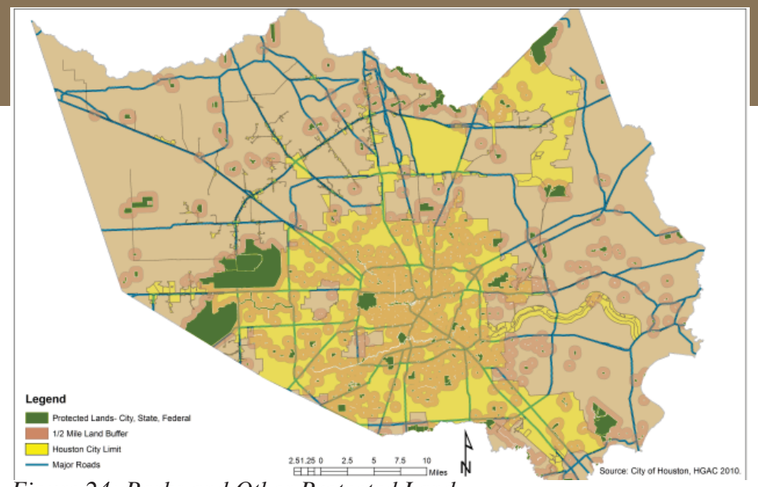


Figure 24: Parks and Other Protected Land
Source: Bryan Carlile, Beck Geodetix, City of Houston and HGAC

these smaller plants will become an important issue in the future and perhaps the metric for an adequate drinking water system for the City and surburbs.

Recommended Metric: Drinking Water Quality.
Number of Wastewater Plants Discharging Into Lake Houston - 274

14. Public Transportation

Public transportation is an important indicator of sustainability in many respects. It is important to provide access for those with limited transportation options. It is important to reduce reliance on individual automobiles – to offer options to personal car usage and increase the efficiency of the overall movement of people from job to home and back again. In order to measure this, student John McWilliams mapped the Metro bus stops and light rail transit stops and compared that the distribution of jobs and population within the City of Houston. The Houston city limits as of the 2000 Census had 2,022,493 people and 1,506,452 jobs. METRO's bus and light rail services have 11,673 stops (11,657 bus stops and 16 light rail stops) within these same city limits. Within a quarter-mile radius of these stops, there are 1,413,746 people and 1,236,129 jobs. The indicator would be calculated as follows:

Figure 25: Galveston Bay Riverine Freshwater Inflows
Source: Google Earth

$$\text{\% of population and jobs within 1/4-mile of all METRO stops} = \frac{1{,}413{,}746 \text{ people} + 1{,}236{,}129 \text{ jobs}}{2{,}022{,}493 \text{ people} + 1{,}506{,}452 \text{ jobs}} = 75.1\%$$

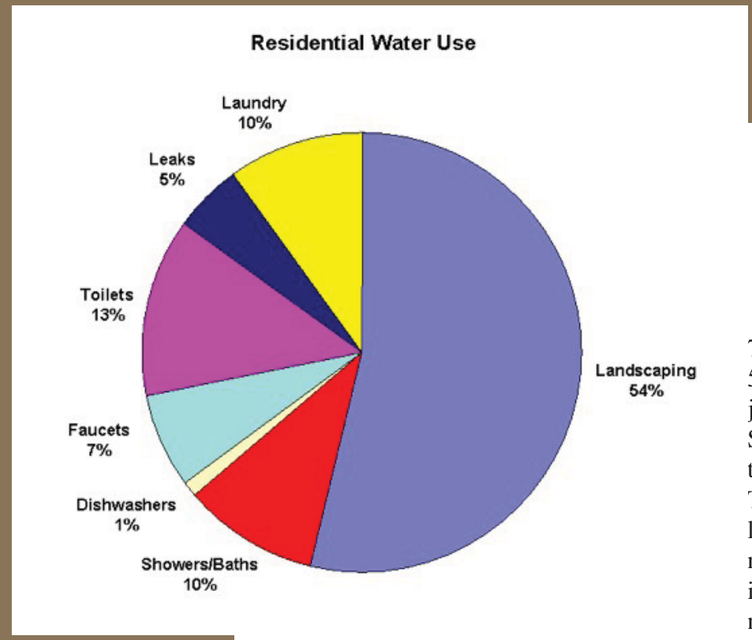


Figure 26: Estmated Allocation of Residential Water Usage from City of Denver, CO

From this, it can be seen that public transportation links 75% of the people and jobs. At this time, 5.4% of the jobs and population are adjacent to the light rail system along Main Street, a number that will increase over time as more rail project are completed. The METRO existing and proposed rail lines is shown in figure 23. It should be noted that the only rail section currently is along the red line extending from just north of downtown southward past the Houston Medical Center to its terminus south of the Reliant Stadium.

