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# Measuring Neighborhood Sustainability:
# A comparative case study of Mueller and Stapleton

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# Measuring Neighborhood Sustainability:

***A comparative case study of Mueller and Stapleton***

**by**

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**Report**

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## Dedication

This report is dedicated to my family in Carrboro, North Carolina for making me the person who I am and to Cassy for her patience and assistance throughout this process.

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I would like to thank my advisors Dr. Patricia Wilson and Dr. Robert Paterson. Thank you to my classmates in the Community and Regional Planning Program. Thank you to Joe Rigdon and Deborah Rigdon for their feedback, ideas, and for listening to my frustrations.

## Abstract


**Measuring Neighborhood Sustainability:**
**A comparative case study of Mueller and Stapleton**



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The University of Texas at Austin, 2013

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This paper will examine two cases where urban infill and sustainable neighborhood development converge: the Mueller redevelopment in Austin, Texas and the Stapleton redevelopment in Denver, Colorado. These projects represent significant efforts to develop sustainably in their respective cities, as well as provide prominent examples of New Urban development. The theoretical similarities between the neighborhood developments are many. However, which project does the better job of meeting the goals of sustainable urbanism?

In order to address this question, the paper will begin by examining the theoretical framework of sustainable urbanism; a critical influence on both projects. The two projects will then be compared in order to assess how well they address critical goals of sustainable urbanism in practice. The comparison will be quantitatively measured using a sustainability indicators analysis in ArcGIS.

The literature review will introduce the concept of sustainable urbanism. Neo-traditional development will then be examined in greater detail, with a focus on New Urbanism. From this literature, a common framework for sustainable urbanism is established. This framework will be used to arrive at a set of concrete goals for

quantitative analysis. The paper identifies four goals of sustainable urbanism that will be measured: density, diversity, connectivity, and accessibility.

The four critical objectives will be used to create a set of 12 spatial indicators for neighborhood sustainability. An analysis of the indicators will be calculated to compare the two sites. The paper looks to identify which of the two projects best meets the goals of sustainable urbanism. Finally, the report will examine the nuances of the projects in order to answer the question: what can the comparison can tell us about the future of the Mueller neighborhood?

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# Chapter 1: Introduction to Cases

This paper examines two instances where planners capitalized on a unique opportunity to develop sustainable neighborhoods. Both projects took advantage of timely calls for sustainable urban forms in each city. The Mueller development in Austin, Texas and the Stapleton development in Denver, Colorado are projects that exist at the intersection of sustainable urbanism and urban infill. More specifically, these projects represent important sustainable New Urban designs on central city infill sites.

This paper will look at how well each of these neighborhoods addresses the theoretical goals of sustainable urbanism; the guiding design practice in each case. The comparison will be conducted through analysis of a set of indicators based on a literature review of sustainable neighborhood development. Later sections will introduce theory, methods, and conduct the indicator analysis. The following section will introduce the two neighborhoods, providing a context for the theory and indicator analysis to follow.

## 1.1. Introduction to the Mueller Development

Mueller is a New Urban infill project located in Austin, Texas. The development is built on the site of the former Mueller Municipal Airport, a 700 acre site located in central Austin. Location is critical to the importance of the site, as it is only 3 miles from the central business district. Mueller was the primary airport for the city of Austin until it was decommissioned in 1999. Decommissioning was necessary in order to accommodate the rapid population growth in the area. Despite the population pressure, airport relocation was a hotly debated issue until Bergstrom Air Force Base was closed in the late 1990s. This allowed for the opening of a new airport in South Austin, freeing up the former site for a new use (Mueller Community Association 2012).

Once the airport was decommissioned, plans began for redevelopment of the Mueller site. The local Austin community expressed excitement about the opportunity to redevelop the site dating back to the early 1990s. From the beginning, the city was

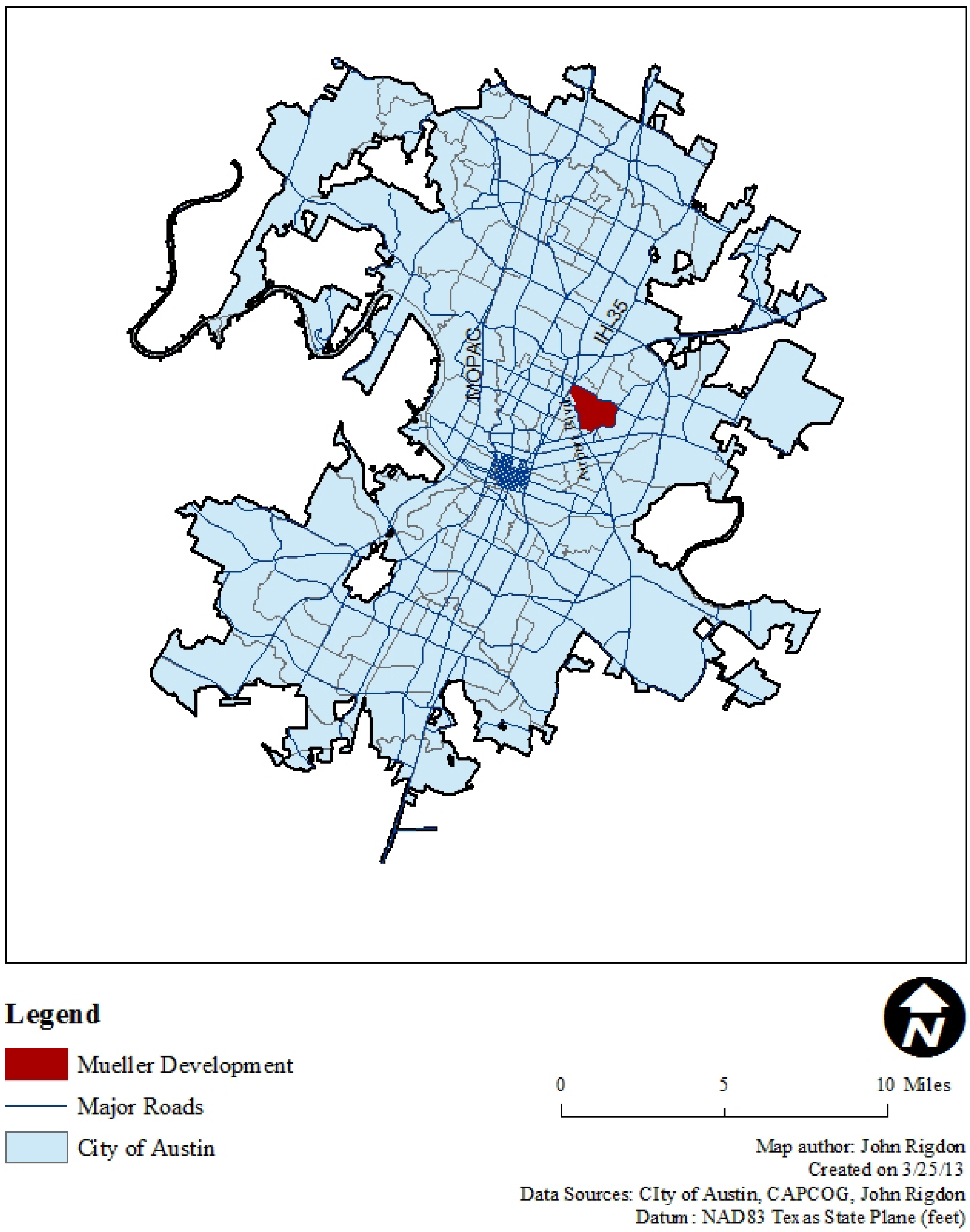


Figure 1: Location of Mueller in Austin

interested in creating higher-density, mixed-use development on the site, or a "town in-town," as it was described in the 1984 CARE Plan. This was followed by the creation of a project task force in 1996. Finally in 2000 Austin created the "Reuse and Redevelopment Plan" to provide guidelines for the Mueller Airport property. These plans were updated in 2002 by the chosen master developer, Catellus. The final updated planning document is called *The Design Book* (Catellus 2004).

Sustainable urban design is the central theme of the *Design Book* neighborhood plan. The vision of this plan is as follows:

> "To create a district that would be a model for responsible urban development - an alternative to land-consumptive and automobile-dependent development patterns throughout the region that could influence the form and pattern of growth within Austin." (Catellus 2004)

The master plan calls for 5,700 residential units, 140 acres of park space, a mixed use town center with abundant commercial space, on-site jobs, and convenient access to transit options. (Catellus 2004) Currently, development is underway towards this goal. There are just over 700 homes built, a commercial center, parks, and anchor offices and businesses.

### 1.2. Introduction to the Stapleton Development

Stapleton is a New Urban infill project in Denver, Colorado. The project is built on the former site of Stapleton International Airport. Stapleton International was the primary airport for the region until it was closed in 1995. The closure left a site that is 4,600 acres in size and located in a prime location, five miles from the Denver central business district (Leccese 2006).

Much like Mueller, redevelopment began immediately after the closure of the airport. Population had been growing dramatically in the region throughout the 1990s, putting pressure on the airport. Thus, Denver had been preparing development plans for the Stapleton site long before it closed which allowed demolition to begin immediately. During the interim period, an updated plan was outlined for the site based on a vision of creating a more compact and connected downtown Denver (Forest City Enterprises 1996).

In 1995 the master plan was created by Peter Calthorpe, a prominent New Urban planner. The final planning document for the development was called the *Stapleton Master Development Plan* or, in short, the “Green Book.” Calthorpe’s plan called for neo-traditional development of the site, focusing on: mixed-uses, transit access, sustainability, and compact development. This plan would guide the eventual implementation of the project by several developers. The lead developer was Forest City Enterprises; however, the secondary developer was the group that would later develop Mueller: Catellus (Forest City Enterprises 1996, Leccese and McCormick 2003).

Today, Stapleton has reached full residential build-out with nearly 11,000 residential units. The neighborhood has also reached goals of 1,000 acres of park and open space, a mixed use town center, and over 100 current commercial tenants (Forest City Enterprises 2013). Future plans remain for expansion of a local light rail line into the area. However, these plans are on hold and will not be implemented until 2015 at the earliest.

Stapleton has been hailed as a tremendous success in the planning and design communities. It is the winner of numerous awards and is viewed as a national model for sustainable urban development (Leccese 2006). With the prestige and similarities in mind, Stapleton offers a great point of comparison for Austin’s Mueller.

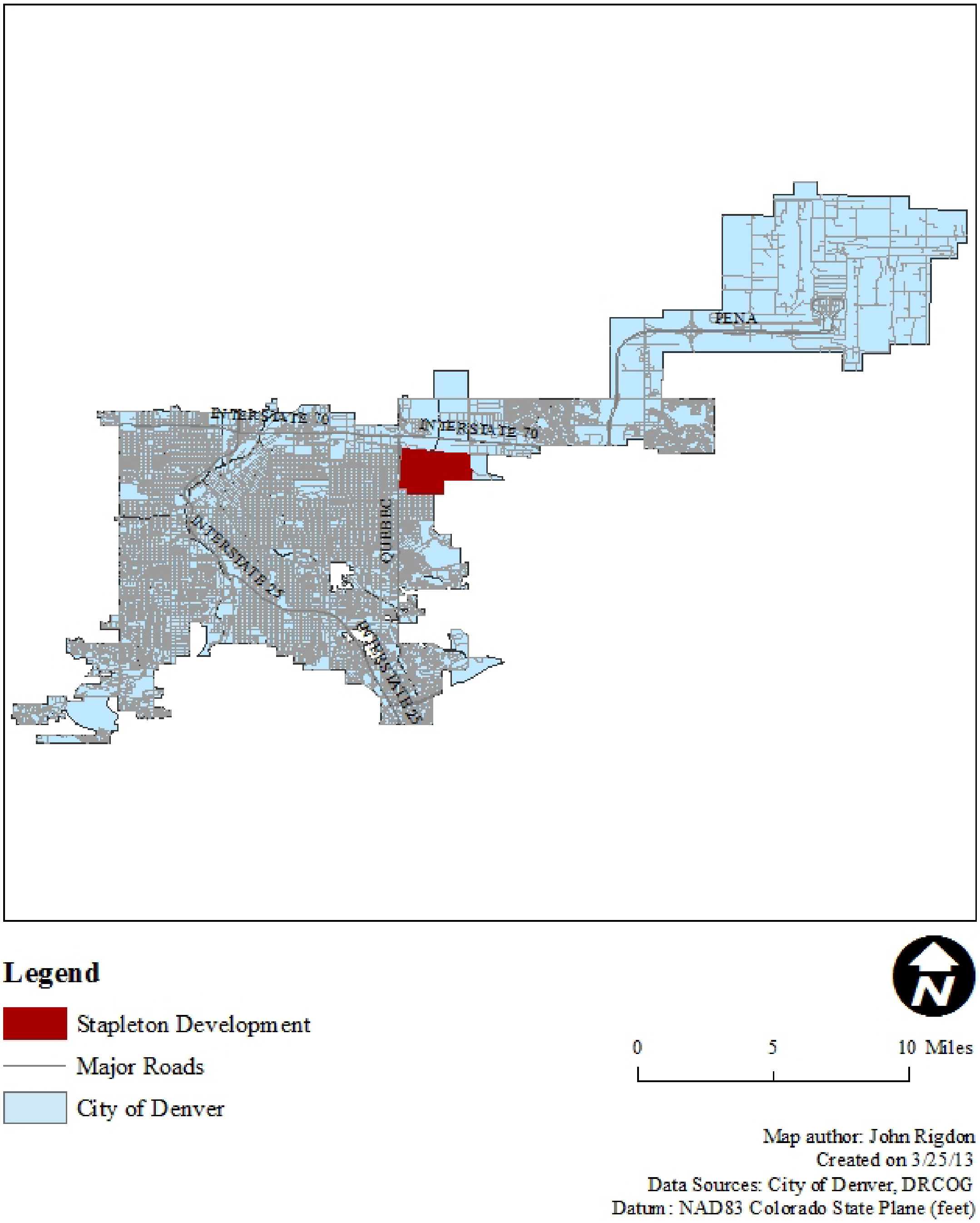


Figure 2: Location of Stapleton in Denver

### 1.3. Research Questions

Mueller and Stapleton are important examples of sustainable urban development. Both projects are directly guided by the principles of New Urbanism and share the additional similarity of being examples of airport urban infill. Due to these significant similarities, this paper will compare the two projects side-by side in order to address two key research questions:

*What are the goals of sustainable urbanism that can be quantitatively measured?*

*Which project, Stapleton or Mueller, does a better job addressing these goals?*

# Chapter 2: Review of Theory

The search for more sustainable urban forms has dominated the planning field since the 1990s. It was then that planners first began to address critical issues with the status quo in land development. Growing concern over the ties between conventional suburban development and a number of threats to the continued health and safety of human settlements led to groundbreaking research into human health and the environment. This research allowed planners to establish links between sprawl development patterns and: carbon emissions (Cervero 2005) the physical health of citizens (Moudon 2006), social equity (Talen 1998) global warming (Ewing 2008) as well as environmental quality (Beatley 2000).