Recommended Metric: Public Transportation.
Per Cent of of Population and Jobs Withing 1/4 mile of public transportation stops - 75.1%
Per Cent of Poplation and Jobs Within 1/4 mile of rail stops - 5.4%
Miles of Rail - 7.5

15. Open Space

The existence of park and open space land proximate to population is a consensus indicator of sustainability. The City of Houston covers over 600 square miles of area and just over 2 million residents. By mapping open space areas and then drawing a one-half mile circle around them, it can be determined how many square miles of the city are within ½ mile of defined park and open space areas and the population residing within this area The area of the City of Houston within ½ mile of parks and recreation areas are shown in Figure 24. This figure shows that about 66% of the city's area is within ½ mile of park and open space resources as are about 1.43 million persons. The areas in yellow are those that are not served within the City's boundaries.

Recommended Metric: Open Space.
Per Cent of City Area within 1/2 mile of park or open space - 66%
Per Cent of Population within 1/2 mile - 65%

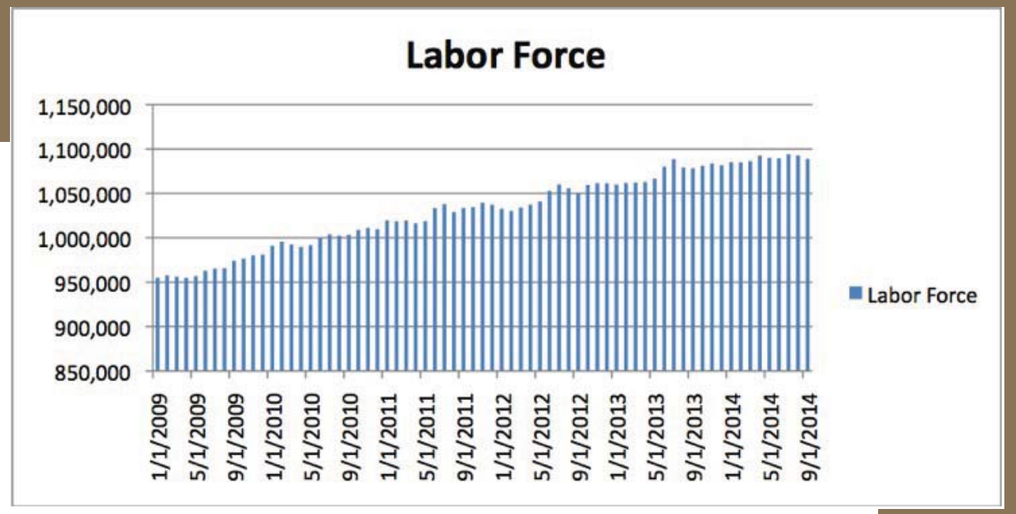


Figure 27: Job Growth In the Houston Region
Source: Texas Workforce Commission

16. Bay Protection

Much of the drainage from the Houston metropolitan area enters Galveston Bay. Hence, the two are closely linked. The Galveston Bay system is a major estuary of national importance and its protection is a key aspect of urban sustainability for the Houston region. Estuaries are highly productive natural areas and Galveston Bay is a national leader in shellfish and fish production and generates hundreds of thousands of recreational fishing hours each year. The key to protection of this estuary is to ensure sufficient freshwater inflows because the freshwater not only regulates salinity in the bay but also brings nutrients that are necessary for bay production. There are conflicting viewpoints of the amount and timing of freshwater inflow to Galveston Bay. Various groups tasked by the Texas Legislature to develop recommendations have developed alternative viewpoints with one group recommending seasonal inflows and another recommendation annual inflow figures. On November 18, 2010, the Texas Commission on Environmental Quality issued a proposed rule to set annual inflow limits of 4.3, 3.4 and 2.1 million acre feet of inflow to be met, respectively, 50%, 60% and 70% of the time. No final decision has been made by TCEQ to date. In early 2011, the City of Houston signed an agreement with several environmental NGO's whereby the City agreed to permanently dedicate approximately 300,000 acre feet of sewage return flows from Buffalo Bayou to Galveston Bay. This marks the first inflows dedicated to Galveston Bay. The Galveston Bay system is shown in Figure 25 along with the principal inflow points of the Trinity River, the San Jacinto River and Buffalo Bayou.

Figure 28: Proposed Bayou Greenway Trail System
Source: Houston Parks Board

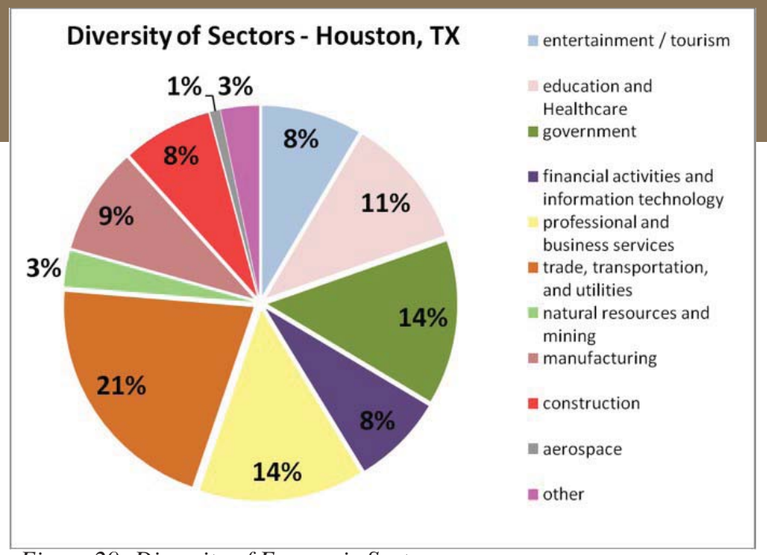


Figure 29: Diversity of Economic Sectors
Source: Roni Dietz and local data sources

Recommended Metric: Freshwater Inflows to Galveston Bay.
Number of Acre Feet Dedicated to Galveston Bay - 300,000 as of 2011

17. Water Consumption Efficiency

In Texas, water is a resource that is valuable and in short supply. Houston is fortunate to be located in East Texas, which is relatively richer in water resources than areas further west. Additionally, Houston made arrangements decades ago to construct Lake Livingston and make arrangements for water to be delivered to the City from the Trinity River in addition to Lake Houston. In light of the potential population growth of several million persons more, the water use profile and per capita water use should be monitored and reduced over time. To its credit, the City of Houston has a per capita water use of about 140 gallons per person per day, much lower than the 240 gallons per capita for the City of Dallas. Nonetheless, there is room for improvement. Here, a key variable is the amount of water used for landscaping and yard maintenance, a use that is arguably not a "basic need". Neither the City of Houston nor the Texas Water Development Board was able to provide a detailed breakdown of municipal water use for either the City of Houston or for Texas. Several knowledgeable sources indicated that the water use profile shown in Figure 26 was a reasonable estimate of water use but it is not verified. Until detailed water use data is developed, it is impossible to fully evaluate policy alternatives. Regardless, the use of water for landscaping is a key use issue, one that may be expected to be addressed in the LEEDS standards that are now being released for landscaping.

Recommended Meric: Water Usage.
Data on Water Use for landscaping in City of Houston needs to be collected
Default Assumption - 52% used on landscaping

18. Job Creation, Local Labor and Equity

The Houston area prides itself on economic expansion and job creation and keeps excellent data in this regard such as that shown in Figure 27. As a general proposition, our region has a solid employment base in manufacturing jobs that is today perhaps unique in the United States given the more recent economic downturn and globalization. However, there is virtually no information available about whether or not our existing and new jobs are being filled by local residents who are unemployed. For example, if a refinery or petrochemical plant is slated to expand, there is general excitement about the new construction jobs as well as the permanent jobs within the facility. However, little attention is focused upon whether or not the new work is being made available to the existing population base that is unemployed or whether there is an effort being made to train local laborers for these jobs. Stated another way, there is a question as to whether or not all residents of our region are benefitting from new job expansion and creation, even as pollution is often unevenly spread over areas of town where the unemployed live. In this regard, there is a social equity and environmental justice issue in job creation and opportunities and data should be developed and collected in this regard.