The planning response to the troubling linkage between conventional development patterns and the aforementioned negative outcomes took a range of forms. One common approach was through efforts to change patterns of urban form. Planners looked to incorporate ideas of sustainability into the way we build communities. Broadly, this approach can be called sustainable urbanism. The following sections will examine sustainable urbanism in theory, as well as the most pertinent offshoot of sustainable urbanism to this research paper: New Urbanism.

## 2.1. What is Conventional Development?

Conventional development refers to the status quo in residential development that has dominated since the conclusion of the Second World War. This standard has not changed much over the last half century in the development community. During these years, many planners have studied conventional residential development in great detail. These studies have revealed many important characteristics about the way we develop communities. From their work, a few important commonalities emerge (Sierra Club 1999, Beatley 2000, Ewing 2002, Ewing 2008). Some of the most common characteristics of conventional residential development expressed in this literature are:

1. Separated land uses

2. Low density development
3. Automobile oriented
4. Leap-frog development on greenfield sites

These characteristics are not inherently negative; however, in combination they have proven to lead to negative outcomes. Specifically, they have been tied with poor health, environmental degradation, and social exclusion. Planners have looked at ways to change development patterns in order to address these concerning outcomes. Mainly, planners have looked at models that reject conventional development altogether.

It is important to understand conventional development in order to understand the impetus for Stapleton and Mueller. Both Denver and Austin were experiencing some of the negative consequences associated with conventional patterns. Out of these concerns, planners and the local community saw an opportunity to change this pattern. Sustainable urban neighborhood development was utilized as the response in both projects.

**2.2. What is Sustainable Urbanism?**

Sustainable urbanism came about as a series of responses to the health, environment, and safety concerns associated with conventional development. The term “sustainable urbanism” has been defined by many in the planning field since the impetus for a change arose in the 1990s (Jabareen 2006, Jenks M 2005, van der Ryn 2008). An examination of the various definitions reveals some shared themes. Specifically referenced overlaps in the design of sustainable urban places are:

1. Compact built forms
2. Connected streets
3. Walkable communities
4. Access to public space
5. Diverse populations and housing types

Today's planners are looking to address the issues created by the last generation of planners through changing the status quo of residential urban form. Thus, these core themes of sustainable urbanism are derived directly from the shortcomings of conventional urbanism (Talen 2011).

Sustainable urbanism primarily advocates for changes to the built environment. Theorists believe that the key to curing the ills of conventional development is to address specific physical issues. The body of literature on sustainable urbanism has established numerous connections between urban forms and sustainability (Beatley 2000, McCormick 2000, Ewing 2002, Fulton 2002, Jabareen 2006). Four of the most commonly cited relationships between urban form and healthier neighborhoods in the literature are as follows:

1. Higher accessibility is better for neighborhood sustainability
2. Higher density is better for neighborhood sustainability
3. Higher diversity is better for neighborhood sustainability
4. Higher connectivity is better for neighborhood sustainability

Attempts to address the connection between urban form and sustainability have varied; however, some of the most widely implemented responses fall broadly under the category of neo-traditional development. These approaches look to past cities in order to correct the problems created in the mid-20th century. The most well-known and widely utilized approach to neo-traditional development is New Urbanism.

### 2.3. What is New Urbanism?

New Urbanism is a leading approach to neo-traditional neighborhood design. It looks to past architectural forms and typologies in order to shape the modern built environment. The approach advocates for traditional design strategies in order to help arrest suburban sprawl and inner-city (Plater-Zyberk 1992, Jabareen 2006). New Urbanism focuses on a few core design strategies:

1. Mix of housing stock to create a wide range of household incomes and structures
2. Design that creates the conditions for greater density and human interaction,
3. Human-scaled environments that tame the negative impacts of the automobile (McCormick 2000).

More specifically, New Urbanism argues that front porches, narrow streets, short blocks, transit access, and diversity of building type are critical. These elements are characteristic of the 1920s, out of which New Urbanism asserts our best and most loved neighborhoods were born (Plater-Zyberk 1992, Jabareen 2006).

New Urbanism tackles these issues through three broad strategies: increased density, mixed land use, and promotion of sustainable transportation. In density, the focus is on promoting higher residential densities that the typical American suburb. This is achieved through smaller lot sizes, shorter blocks, and narrower streets. Mixed land uses are achieved through a suggested mix of residential, commercial, and civic spaces on the neighborhood level. This represents a dramatic move away from the Euclidean approach to land use in the typical American town. Transportation patterns encourage walkability and limit the visual and social impacts of the automobile. Narrow streets, low speed limits, and pedestrian-friendly street designs limit the impact of the car. Additionally, transit options are encouraged and designed for. The belief is that these choices will lead to better health and more human interactions within the neighborhood (Jabareen 2006).

New Urban planning theory asserts that by meeting the aforementioned goals, neighborhoods will be more sustainable. Better land use mix, smaller blocks and lots, better access to amenities, and higher overall densities will lead to better human health, environmental health, and quality of life (McCormick 2000, Jabareen 2006). These goals are also believed to make longer lasting communities, much like the communities of the past. This goal speaks to a more sustainable and permanent settlement pattern. Overall, New Urbanism draws a strong link between these particular urban form characteristics and sustainability.

New Urbanism has been employed in over 600 projects of widely differing scales across the country. These projects have achieved somewhat mixed results. Projects that have been widely celebrated by proponents, such as Seaside, Florida, have been equally criticized by planning professionals. New Urban plans can often be heavy on rhetoric, yet lack in terms of implementation. Frequent descriptions of developments as “livable,” “sustainable,” “connected,” and “green” can be found in contemporary master plans. However, these plans struggle to live up to the rhetoric in implementation. Instead of meeting all of the sustainable urban goals, they develop as nuanced conventional neighborhoods (Talen 1996).

New urbanism is a polarizing movement in the planning and architecture professions. Some see it as a practical way to approach the need to move away from the suburban status quo, and it remains popular in many circles. However, other planners have critiqued it for a number of reasons. Specifically, it has been critiqued for a lack of performance, being ideologically exclusive, and being aesthetically bland (Ellis 2002). Nostalgia is a critical component of New Urban plans. The reverence of tradition in New Urbanism has been questioned frequently by critics. Critics believe that while nostalgia can create strong positive emotion, it also is inherently conservative. Conservatism is an obstacle to new design thinking and creative solutions. This has led many to accuse plans of being bland and lacking architectural skill (Sandercock 1998). Along these same lines, critics in a wide range of fields have critiqued the social implications of conservatism. In particular, they believe that New Urbanism facilitates social exclusion and harms disadvantaged groups. Groups who were historically not a part of the very particular nostalgia of New Urbanism are excluded. This has numerous equity impacts that are not yet fully understood (Milgrom 1996, Sandercock 1998). Finally, critics have argued that there are very few projects that live up to the goals espoused by New Urbanism. They believe that many of the projects are simply nuanced conventional developments, or a repackaging of old ideas (Ellis 2002).

In the case of Stapleton and Mueller, the new urban rhetoric is very strong in both the plans as well as the continued publicity of the neighborhoods. These neighborhoods are described as “livable communities,” “active and walkable,” as well as various labels related to sustainability and greening.

### 2.4. How is Neighborhood Sustainability Measured?

This paper focuses on measuring New Urban development in practice in the two case study neighborhoods of Mueller and Stapleton. Efforts to quantify the effectiveness of new urbanism have mainly been through the use of sustainability indicators (Allen 2001, Song and Knaap 2007). The following section provides an overview of the history of the development of these tools and establishes the inspiration for the methods utilized in the analysis section that follows.

Planners have developed a range of methods to measure neighborhood sustainability, or the lack thereof. These efforts began in the 1960s with the first attempts at measuring the growth of suburbs relative to that of central cities. Studies used quantitative measures to establish a pattern of rapid suburban growth and slowing urban growth (Chinitz 1965). These early efforts usually focused on one or two characteristics of sprawl and compared them across an entire city or in between two cities. Measurement primarily focused on the city as a unit rather than a series of neighborhoods (Torrens 2008). Such approaches compared density inside and outside of cities with population growth and land area. Studies continued to look at this relationship well into the 1990s. In effect, these early efforts examined ways to quantify which cities were most prone to sprawl, and in some cases, the conditions that facilitated that sprawl (Wassmer 2000, Fulton 2002). Macro-scale data was critical to these studies, which have been noted to suffer from an over-reliance on aggregated Census data. Such broad data told planners little about the characteristics of sprawl on a neighborhood/development scale (Torrens 2008).

One of the first approaches to measuring sprawl on a smaller scale was conducted by George Galster (Galster 2001, 2005). This study identified eight primary measures to indicate sprawl: density, continuity, clustering, concentration, centrality, nuclerity, mixed uses, and proximity. These dimensions were used to measure the relationships between a series of small grids based on census blocks. GIS analysis was used to identify hotspots of sprawl and look for patterns in the Census data. This analysis provided planners with information that was more micro-scale and specific than the raw numbers of previous approaches.

Galster's approach was refined for the INDEX system created by Criterion (Allen 2001). Policy-based indicators were also added to provide a more human face to indicator measures. INDEX included over 30 indicator measures on a range of geographic scales for planners to analyze. This model was effective for forecasting planning proposals and comparing the effects of the proposed projects in terms of sustainable urban development. The 30 measures that are used in INDEX are relatively easy to compute in GIS, yet are more meaningful for comparison than the large-scale measures of Galster and Chinitz.

This paper draws primarily on the work of the planners who built on Galster and INDEX. These recent efforts borrowed from the indicators of these predecessors and found ways to better apply them to a neighborhood scale. The authors also identified the characteristics of a neighborhood that can be measured spatially using GIS (Song and Knaap 2007, Torrens 2008). Based on these studies and the review of sustainable urbanism literature, the following four neighborhood sustainability criteria will be measured in the analysis section of this document.

1. Accessibility
2. Density
3. Diversity
4. Connectivity

Examining these four issues, Song and Knaap (2007) conducted a wide-ranging analysis of neighborhoods across the country. They analyzed both conventional development and neo-traditional development neighborhoods based on these four categories. Through statistical and spatial analysis of the data, they arrived at conclusions about the relationship between indicators and sustainability goals of neighborhood development. These findings support the conclusions of aforementioned authors in the field of sustainable development, specifically they found:

1. Higher accessibility is better for neighborhood sustainability
2. Higher density is better for neighborhood sustainability
3. Higher diversity is better for neighborhood sustainability
4. Higher connectivity is better for neighborhood sustainability

The findings of Song and Knaap support the assertions of other authors on this subject. These four core relationships are the baseline for the comparison Mueller and Stapleton in the indicator analysis results section to follow. The paper will use indicators to determine which project better meets the goals of sustainable urbanism, as expressed through these 4 relationships.

# Chapter 3: Methods

## 3.1. Research Methods

The research approach in this document is a comparative analysis of two case studies. The paper examines two cases in the United States of sustainable urban development on infill sites; Denver's Stapleton and Austin's Mueller. The two developments are compared using a series of quantitative measures.

## 3.2. What characteristics will be measured?

The review of theory introduced sustainable urbanism and the specific approach of New Urbanism. Additionally, this section outlined four aspects of sustainable urban form that have been quantitatively measured in existing literature. These are:

1. Accessibility
2. Density
3. Diversity
4. Connectivity

These characteristics will be measured in this report using a series of simple Sustainability indicators. The next section will outline these indicators and provide a context for interpreting the results.

## 3.3. Indicator Measures Explained

This report evaluates the outcomes for a series of indicators in order to compare the two case studies. The indicators are derived from the work of Song and Knaap (2007) and Allen (2001). Based on the work of these authors, this paper will examine the indicators outlined in the following sections. The twelve indicators chosen address the four core criteria outlined in the literature review of sustainable urbanism. The primary objective is examine which development, Stapleton or Mueller, best addresses each criteria through 2-4 associated indicators. Accompanying tables in each section will provide the indicator calculation and the meaning of the result for the purpose of this comparison.

**Connectivity Measures Explained**

Conventional development patterns contain many long and undulating streets as well as cul-de-sacs that offer limited connectivity. These patterns limit the efficacy of walking, biking, and other non-automobile travel options. Better connectivity has been noted to alter these behaviors by offering higher quality, contiguous networks of streets. More walking and biking, fewer vehicle miles traveled, and better health have been noted as important side-effects of improved connectivity (Benfield 1999).

| Criteria | Indicator | Calculation | Meaning of Result? |
|---|---|---|---|
| Connectivity | Internal Connectivity | $\frac{Streeet\ intersections}{Street\ intersections + Culdesacs}$ | Higher ratio means better connectivity |
| | External Connectivity | $\frac{External\ Connections}{Neighborhood\ Area}$ | Higher ratio means better connectivity |
| | Block Area | $Mean\ block\ Area$ | Smaller number means better connectivity |
| | Total Blocks | $\frac{Total\ blocks}{housing\ units}$ | Fewer blocks means better connectivity |

Indicator measures adapted from (Song and Knaap 2007)

Table 3.1: Connectivity Measures

This report will examine four indicators that address neighborhood connectivity. Internal connectivity measures transportation route options in a neighborhood by calculating the number of intersections compared to intersections plus cul-de-sacs. Cul-de-sacs do not provide transportation options, so they lower the overall ratio score. A ratio close to 1.0 indicates high internal connectivity. Secondly this report will measure mean block size. Smaller, more compact blocks mean easier and more efficient transit access. Additionally, the report will measure external roadway connectivity as a measure of connections outside of the neighborhood area per acre of land. More connections mean better access to and from the neighborhood, providing more travel options and lowering congestion. The final connectivity measure is total blocks divided by housing units. This measure addresses the compactness of housing network; or how far a resident will need to walk to get anywhere. A higher number of housing units per block ratio indicates an easier walk or bike to the nearest attraction.

**Density Measures Explained**

Sustainable urbanism argues that conventional development is dominated by large single-family homes on oversized lots. Sustainable urban approaches argue that by increasing residential density, we can lower VMT and improve the negative human and environmental health outcomes of conventional development. Oversized single family lots are viewed as the primary culprit, so two of the measures in this report will look at how well density is used to mitigate the effects of the SFDU. Mean lot size and SFDU density will be compared for each neighborhood. It is important to note that SFDU density is distinct from lot size because it includes the entire area zoned residential, not just the individual residential parcels. Finally, this section will measure the net residential density of each neighborhood. This measure looks at residential units per acre of residential land use. However, all un-related land uses such as public ROW and roads are not included. The three measures are summarized below.

| Criteria | Indicator | Calculation | Meaning of Result? |
|---|---|---|---|
| **Density** | Lot Size | $Mean\ neighborhood\ SFDU\ lot\ size$ | Smaller lot means higher density |
| | SFDU Density | $\frac{Single\ family\ dwelling\ units}{Residential\ area\ of\ neighborhood}$ | Higher ratio means higher density |
| | Net Residential Density | $\frac{Residential\ dwelling\ units}{Residential\ area\ of\ neighborhood}$ | Higher ratio means higher density |

Indicator measures adapted from (Song and Knaap 2007)

Table 3.2: Density Measures

## Land Use Diversity Measures Explained

Sustainable urban approaches also respond to the homogeneity of land uses found in conventional development. New Urbanism argues that mixing of land uses shortens the distance between the residential home and the desired destinations of the resident. Including work, activity, and shopping uses in residential neighborhoods provides a mix of local options. In theory this will limit the number of car trips required and increase walking and biking behaviors among residents. Additionally, New Urbanism cites mixing land uses as a remedy to the monotony of the conventional suburb. It is argued that commercial and restaurant uses bring foot traffic and life to neighborhoods.

In this report, two approaches to land use mix are measure: land use mix built and land use mix zoned. These measures both look at the proportion of residential land use compared to non-residential uses. Both indicators are used to shed light on how well each neighborhood does in providing the mix of uses and destinations called for in New Urban theory. Due to the fact that Mueller is not fully built, including the zoned land use mix ratio provides an additional insight into the future mix, assuming development will go ahead as planned. This allows for a more fair comparison of the two neighborhoods given the different levels of progress towards full build-out. The two measures are summarized below in Table 3.3.

| Criteria | Indicator | Calculation | Meaning of Result? |
|---|---|---|---|
| Diversity | Land use Mix Built | $\frac{commercial + industrial + public\ land\ acres}{number\ of\ housing\ units}$ | Higher ratio means greater diversity of land use |
| | Zoned use mix | $\frac{commercial + industrial + public\ land\ (ZONED)}{Residential\ Land}$ | Higher ratio means greater diversity of land use |

Indicator measures adapted from (Song and Knaap 2007)

Table 3.3: Land Use Diversity Measures

### Accessibility Measures Explained

Sustainable urbanism argues for the importance of high accessibility from residential homes to places of work and play. Conventional development patterns leave residents relatively isolated once they arrive at home. There are no destinations where a resident can walk and bike, so the resident does not end up leaving home. A healthy, sustainable neighborhood will have a significant percentage of residential homes within walking distance of important destinations or amenities. Three of the most important destinations for the average resident are: parks/open space, transit, and commercial shopping. Access to these allows a resident to stay in the neighborhood and walk to meet their shopping and exercise needs or to access transit to leave the neighborhood for other needs.

This report measures access to these three amenities by calculating the number of residential homes within walking distance of each. This number is divided by the total residential units in order to arrive at a percentage of residences within walking access.

| Criteria | Indicator | Calculation | Meaning of Result? |
|---|---|---|---|
| Accessibility | Commercial Access | $percentage\ of\ housing\ within \frac{1}{4} mi.of\ comm.$ | Higher % means better access |
| | Bus access | $percentage\ of\ housing\ within \frac{1}{4} mi.of\ bus\ stop$ | Higher % means better access |
| | Park Access | $percentage\ of\ housing\ within \frac{1}{4} mi.of\ parks$ | Higher % means better access |

Indicator measures adapted from (Song and Knaap 2007)

Table 3.4: Accessibility Measures

### Summary and Notes on Measures

It is important to note that some of these indicators focus on the single family dwelling unit (SFDU). The reason to focus on the SFDU as the standard unit is due to data limitations. Data required for some of the density indicators is not available for multifamily units. Additionally, the indicator framework being used for this analysis does not adjust for multifamily units believing that it is best used to compare the SFDU across various neighborhood developments (Song and Knaap 2007). It is likely that including multifamily would improve neighborhood performance for the measures; however, this is an area in need of further study.

Analysis of the indicators in Table 3.5 was conducted in ArcGIS. The following section will outline the methods used to gather data, organize data, and analyze the results. These results will be presented in Chapter 4.

| Criteria | Indicator | Calculation | Meaning of Result? |
|---|---|---|---|
| Connectivity | Internal Connectivity | $\frac{Streeet\ intersections}{Street\ intersections + Culdesacs}$ | Higher ratio means better connectivity |
| | External Connectivity | $\frac{External\ Connections}{Neighborhood\ Area}$ | Higher ratio means better connectivity |
| | Average Block Size | $Mean\ Block\ Area$ | Smaller number means better connectivity |
| | Housing/Block Ratio | $\frac{Housing\ Units}{Total\ Blocks}$ | Fewer blocks means better connectivity |
| Density | Lot Size | $Mean\ neighborhood\ SFDU\ lot\ size$ | Smaller lot means higher density |
| | Net Residential Density | $\frac{Residential\ dwelling\ units}{Residential\ area\ of\ neighborhood}$ | Higher Ratio means higher density |
| | SFDU Density | $\frac{Single\ family\ dwelling\ units}{Residential\ area\ of\ neighborhood}$ | Higher ratio means higher density |
| Diversity | Land use Mix Built | $\frac{commercial + industrial + public\ land\ acres}{number\ of\ housing\ units}$ | Higher ratio means greater diversity of land use |
| | Zoned use mix | $\frac{commercial + industrial + public\ land\ (ZONED)}{number\ of\ housing\ units}$ | Higher ratio means greater diversity of land use |
| Accessibility | Commercial Access | $percentage\ of\ housing\ within \frac{1}{4} mi.of\ comm.$ | Higher % means better access |
| | Bus access | $percentage\ of\ housing\ within \frac{1}{4} mi.of\ bus\ stop$ | Higher % means better access |
| | Park Access | $percentage\ of\ housing\ within \frac{1}{4} mi.of\ parks$ | Higher % means better access |

Indicator measures adapted from (Song and Knaap 2007)

Table 3.5: Summary of Indicators to be used in Analysis

### 3.4. Materials

This report relied on the research framework established by land use planners in various journals. The Journal of the American Planning Association was utilized for the core documents that shaped this analysis. Additionally, books from the University of Texas Library, course materials from Dr. Robert Paterson's "Sustainable Land Use Planning" class, and newspaper articles accessed online were utilized.

ESRI ArcGIS 10.1 was used for the overlay and indicators analysis conducted in the following sections. Spatial analysis tools such as clip, merge, dissolve, buffer, and intersect were used for the map output and data analysis. Calculate Geometry, Field Calculator, and spatial statistics were also used to calculate the indicator measures used for each neighborhood. In some cases these calculations were also duplicated in Microsoft Excel for verification.

AutoCAD was utilized in this report in order to create shapefiles that did not exist, yet were needed to complete the analysis. These files were created to fill gaps in the City of Austin's spatial data for the Mueller neighborhood. Data were drawn in CAD and then imported and spatially referenced using ArcCatalog and ArcMap. Arc Catalog was utilized throughout the data analysis process to manage and project data.

### 3.5. Data Collection

Data collection was conducted primarily through online sources. Some data were also gathered through email contact with the City of Denver, the City of Aurora, and the Catellus Development Corporation. Additional data were gathered and digitized for analysis by the author.

#### Mueller Data

Data for the analysis of the Mueller neighborhood were gathered primarily from the City of Austin GIS Data website. The free online database provided a wide range of data for the base maps as well as the analysis. Data were also gathered from the Capital Area Council of Governments (CAPCOG) website. CAPCOG was the primary source for transportation related data. Catellus Corporation provided land use and lot maps through email and phone contact. These data were used to create base maps in ArcMap, on which the analysis would later be conducted.

The author created ArcGIS shapefiles for the building footprints and building land use designations on the Mueller site. These data were created through on-site data collection in the form of a field survey as well as email correspondence with Catellus Development. Survey information was used to guide the author's use of Google Earth to identify the most up-to-date building footprints. Images were stitched together to create a digital base map to trace. Finally, the spatial data file was created in AutoCAD as a series of building polygons and then imported into ArcGIS.

**Stapleton Data**

Data for the Stapleton neighborhood were obtained from the Denver Open Data Catalog and the Denver Regional Council of Governments (DRCOG) Open Data Page. Both of these sources are publicly accessible data sites that have descriptive GIS data files for download. The City of Denver data provided a majority of base map shapefiles while the DRCOG provided needed transportation data. The GIS office in the planning department was also contacted by email for assistance in locating data.

City of Denver data were incomplete for the neighboring community of Aurora in the GIS database. This required additional data to be gathered from the Aurora, Colorado online GIS resources page. Data that were not available online were requested by email from the Aurora Planning office.

Google Earth and Google Maps were utilized to cross-reference the quality of the data sets. This was primarily used as means to ascertain how current these data were. In particular, this was used to check the building footprint and land uses for the land use diversity measures calculated.

## 3.6. Indicator Calculations

This section provides step-by-step methods for each indicator calculation that is used in the analysis section of the report. Indicators were calculated the same for each development unless otherwise noted. All indicators were calculated in ArcGIS using geoprocessing tools and statistical operations. Some indicators (where noted) were also calculated in Microsoft Excel for verification.