Recommended Metric: Workforce As of 9/2010 - approx. 1 million workers

19. Obesity and Outdoor Recreation

Obesity is a major sustainability issue. It is directly related to health, particularly diabetes and heart disease. Obesity statistics vary by ethnicity and by income level. In the Houston-Sugarland area, approximately 26% of the whites are obese, 38% of the blacks are obese and 27% of the Hispanics are obese. These numbers should be monitored over time and are directly related to the amount that we walk and enjoy outdoor recreation. In this regard, the creation and usage of trails and open space within the region should be monitored over time. Proposals exist for a major trail system along the Houston Bayou system called the Houston Bayou Greenway, which is being overseen by the Houston Parks Board. Additionally, the 650-mile Sam Houston Trail is proposed to encircle the entire Houston Region. The proposed Bayou Greenway trail system is shown in Figure 28. Clearly, a metric for Houston urban sustainability would be to monitor the increase in the miles of trails created over time.

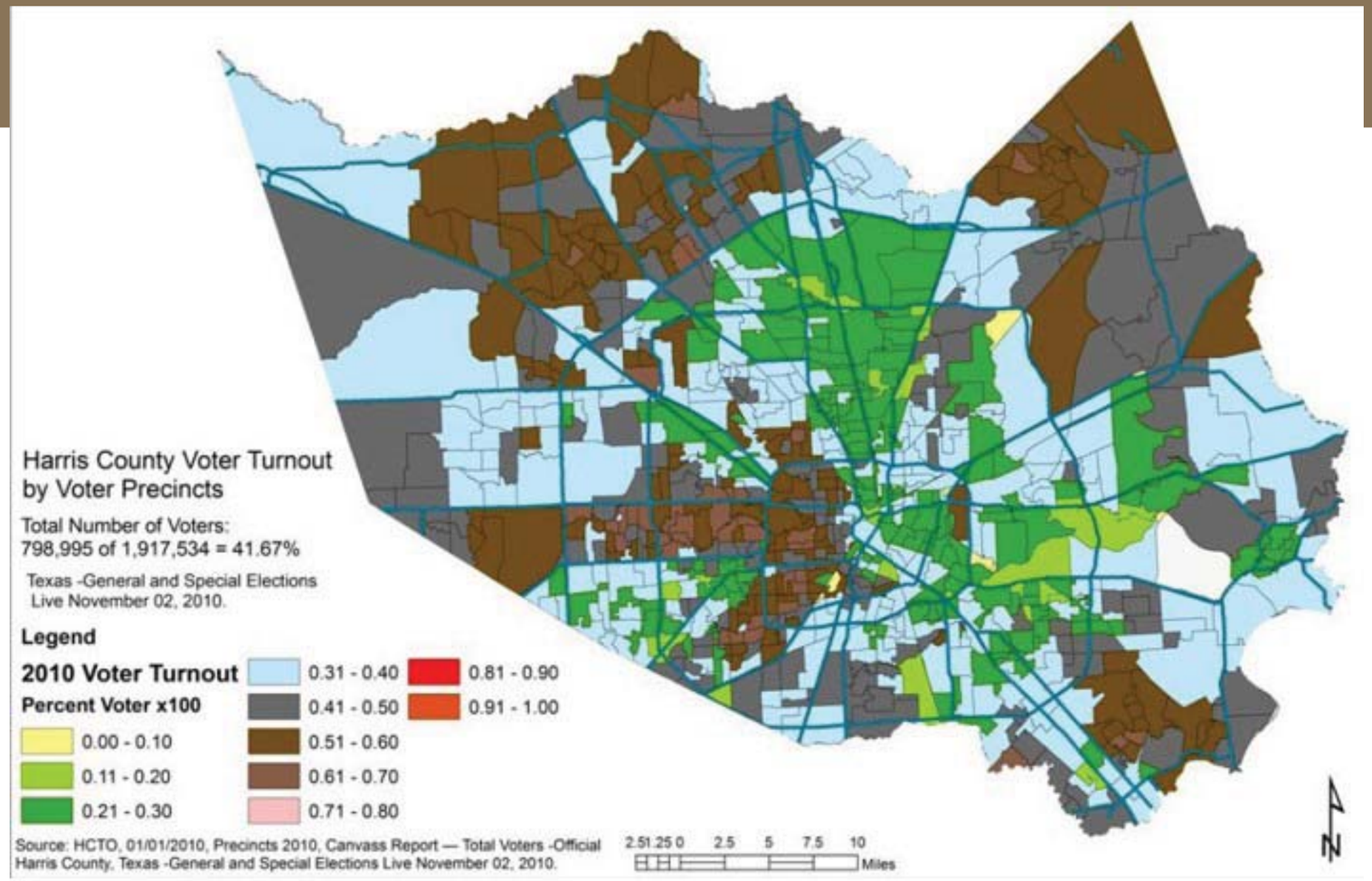


Figure 30: 2010 Voter Turnout in November Election
Source: Bryan Carlile, Beck Geodetix

Recommended Metric: Obesity and Outdoor Recreation % of population with obesity issues: Anglo - 26%; African American - 28%; Hispanic - 27%
Miles of Bayou Greenway Trails Completed - 15.5 + 3.6 under construction as of 2011

20. Economic Diversity

A key indicator of a sustainable economy is one that is diverse and able to withstand perturbations to one economic sector or another. Data regarding economic diversity is somewhat difficult to obtain due to variations in the classification of jobs and employment. On the basis of the data collected by Roni Dietz, (Figure 29), the economy of Houston appears to be much more balanced than one might expect due to the large number of persons engaged in oil and gas activities. Although