**Density Measures:**

*Single Family Dwelling Unit Density*

1. Identified SF land use in the attribute table for land use shapefiles provided by the cities
2. Selected by attributes based on general land use codes
3. Calculated the area of this selection in ArcMap by starting an editing session and then: Open Attribute Table > Calculate Geometry > Shape Area for SF Land use
4. Divided the area of the selection by the number of SFDU established when creating the Mueller_SFDU shapefile

*Mean SFDU Lot Size*

1. Identified single family lots through attribute table
2. Selected SF lots by attribute
3. Calculated sum area for all SF lots using summary statistics
4. Divided this area by the number of SFDU calculated previously

*Net Residential Density*

1. Identified Residential land use in the attribute table for the land use shapefile
2. Selected by attributes based on general land use codes
3. Calculated the area of this selection in ArcMap by starting an editing session and then: Open Attribute Table > Calculate Geometry > Shape Area for multifamily + Single family land use categories

4. Subtracted the streets area from the residential selection to arrive at a Net Residential area
5. Divided the number of residential units for each neighborhood by the residential area for each neighborhood

**Accessibility Measures**

*Commercial Access*

1. Identified commercial building uses by selection by attributes in the land use category for building footprints.
2. Created a new shapefile for "commercial_buildings" for each city
3. Created a ¼ mile buffer around "commercial_buildings"
4. Clipped neighborhood single family units to the new "commercial_access_buffer" file
5. Opened attribute table and identified the number of residential buildings in the new "commercial_accessible_residential" file
6. Divided this number by the total number of residential buildings in each neighborhood

*Park Access*

1. Identified parks through selecting by attribute in the general land use category of the city-wide land use shapefiles
2. Created a new shapefile for parks for each city based on this selection
3. Created a ¼ mile buffer around parks
4. Clipped neighborhood single family units to the new "park_access_buffer" files
5. Opened attribute table and identified the number of residential buildings in the new park buffer file
6. Divided this number by the total number of residential buildings in each neighborhood

*Transit Access*

1. Identified transit stops in each city transit stop shapefile
2. Created a ¼ mile buffer around the stops
3. Clipped neighborhood single family units to the new “transit_access_buffer” files
4. Opened attribute table and identified the number of residential buildings in the new transit buffer file
5. Divided this number by the total number of residential buildings in each neighborhood

**Diversity Measures**

*Land Use Mix Zoned*

1. Opened attribute table for city land use map
2. Used select by attributes to select commercial + Industrial + open space land uses
3. Opened attribute table for selection
4. Calculated area for selection by opening Editor then: Calculate Geometry > Shape Area in ft. for selection
5. Conducted summary statistics to identify total area
6. Divided the area calculated by the number of residential buildings (conducted in Excel)

*Land Use Mix Built*

1. Opened attribute table for neighborhood parks map
2. Summary statistics in order to calculate total built parks area
3. Opened building footprints attribute table
4. Selected by attributes non-residential uses
5. Calculated area for selection by opening Editor then: calculate geometry > Shape area in feet for the selection
6. Summary statistics for total area of attributes selected

7. Added together total area for two measures
8. Divided by the number of residential buildings in neighborhood (conducted in Excel)

**Connectivity Measures**

*Internal Connectivity*

1. Opened streets shapefile for each neighborhood
2. Identified intersections manually and created a point shapefile for intersections of each neighborhood
    a. Created new shapefile intersections_mueller/stapleton in Arc Catalog
    b. Opened ArcMap and opened Editor > Start Editing > intersections_mueller/stapleton
    c. Opened Create Features dialogue and manually added intersection points
    d. Saved edits and exited editing session
3. Counted total intersections in each neighborhood
4. Examined street shapefile for any cul-de-sacs in neighborhood
5. Added cul-de-sac count to intersection count
6. Divided intersections by cul-de-sacs + intersections (using Microsoft Excel)

*External Connectivity*

1. Opened streets shapefile for each neighborhood
2. Identified intersections manually and created a point shapefile for intersections of each neighborhood
    a. Created new shapefile intersections_mueller/stapleton in Arc Catalog
    b. Opened ArcMap and opened Editor > Start Editing > intersections_mueller/stapleton
    c. Opened Create Features dialogue and manually added intersection points
    d. Saved edits and exited editing session

3. Counted total external intersections in each neighborhood
4. Divided intersections by total area in acres of each neighborhood (using Microsoft Excel)

*Housing/Block Ratio*

1. Opened parcels and roads shapefiles in ArcMap
2. Manually counted the number of street blocks in each neighborhood
3. Divided total number of housing units (previously measured) by the number of blocks in each neighborhood

*Average Block Size*

1. Opened attribute table for streets shapefile for each neighborhood
2. Identified road width and number of lanes in attribute table for each road section
3. Identified segment length for each road segment
4. Multiplied (road width)*(number of lanes)*(segment length) to arrive at the area of the neighborhood that is road use
5. Opened attribute table for parcels in each neighborhood
6. Calculated the total parcel area for each neighborhood
7. Subtracted neighborhood road use area from total parcel area
8. Divided (parcel area – road area) by the number of blocks calculated for the previous block measures

# Chapter 4: Results

In this section the results of the indicators analysis will be presented. The indicators are broken into four categories, as outlined in the methods section.

1. Connectivity
2. Density
3. Diversity
4. Accessibility

Analysis maps were created for each of the four categories, and calculations were made based on these maps. The following sections will present the maps and the results of the calculations for each development. The Results section will conclude with a table comparing Mueller and Stapleton based on the 12 indicators.

## 4.1. Connectivity

Connectivity measures used in this report examine how well the street network in the neighborhood is connected. Internal connectivity measures the street intersections compared to intersections and cul-de-sacs. A higher ratio here means better neighborhood connectivity. External connectivity measures the number of external intersections per acre on the site. More connections per acre are better for connectivity. Average block length examines the length in feet of each block; shorter blocks mean better connectivity. Finally, total blocks per SFDU are examined for each neighborhood. Less blocks per SFDU means a more connected neighborhood.

| | **Stapleton** | **Mueller** |
|---|---|---|
| **Internal Connectivity** | ***1.0*** | ***1.0*** |
| **External Connectivity** | ***0.012*** | 0.011 |
| **Average Block Area** | ***6.02*** | 13.11 |
| **Housing Units/Block** | 13.22 | ***13.83*** |

Table 4.1: Neighborhood Connectivity Results

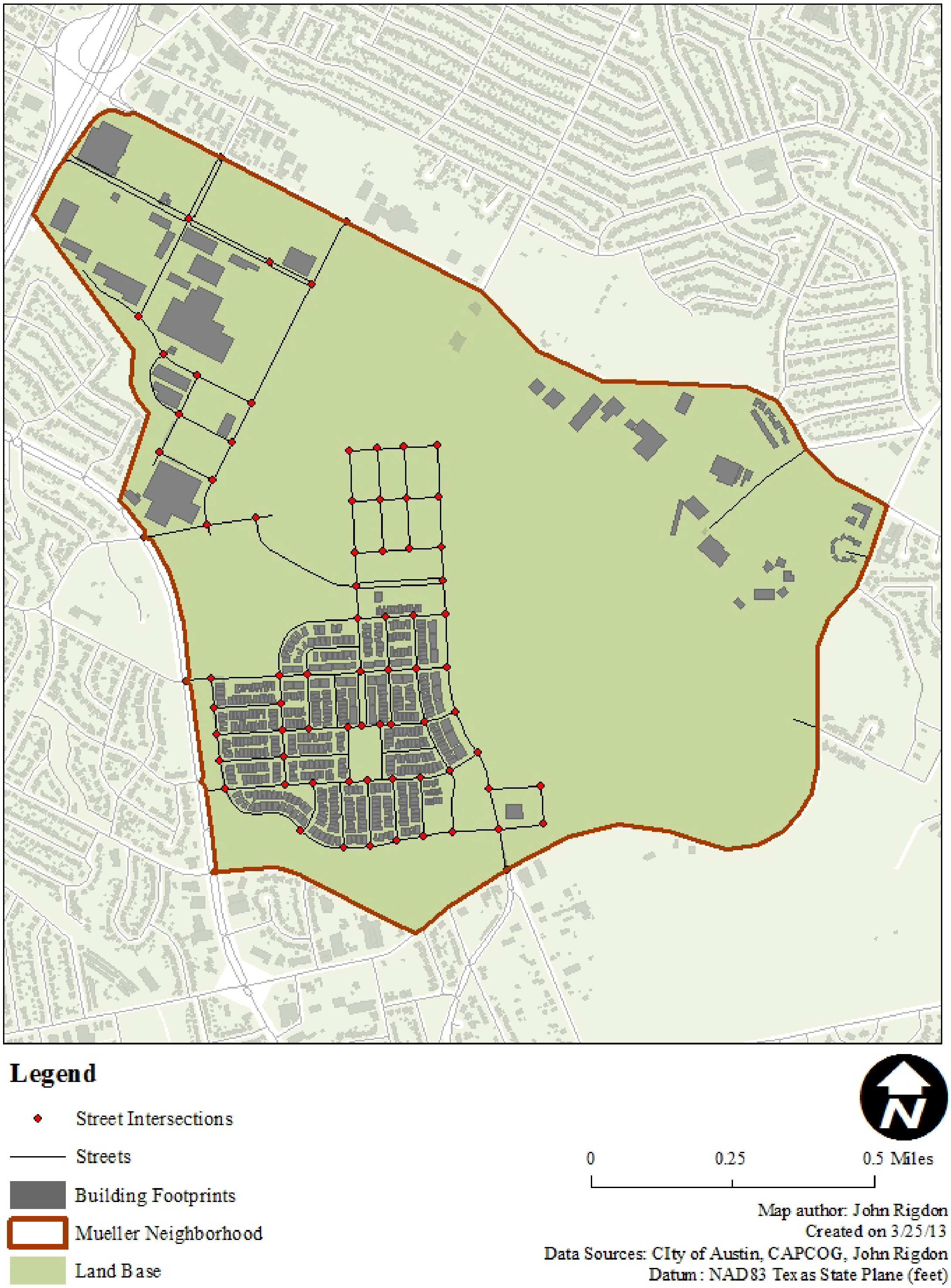


Figure 3: Mueller Street Network

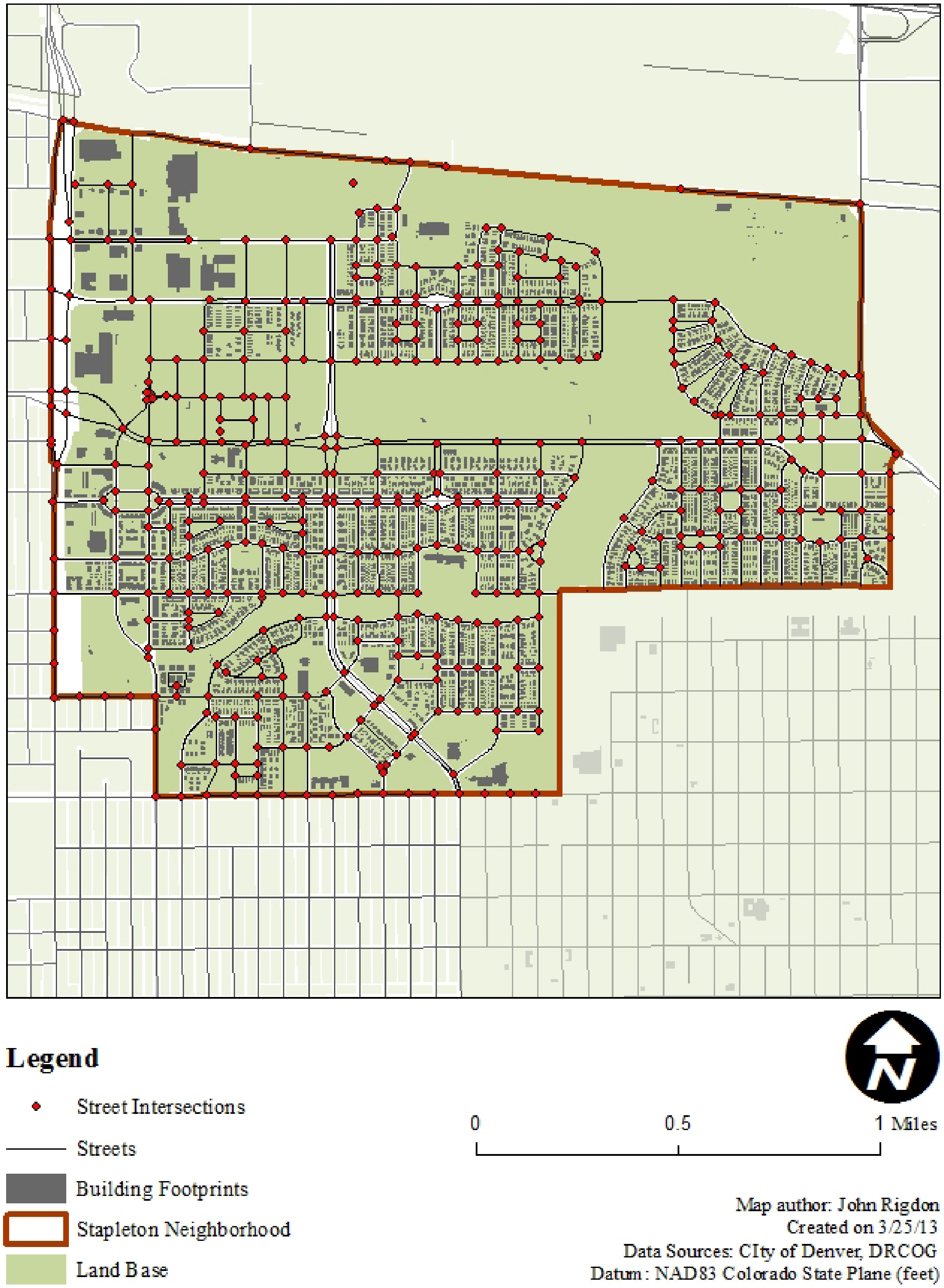


Figure 4: Stapleton Street Network

## 4.2. Density

Density measures look at the compactness of development in a neighborhood. This section examines three measures of density in the two case studies: Average single family residential lot size, single family residential density, and net residential density. SFDU Density measures single family units per acre residential area. This includes all neighborhood land zoned residential, not just residential lots. The higher the ratio, the better the neighborhood meets sustainable development goals. Average SFDU lot size measures the size of lots in the neighborhood that are zoned for residential. The lot size is also presented in acres. Finally, Net Residential Density is measured. This is measure that looks at the number of residential units per acre, excluding unrelated land uses. This includes excluding public right of way and roads. A higher ratio of units per acre means better density.

| | **Stapleton** | **Mueller** |
|---|---|---|
| **SFDU Density** | 12.59 | ***13.65*** |
| **Average SFDU Lot Size** | .079 | ***.073*** |
| **Net Residential Density** | ***24.25*** | 12.19 |

Table 4.2: Neighborhood Density Results

Figures 5 and 6 highlight the three measures of density for Mueller and Stapleton. The image also provides the lot outlines for each neighborhood. This data was used to conduct the density calculations presented in the table above.