supporting data is spotty, it is reasonable to expect that oil and gas related employment likely represents the majority of the 21% shown in trade, transportation and utilities, the 3% in natural resources and mining, the 9% in manufacturing, a portion of the 8% in construction, a portion of the 8% in financial activities and information technology and a significant portion of the 14% professional and business services. On the other hand, Houston clearly has significant medical and university complexes as well as space and technology research that certainly lend to diversity.

Recommended Metric: Economic Diversity - # of sectors >20% of economic activity in region = 1

21. Debt Structure

Within the class, there was great concern about the nature and extent of debt and revenue sources within the community. And during the recent gubernatorial election, one of Governor Perry's advertisements stated that the per capita debt from the City of Houston was greater than the per capita debt of the State of California. While this may not be a proper comparison, the point is that debt is a major concern, and there was a general belief in the class that debt is inherently unsustainable. There was also concern that a consolidated picture of debt in different areas of the region was not available for comparative purposes, particularly given the existence of various governmental entities providing different functions based upon debt, including the City of Houston, Harris County, Harris County Flood Control District, the Port of Houston, Houston Independent School District, various utility districts and tax increment finance districts, along with subparts of the City such as pension plans. One should be able to find a clearly understandable and accurate assessment of the current debt situation. The consensus from the class is that such data do not currently exist for our region.

Recommended Metric: Debt Structure.
No acceptable metric determined - ideally debt per capita but not sure about debt reporting