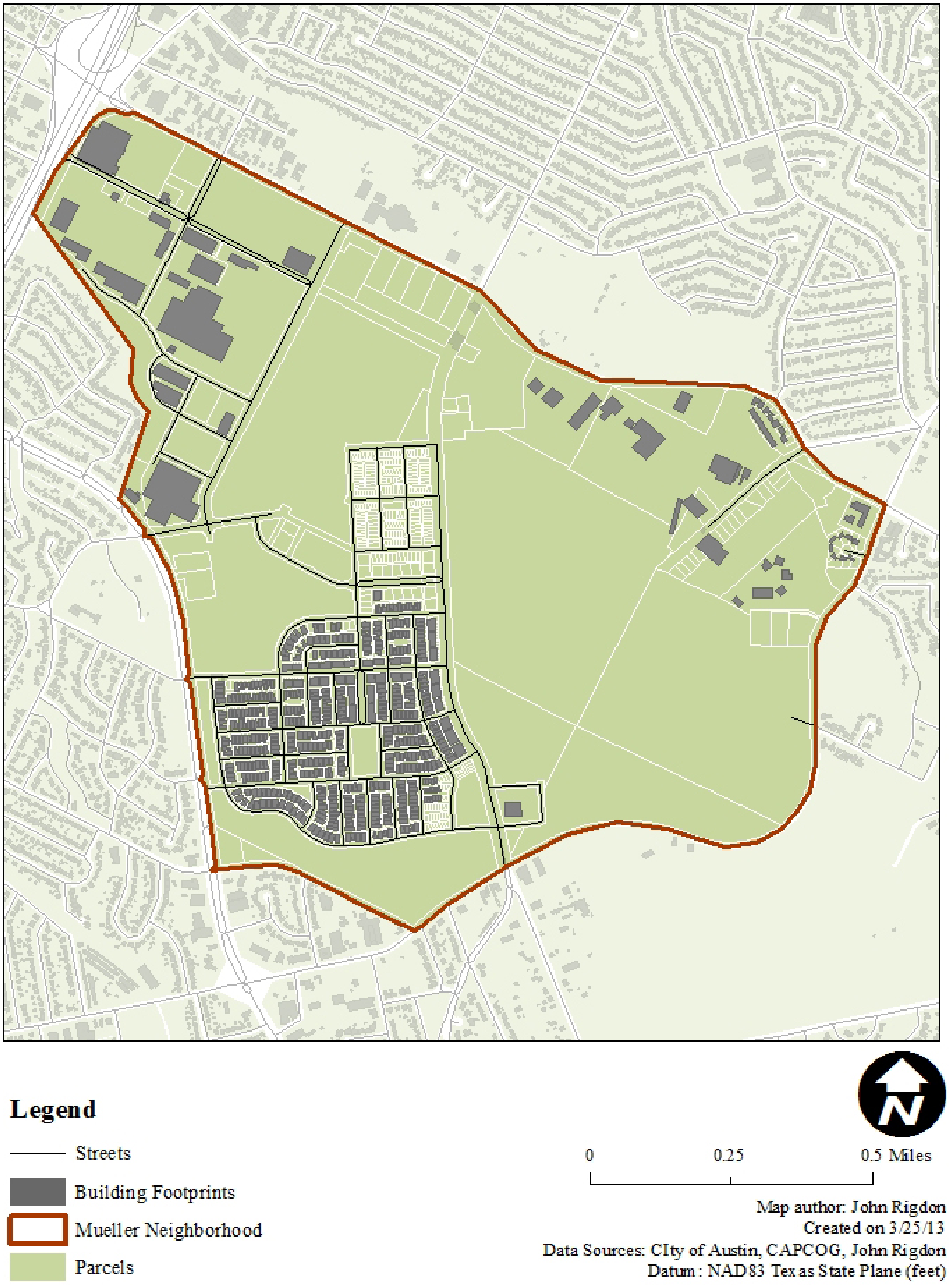


Figure 5: Mueller Building Density

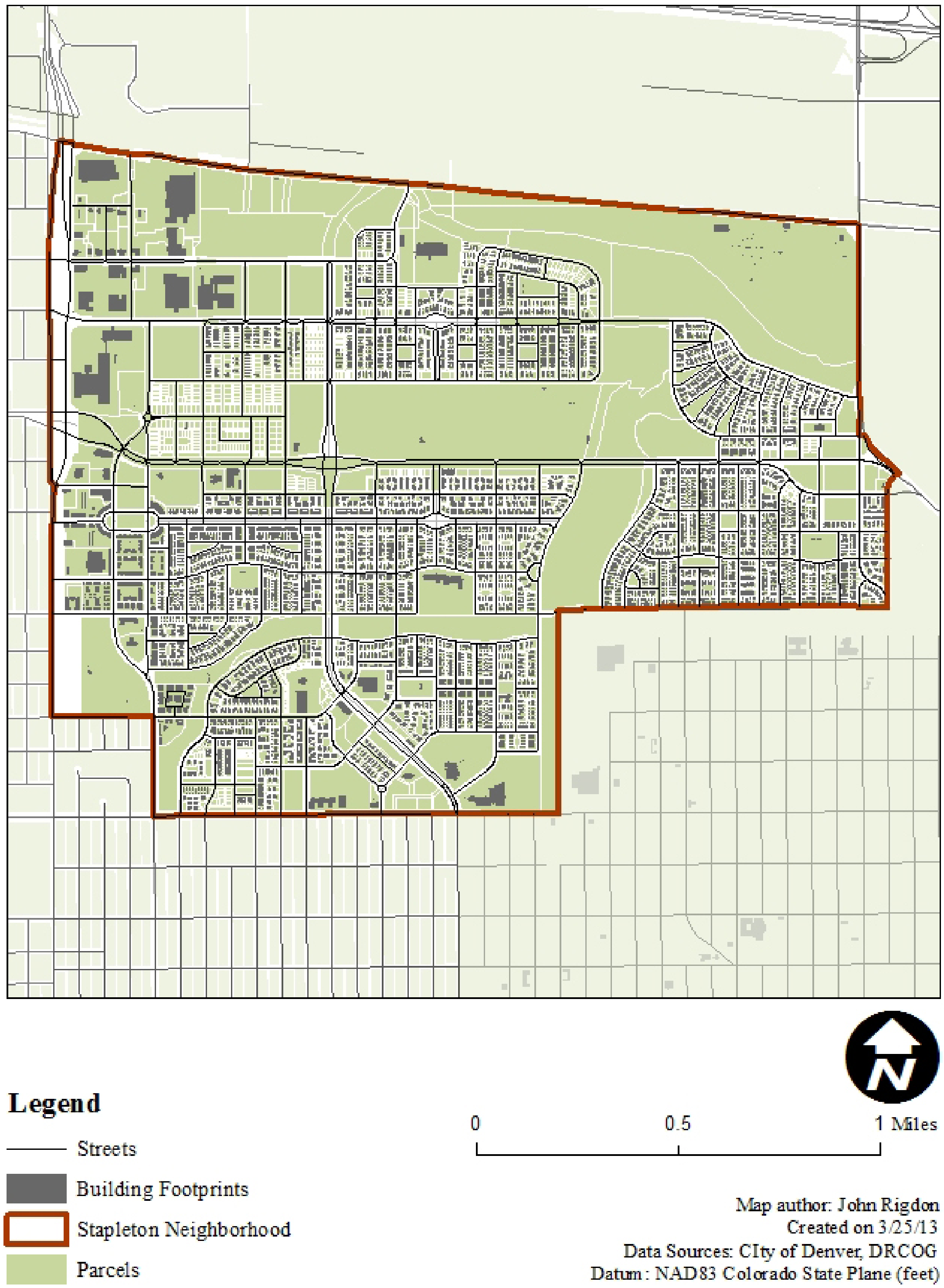


Figure 6: Stapleton Building Density

### 4.3. Diversity

Land use diversity measures analyze the mix of land uses in each neighborhood. A better mix of non-residential and residential land uses means a more diverse neighborhood. This section will look at two measures of land use mix: the zoned land use mix and the built land use mix.

Zoned land use mix refers to the mix of land uses zoned by the city in their most recent zoning map for a neighborhood. The number of non-residential acreage is compared to the residential units to arrive at a ratio. A higher ratio means more diverse land use in the given neighborhood.

The second measure calculated is the land use mix as built. This measure examines the most recent building footprint data and uses the building classifications to determine what uses have actually been built in the neighborhood. The number of non-residential buildings is compared to the number of residential buildings to arrive at a ratio. A higher ratio means a more diverse land use mix.

| | **Stapleton** | **Mueller** |
|---|---|---|
| **Acres Zoned Non-Residential per residential building** | 0.11 | ***0.53*** |
| **Acres Built Non-Residential per residential building** | 0.076 | ***0.39*** |

Table 4.3: Neighborhood Diversity Results

Figures 7 and 8 display the land uses as zoned for Stapleton and Mueller. Figures 9 and 10 display the land use as built for each neighborhood. The data in the images was used to calculate the measures presented in Table 4.3 above.

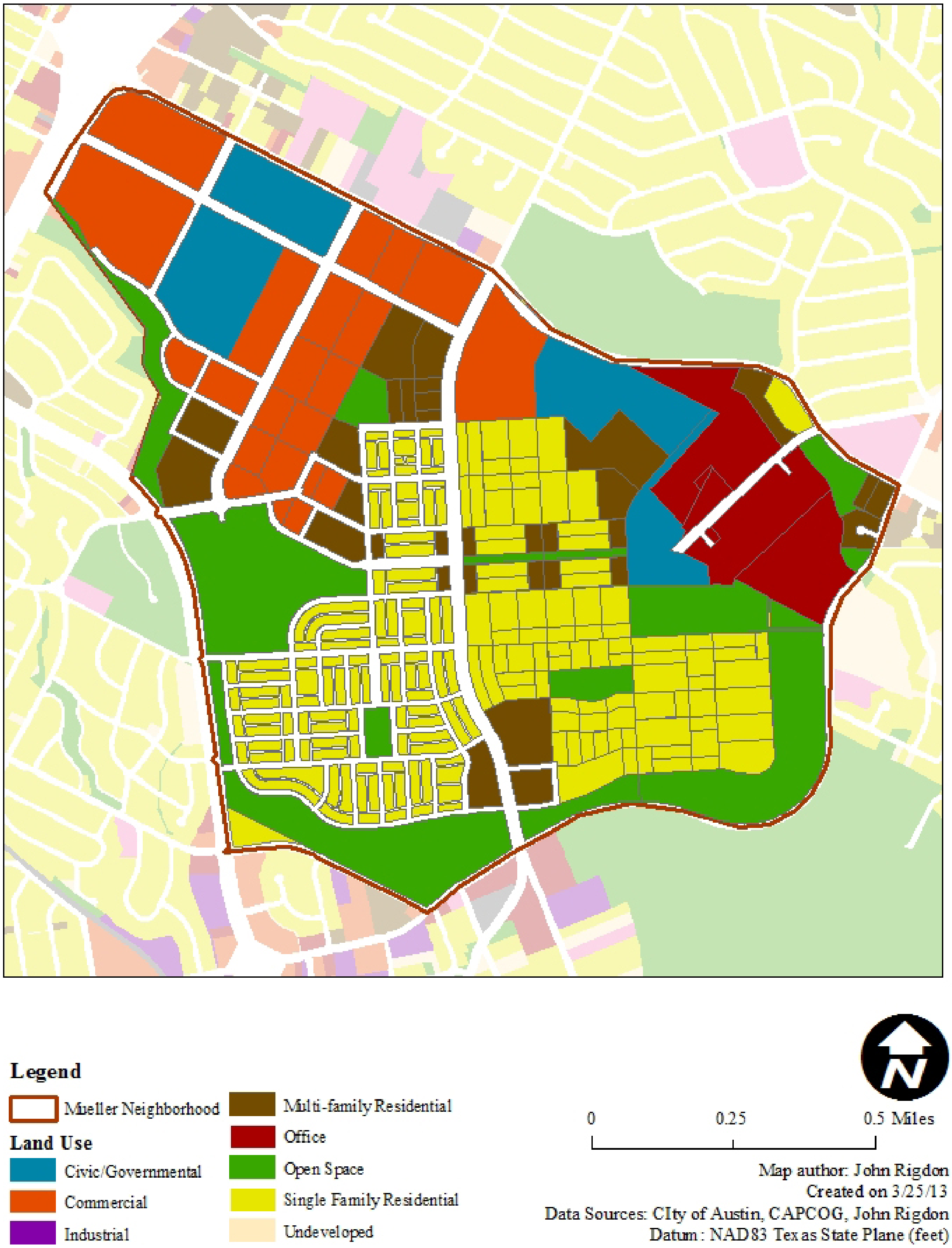


Figure 7: Mueller Land Use Diversity Zoned

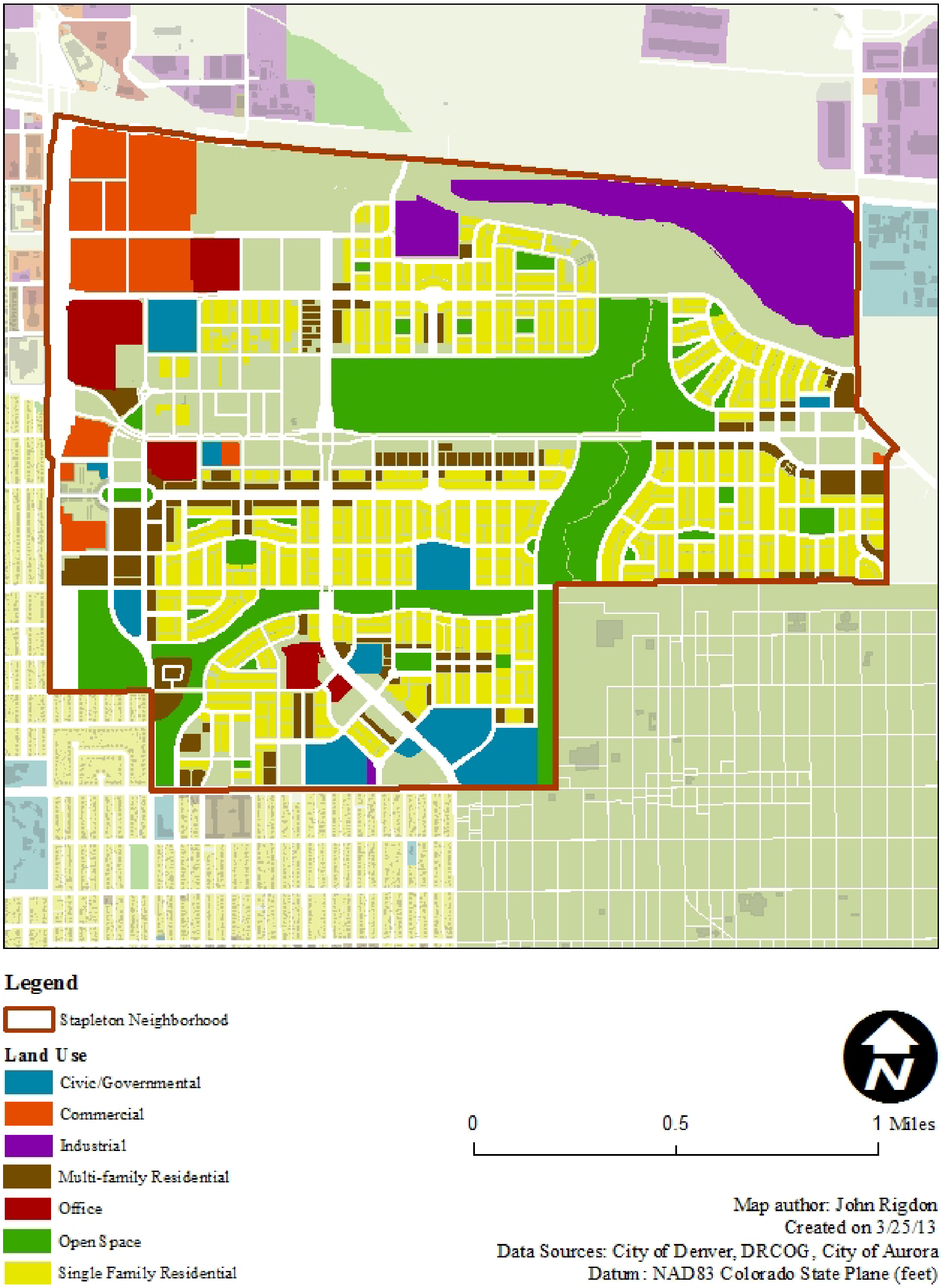


Figure 8: Stapleton Land Use Diversity Zoned

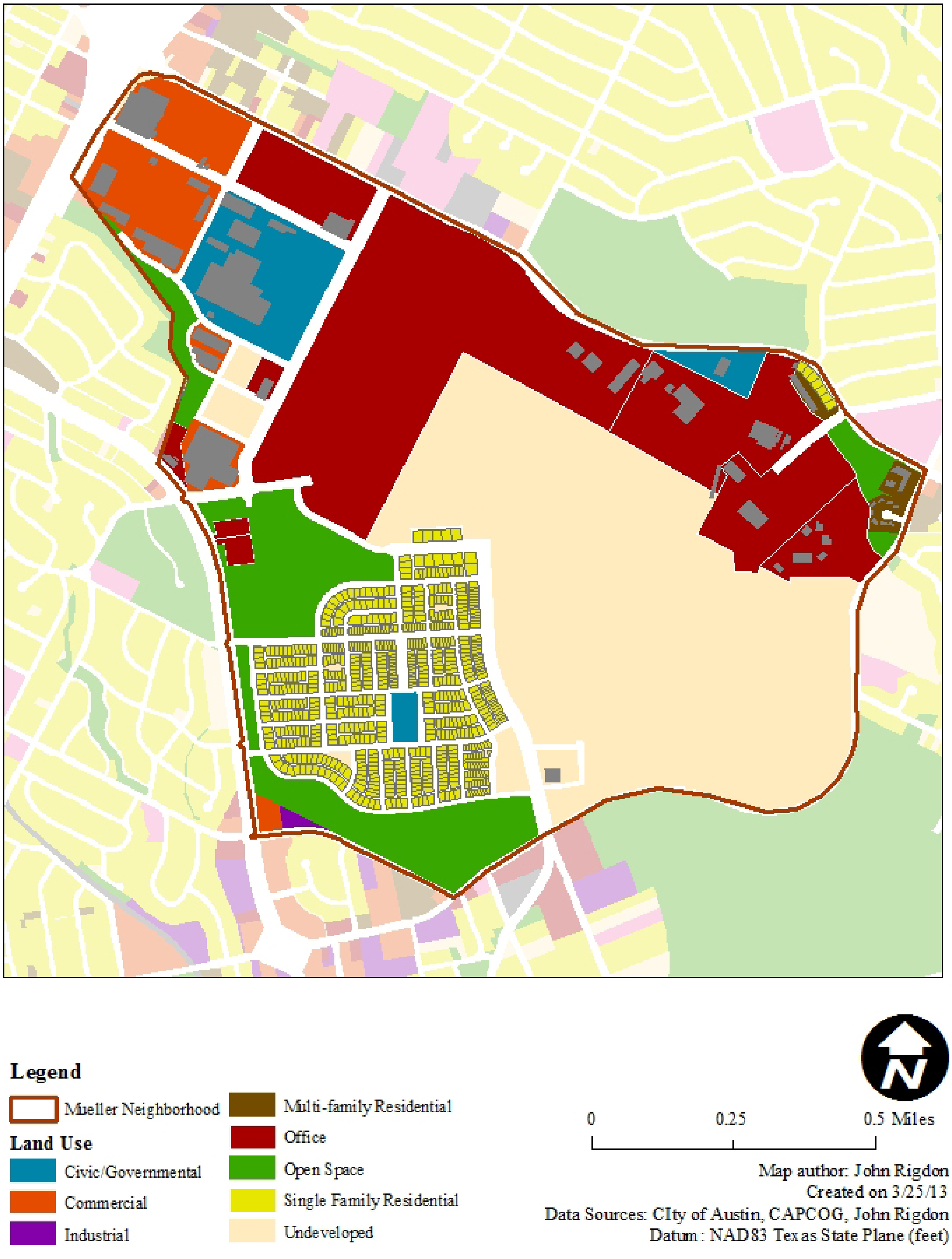


Figure 9: Mueller Land Use Diversity Built

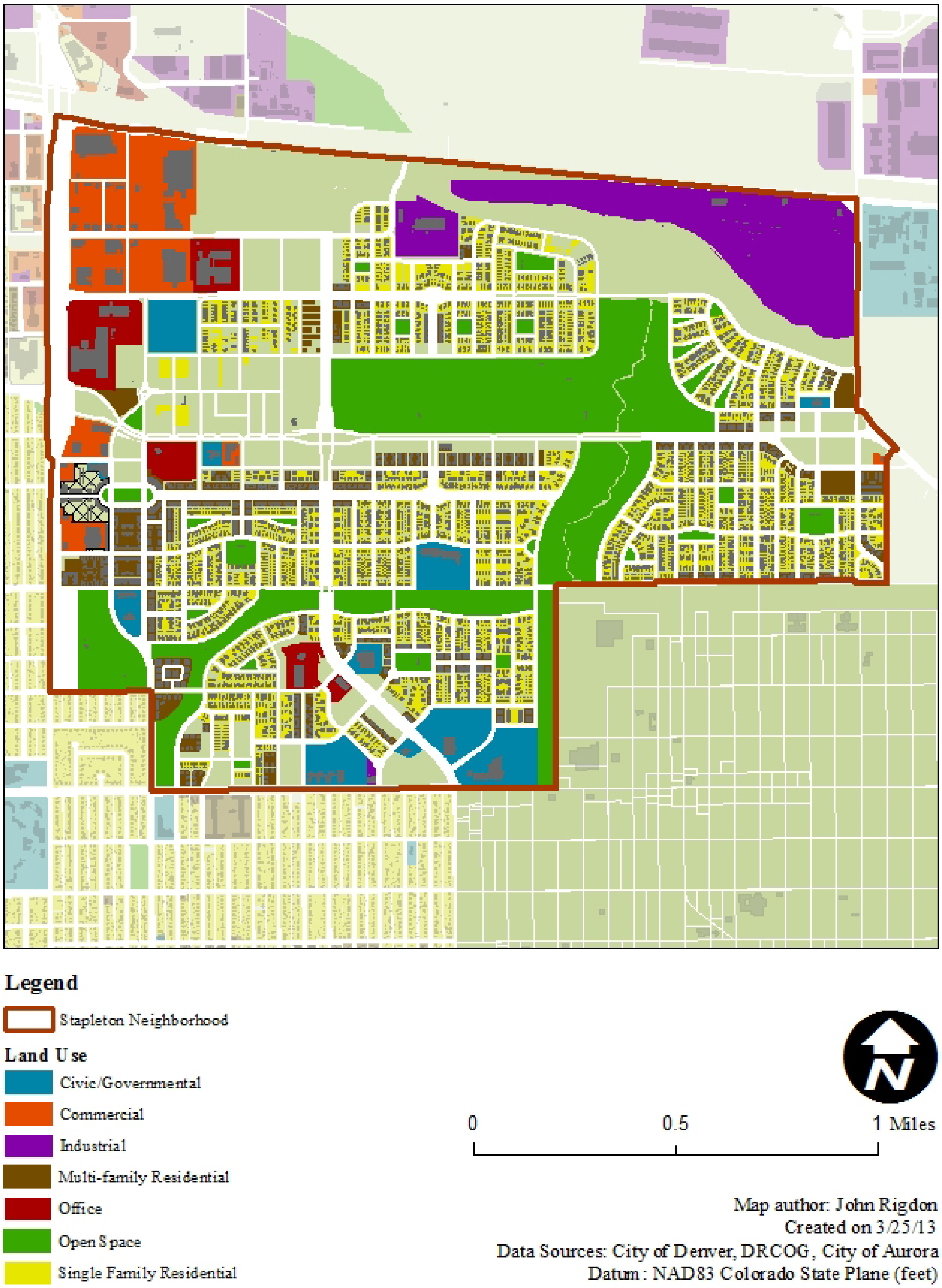


Figure 10: Stapleton Land Use Diversity Built

## 4.4. Accessibility

Accessibility measures examine the level of access residents of each neighborhood have to three key amenities. The amenities measured for each neighborhood: parks, commercial establishments, and transit stops. Access was calculated based measuring the number of residential buildings within walking distance of each amenity. The percentage of residential within ¼ mile of each amenity is presented in Table 4.4. A higher percentage means better access.

| | **Stapleton** | **Mueller** |
|---|---|---|
| **Residential with Access to Transit** | ***43.02%*** | 38.75% |
| **Residential with Access to Parks** | 88.56% | ***100%*** |
| **Residential with Access to Commercial Establishments** | 20.25% | ***43.79%*** |

Table 4.4: Neighborhood Accessibility Results

The following figures display the above data in spatial form. The transparent buffer areas represent area within walking distance of each amenity. These maps were used for the calculations provided in Table 4.4 above.