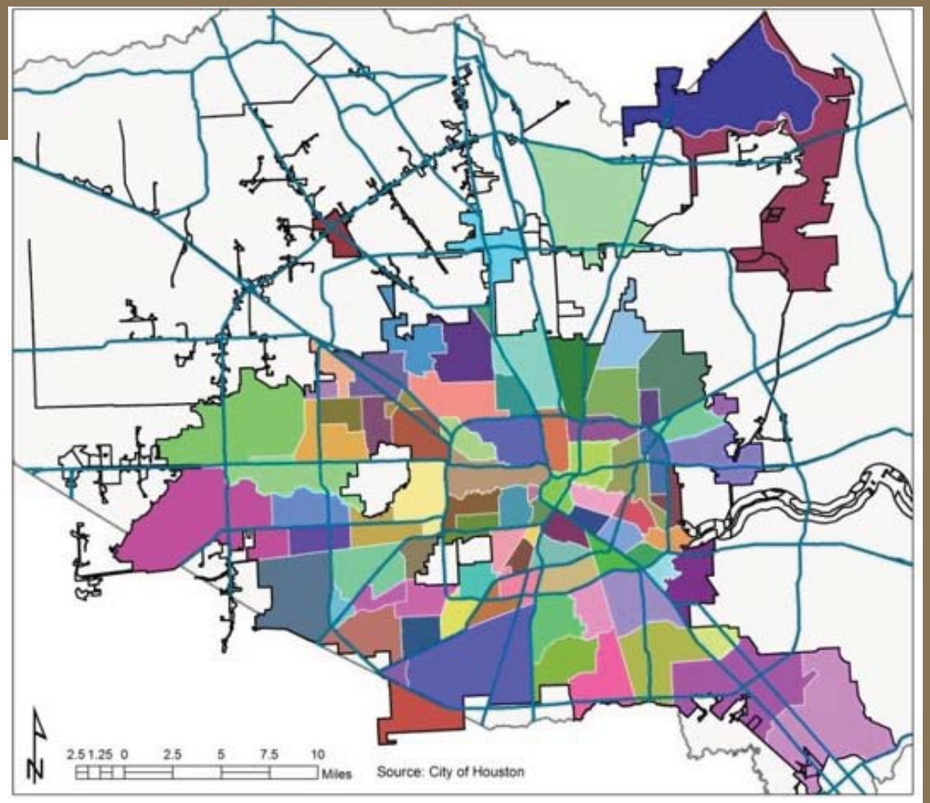


Figure 31: City of Houston Superneighborhoods
Source: Bryan Carlile, Beck Geodetix and City of Houston

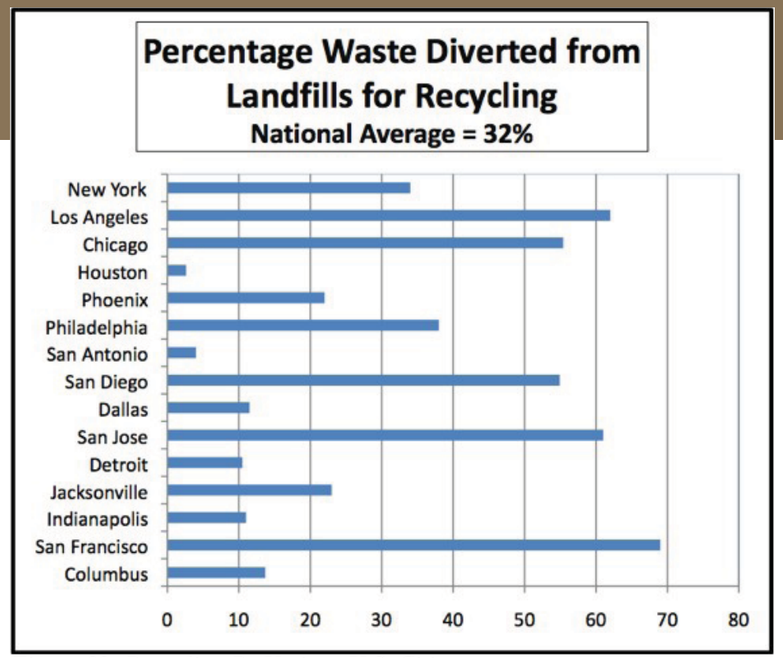


Figure 32: Recycling By Various U.S. Cities
Source: Marilu Corona, Rice University Student citing U.S. EPA. 2008

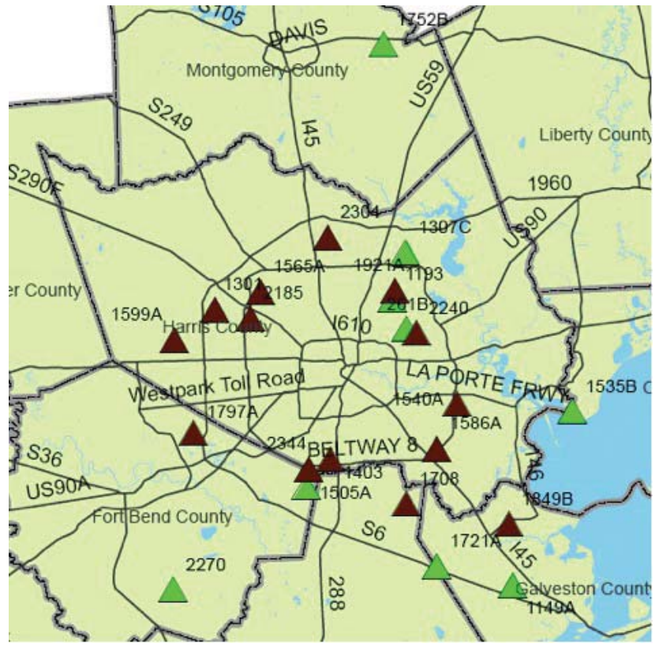


Figure 33: Distribution of Solid Waste Disposal Facilities
Source: Houston Galveston Area Council