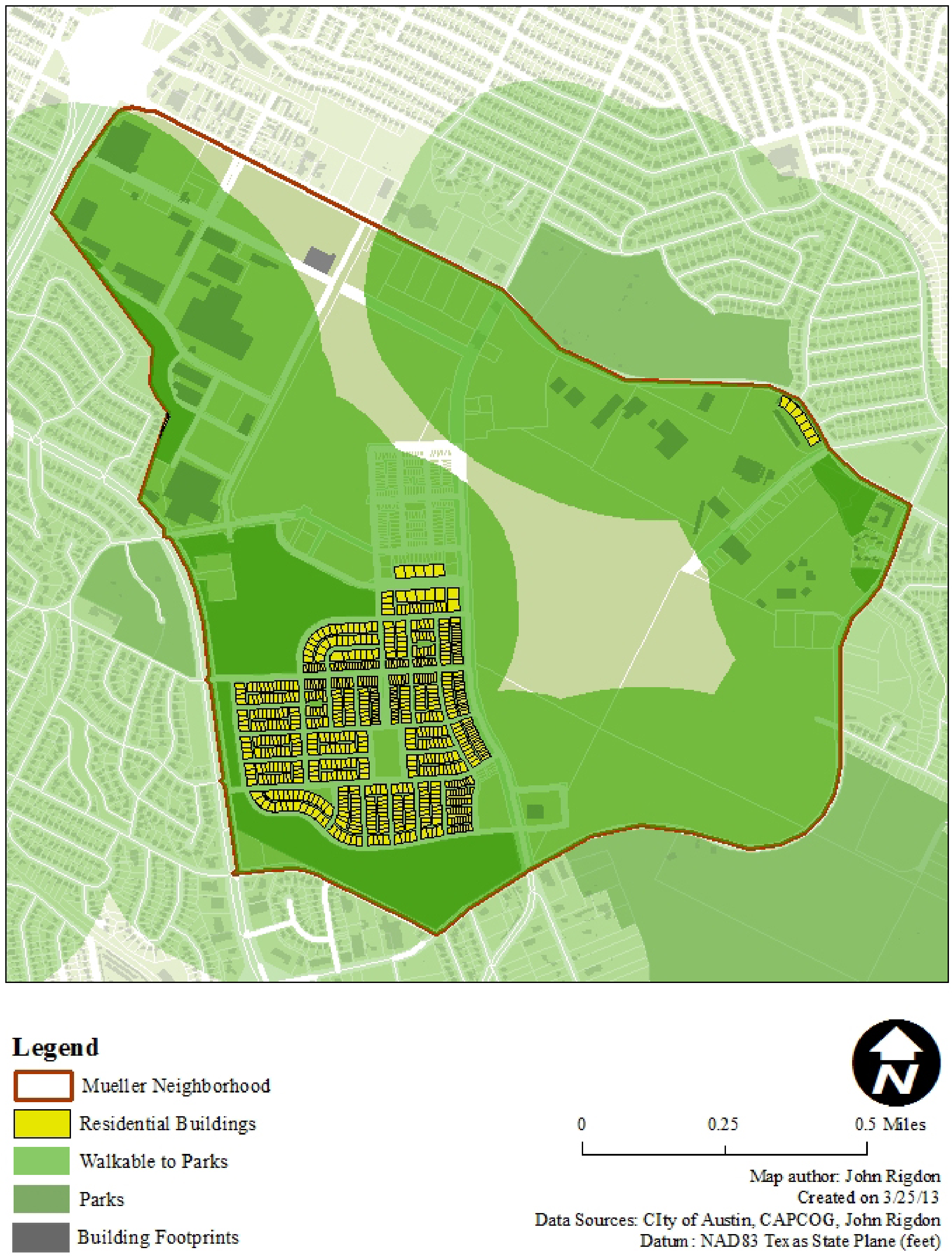


Figure 11: Mueller Park Access

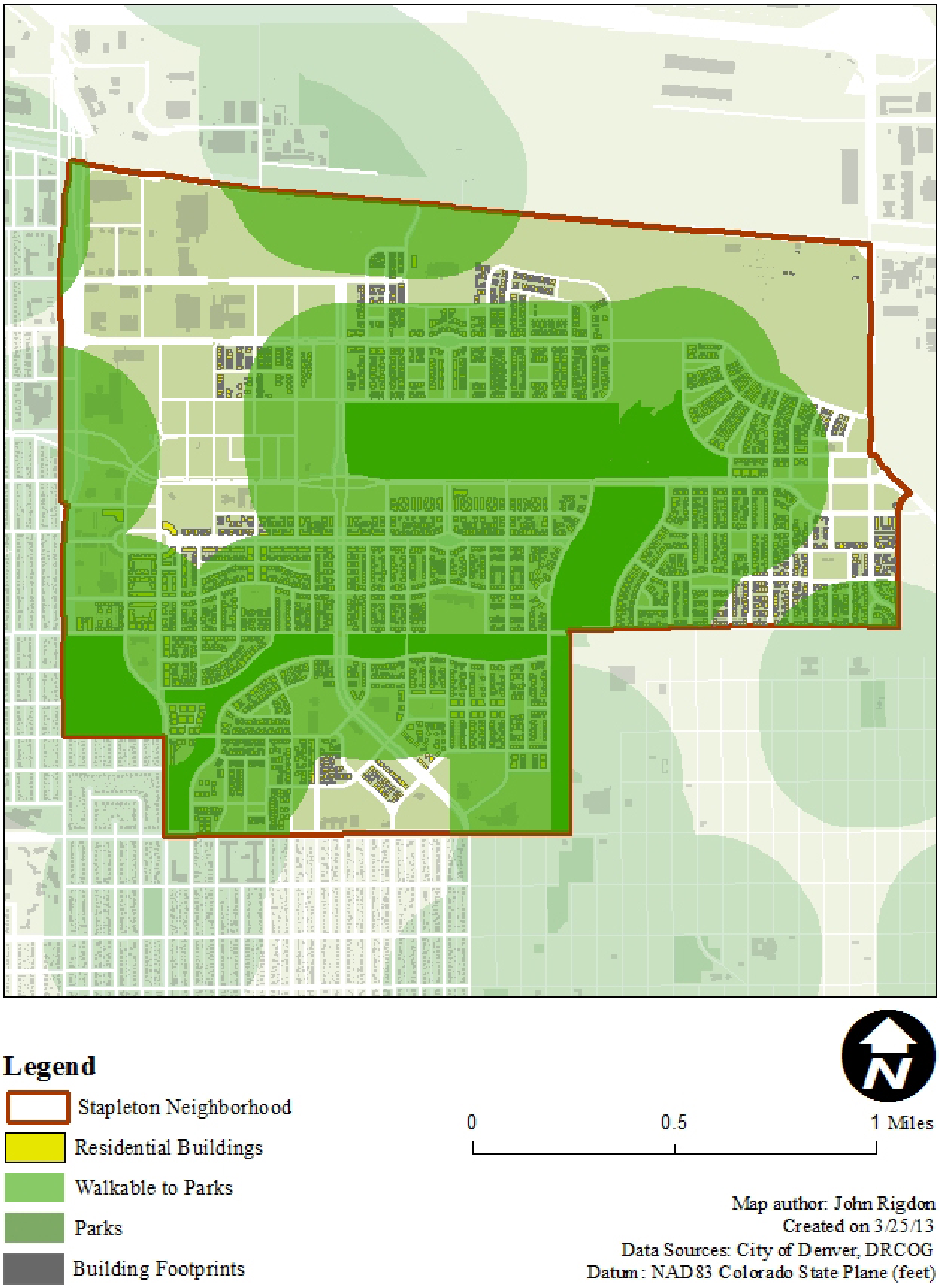


Figure 12: Stapleton Park Access

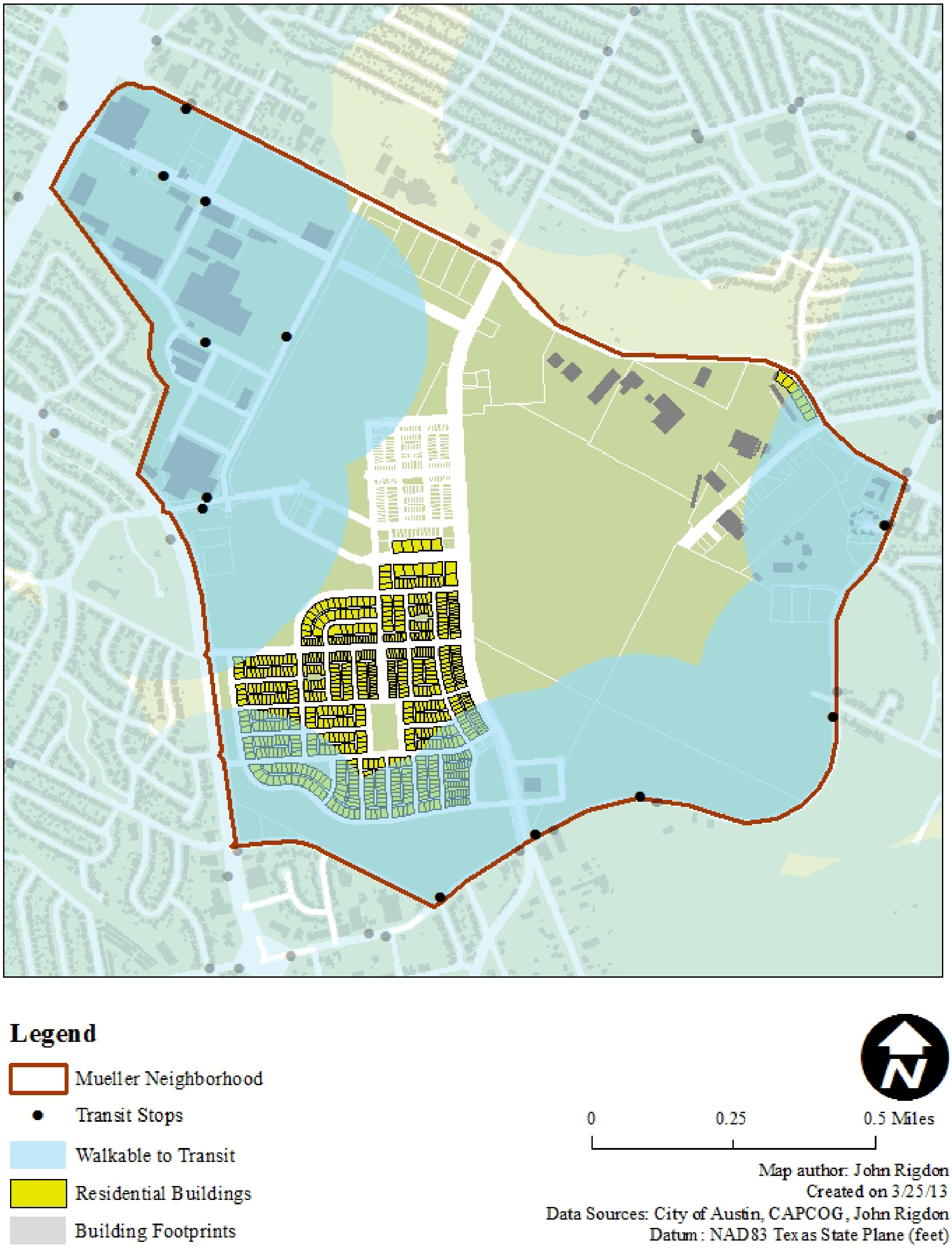


Figure 13: Mueller Transit Access

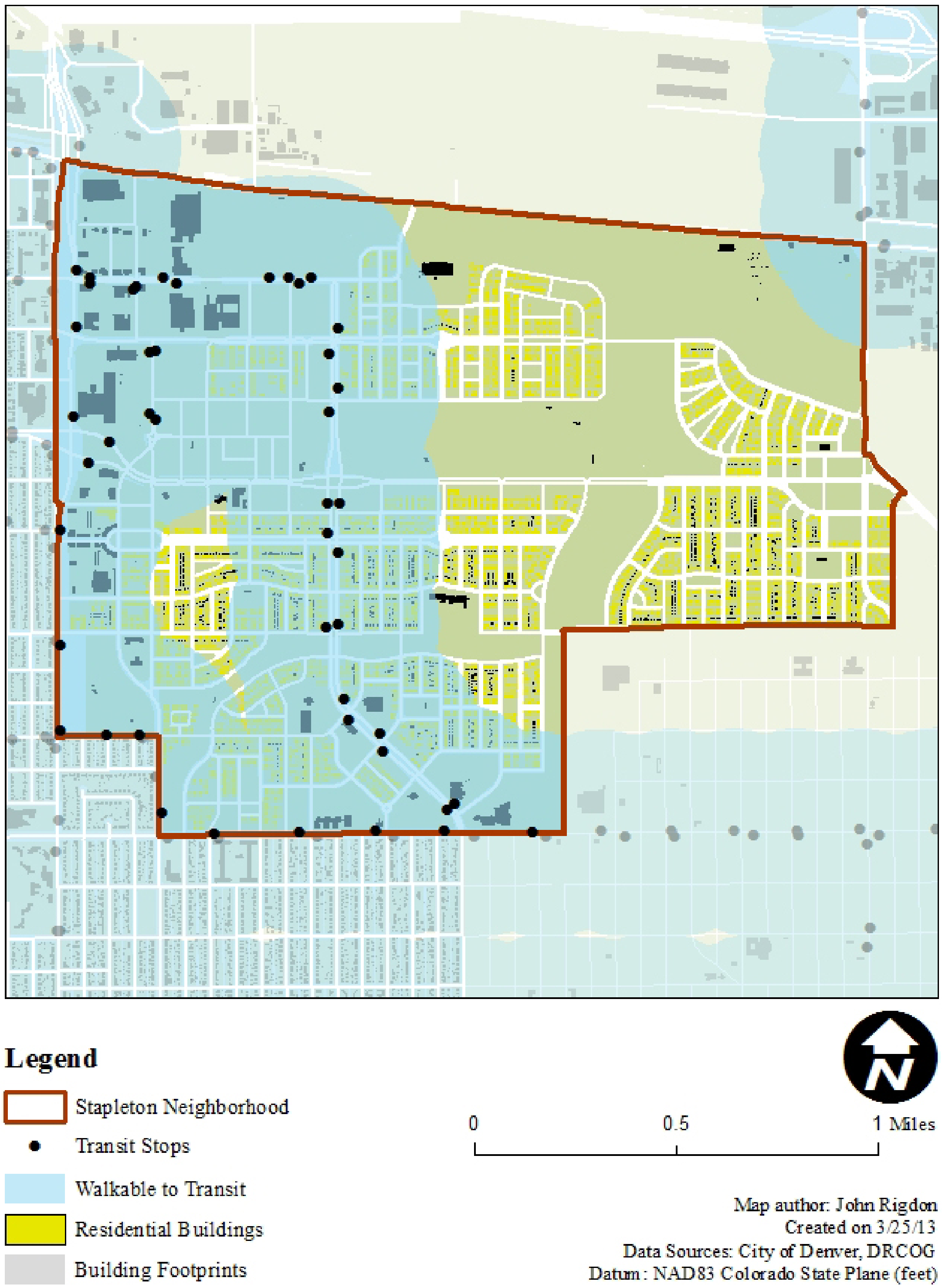


Figure 14: Stapleton Transit Access

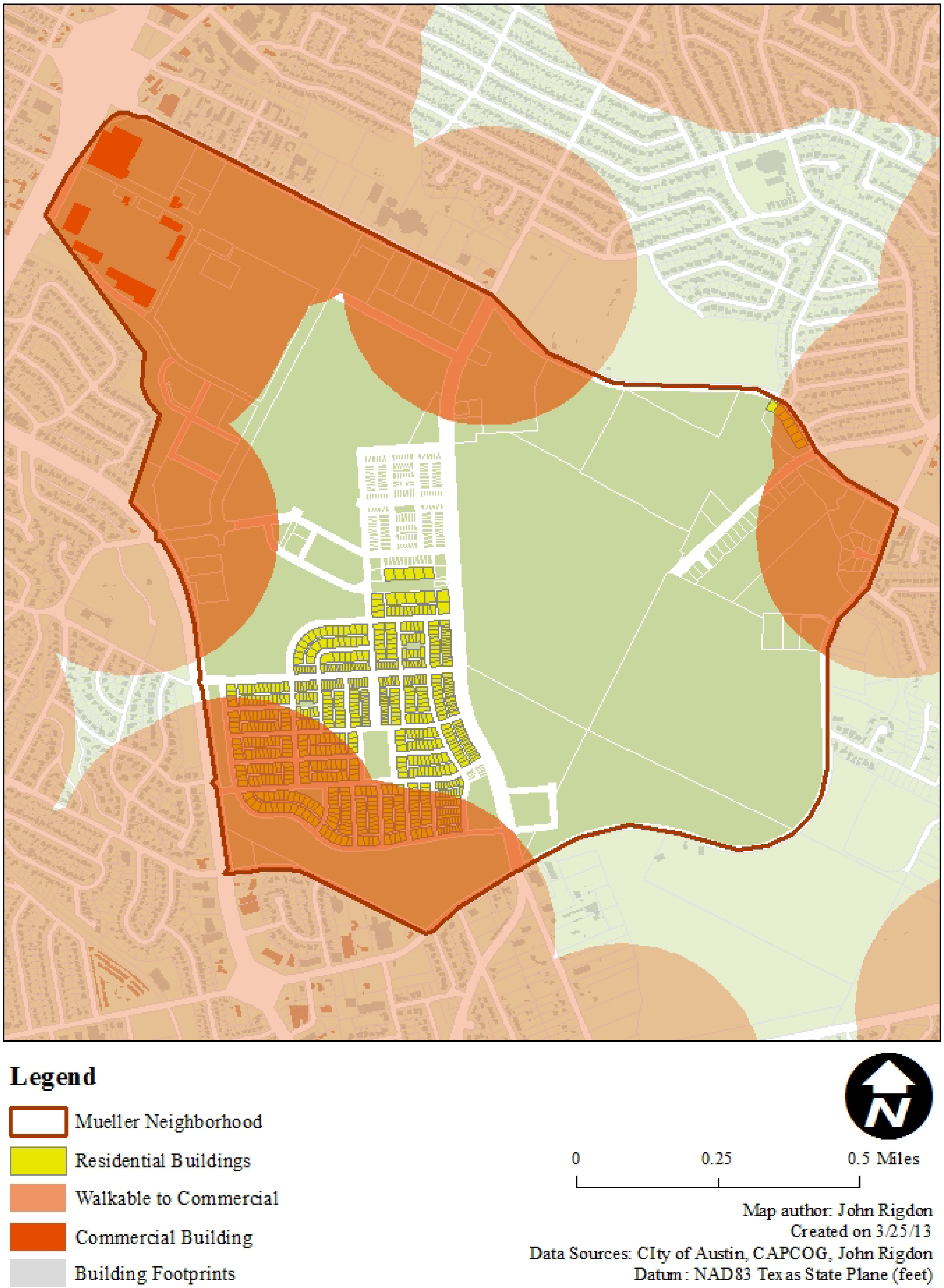


Figure 15: Mueller Commercial Access

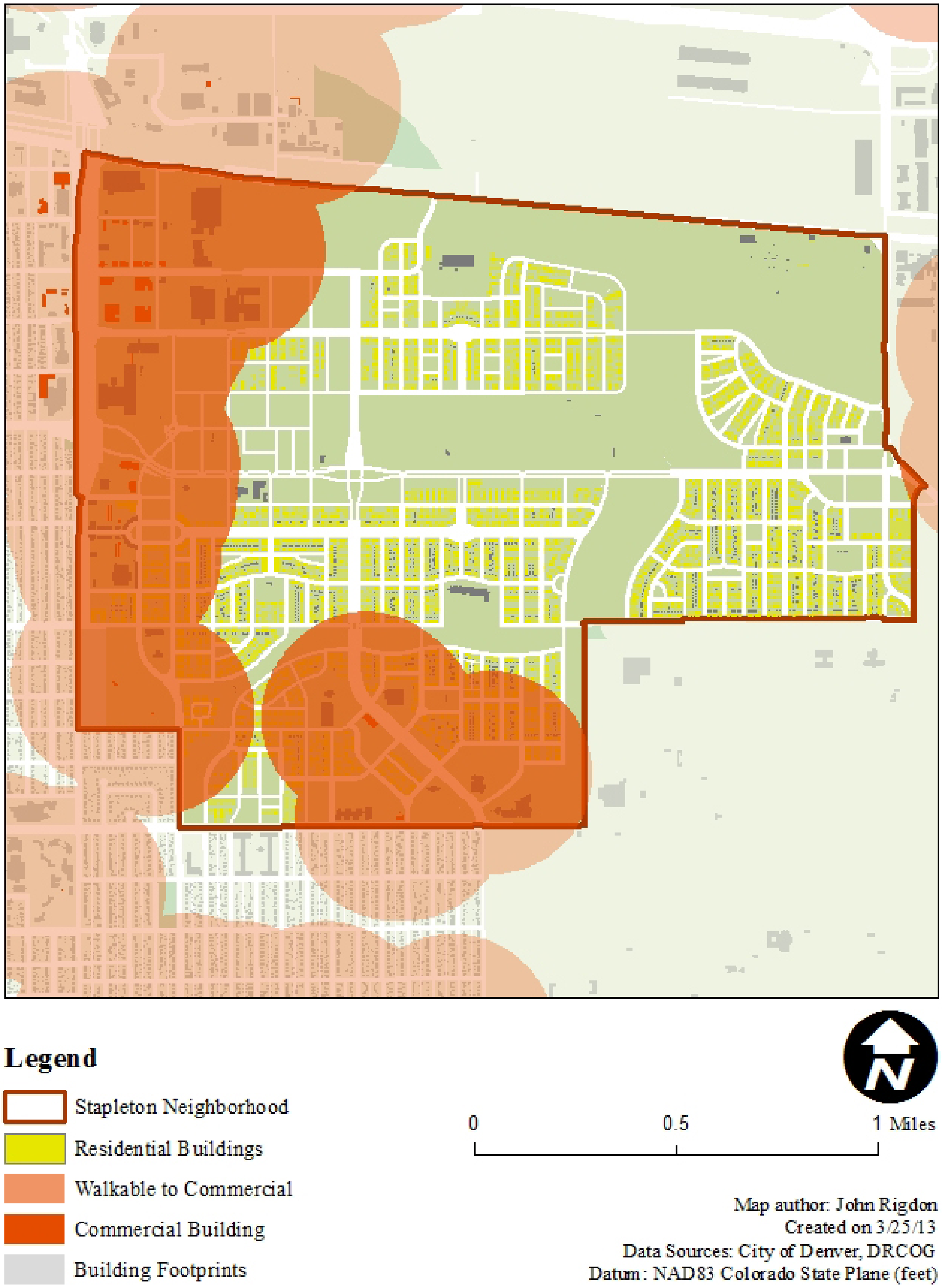


Figure 16: Stapleton Commercial Access

# Chapter 5: Findings/Conclusion

This section will outline the findings of the analysis, introduce some caveats/limitations, and provide some concluding thoughts. The results section provides the final numbers for the indicators measured in this report. These results are summarized for ease of reference below in Table 5.1.

| Criteria | Indicator | Stapleton Development | Mueller Development | Meaning of Result? |
|---|---|---|---|---|
| Connectivity | Internal Connectivity | ***1.0*** | ***1.0*** | Higher ratio means better connectivity |
| | External Connectivity | ***0.012*** | 0.011 | Higher ratio means better connectivity |
| | Block area | ***6.02*** | 13.11 | Smaller area means better connectivity |
| | Residential Houses per Block | 12.59 | ***13.65*** | More homes per block means better connectivity |
| Density | SFDU Density | 12.59 | ***13.65*** | Higher ratio means higher density |
| | Lot Size | .079 | ***.073*** | Smaller lot means higher density |
| | Net Residential Density | ***24.25*** | 12.19 | Higher ratio means higher density |
| Diversity | Land use Mix Zoned | 0.11 | ***0.53*** | Higher ratio means greater diversity of land use |
| | Zoned use mix Built | 0.076 | ***0.39*** | Higher ratio means greater diversity of land use |
| Accessibility | Transit Access | ***43.02%*** | 38.75% | Higher % means better access |
| | Parks access | 88.56% | ***100%*** | Higher % means better access |
| | Commercial Access | 20.25% | ***43.79%*** | Higher % means better access |

Table 5.1: Findings Summarized

## 5.1. Findings

The indicators presented in the table paint a clear picture of which development better meets the goals of sustainable urbanism: the Mueller Neighborhood in Austin. Mueller performs better in a majority of the indicators tested for this analysis. This section will outline some of the key findings from these results and present some important areas for future study.

### Land Use Diversity

Mueller excels in the measures of diversity of land use analyzed in this report; In particular, Mueller has a much better mix of built land uses on site. As Figure 9 shows, there is approximately a 60%-40% balance of residential land use to non-residential use as currently built. Stapleton, on the other hand, is almost 90% residential as built. This is a significant difference in residential land use share.

Mueller performs well in the land use diversity built measure due to the large shopping complex on the western side of the development. This complex offers a tremendous amount of non-residential square footage in the neighborhood. It differs from traditional neighborhood stores, which are much smaller due to the smaller population that they are designed to serve. This complex is used by the entire city, not just Mueller residents. Thus, it is not truly a neighborhood retail center. Stapleton has a similar commercial and business complex in terms of size and commercial tenants. However, the effects of this complex on the land use diversity indicator are much lower due to the larger overall area of the Stapleton neighborhood. The share of total neighborhood area dedicated to a shopping center is much lower in Stapleton than Mueller.