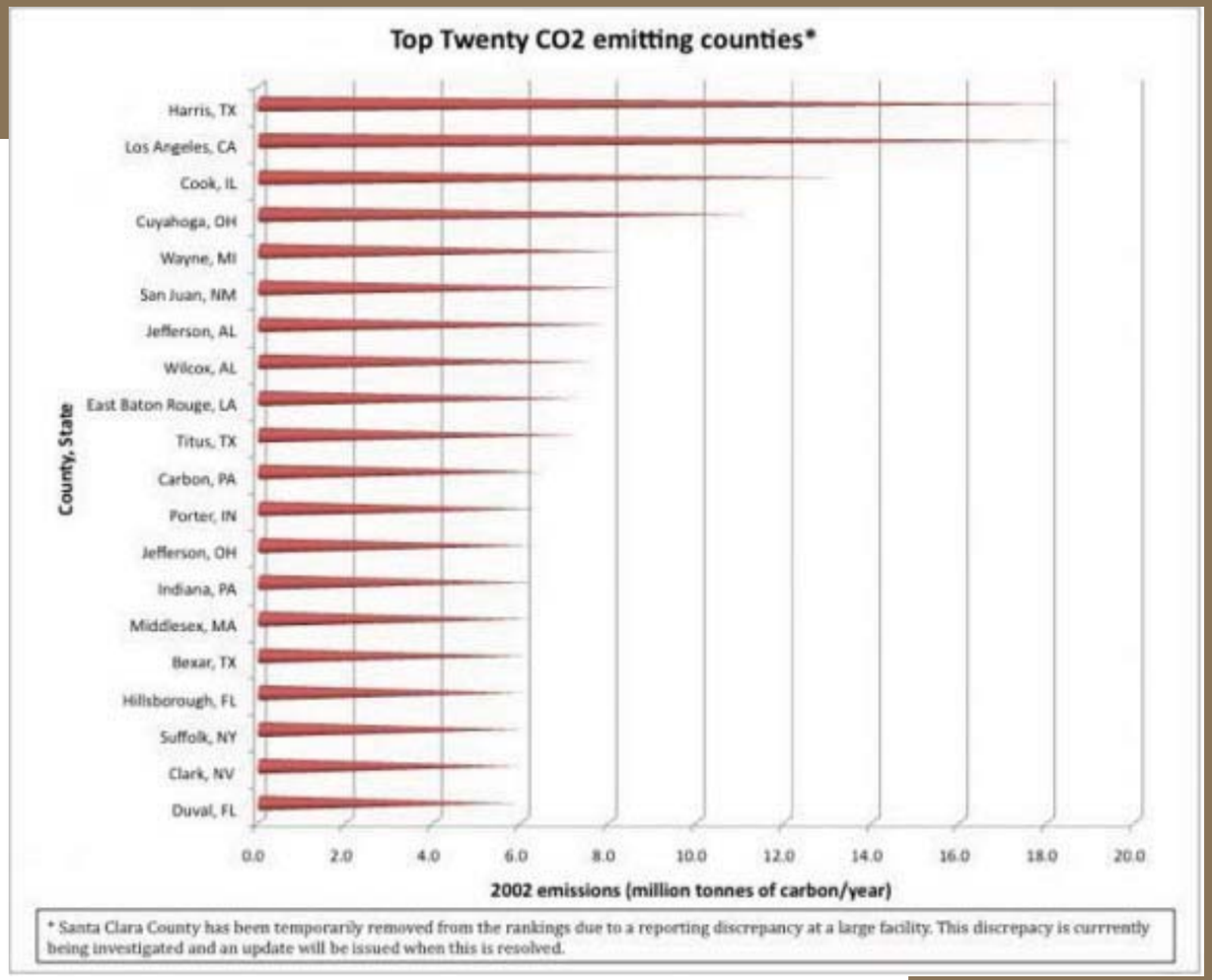


Figure 34: Top Twenty Carbon Dioxide Emitting Counties in U.S.
Source: ScienceDaily (April 17, 2008) reporting Purdue University Research

22. Green Jobs

A goal set out by many of the surveyed cities was to create so-called green jobs. However, there was no general consensus as to what a green job might entail. As such, it is not surprising that there is no data on green job creation. As a result of the work in the class, it became clear that green jobs can be of different types. First, it seems clear that employment of otherwise unemployed members of the community could be considered a form of green job in the sense that any job that forwards community sustainability is a green job. This is a concept that warrants substantial attention. Second, green jobs may be of a scale and type different from that typically pursued by institutions such as the Greater Houston Partnership. Green jobs are likely to be community-based and may seek to provide basic needs rather than to make large amounts of money for a single entity. For example, training large numbers of people to grow vegetables for their own use and to sell in community-supported agriculture facilities would be an example of green job creation, although not necessarily of a type typically pursued by economic development institutions. Another similar example would be to train unemployed persons to install weatherproofing, reflective film, solar panels and other energy efficiency devices. Here, the end point of the class was not a metric for there is no good data, but rather a goal of working in the community to create these jobs. This area offers an excellent subject for future work.

Recommended Metric: Green Jobs.
No acceptable metric determined - ideally measure the recruitment of unemployed local workers into workforce

23. Community Involvement

Community involvement is concerned with the time and attention that the population of a particular place puts to civic affairs. Here, the interest is in determining the involvement of the local population in their community, an issue that the students identified as one relating to sense of place. One measure would be to track the trends in voting to determine if the population is actively involved in voting. In the 2010 November election, approximately 57% of residents within the City of Houston voted. The distribution of the voting pattern is shown in Figure 30. Another measure of community involvement would be the level of activity by the various civic associations. As can be seen on Figure 31, there are 88 superneighborhoods in Houston that can be monitored and used to better understand community involvement in Houston.

Recommended Metric: Community Involvement.
% of Harris county residents voting in most recent election - 57%

24. Recycling

A student paper completed by Marilu Corona in CEVE 302, Sustainable Design, indicates that the City of Houston has much work to do. At this time, the City has barely begun a recycling program and is far behind other areas of the United States. As can be seen in Figure 32, Houston ranks very low on recycling rates and there are various reasons for this. Although the City collects much of the solid waste within the corporate boundaries, all solid waste disposal activities are under-

taken by private waste disposal companies that own and operate several landfills surrounding the city itself. As such, the City of Houston is not as directly involved in solid waste decision-making as are many other cities in the United States and Texas. The City has recently begun curbside pickup of some recycled material but we are far from a comprehensive recycling system at the City.

Recommended Metric: Recycling.
% waste diverted for recycling in City of Houston - 4%

25. Climate Change & Carbon Dioxide Reduction

Perhaps no issue is more challenging for the Houston region than is climate change and carbon dioxide reduction, due in part to the large carbon footprint of the Houston region. Industrial and automotive CO2 emissions in Harris County are the highest in the United States according to Purdue University as can be seen from Figure 34. There are many metrics that address aspects of the carbon footprint, including overall energy efficiency and density. However, with regard to carbon dioxide reduction, apart from following the overall trend in carbon emissions, it is important to track formal proposals to sequester carbon in and around the Houston region. There is great potential to sequester carbon in various ecosystems surrounding the Houston area, including the salt marshes, brackish marshes, prairies and timberlands. Here, the proposed metric is to identify the number of acres that are formally dedicated to sequestration. To date, one project of approximately 1000 acres has been identified by Reliant Energy that proposes to plant pecans in the Columbia Bottomlands along the Brazos River.

Recommended Metric: Climate Change.
Harris County metric tons of CO2 emissions - 18.625 million tons (Project Vulcan 2002 data) - better data forthcoming based on industrial reporting initiated in 2010
Acres of land dedicated to carbon sequestration - 1000

Conclusion

This work is intended as a beginning, not an end. The compilation and analysis of these factors is a humbling task. These and many other factors can and should be studied to establish whether or not the Houston-area is making progress toward sustainability. However, during the course of this work, it became clear that measuring these issues is relatively insignificant when compared to both the challenge and need for implementation in these many diverse areas. For this reason, it is suggested that in addition to carrying forward this work, the Shell Center for Sustainability consider working with the City, Harris County, Houston-Galveston Area Council, various non-governmental entities and others to create partnerships to better define and initiate and/or continue action to improve upon these many factors. It is not a simple task to move toward sustainability. It is a worthy challenge for a wonderful place we call Houston.

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Shell Center for Sustainability

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Rice University
School of Social Sciences
6100 Main Street
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