Diversity of zoned land use provides some more nuanced insights into the comparison. Mueller has plans for several additional phases of development over the next decade. If these plans are carried out, they will add significantly to both the residential and non-residential buildings. However, within the plans, the proportion of new residential will be much greater than non-residential. With these plans in mind, Mueller should see the diversity ratio decrease significantly over the next decade if the plans are carried out. Zoned land use mix takes into account these important future plans which lower the performance of Mueller; however, Mueller still performs better than Stapleton.

**Neighborhood Density**

Mueller is slightly denser overall than Stapleton. Mueller has smaller average SFDU lots (0.073 acres compared to 0.079 acres) than Stapleton, indicating a more compact development pattern in the neighborhood. Both neighborhoods were master planned from the ground up and were planned to have small, dense lots. This forethought explains the very similar low average block sizes.

Mueller also has a higher residential density. Each SFDU in Mueller uses, on average, less total residentially zoned space than SFDU in Stapleton. This measure includes not only the residential lots, but also the land used by the associated infrastructure such as roads and sidewalks. Analysis reveals that Mueller has smaller lots and less land dedicated to supporting the residential lots. This further supports the finding that Mueller has been able to build more compactly so far.

Despite the significantly worse SFDU results, Stapleton performs better in terms of Net Residential Density than Mueller. This measure looks at the number of units in the area per acre zoned residential, excluding roads and public right of way. Compared to the other measures in this section, this one includes not only SFDU but also multifamily. Including MF greatly improves the performance of Stapleton and has almost no effect on Mueller. This is because the MF units are not yet built for Mueller and Stapleton has many. Overall, this displays the critical importance of multifamily units to improving neighborhood density.

These measures show that both projects exemplify efficient land use. Mueller does so slightly better at this point in development; however, it is important to note the impact that multifamily uses have on measures of density.

**Accessibility**

Both neighborhoods perform similarly in measures of accessibility, with one exception. Mueller performs significantly better in terms of access to commercial space. This is due in large part to the shopping center on the western side of the development as well as the smaller overall size of the community. Mueller has not yet built the proposed mixed use downtown center, so this measure is likely to improve.

Park access is exceptionally high in both neighborhoods. Open space is thoroughly incorporated into the neighborhood fabric, as can be seen in Figures 11 and 12. The neighborhoods both feature a linear network of parks, cutting through the neighborhoods and providing efficient access points throughout. Mueller performs slightly better in terms of park access. The currently built homes are clustered in one southern area of the neighborhood that is currently surrounded by parks. Performance in this measure is likely to change if the neighborhood reaches full build-out.

Stapleton has slightly better transit access than Mueller does currently. The number of transit stops in Stapleton much higher, as is the number of different bus routes. However, Mueller is more compact, so fewer stops provide almost equal access to the current residential units. Based on the location of current stops and routes, the City of Austin will need to expand the network in order to provide access to new segments of the Mueller neighborhood.

**Connectivity**

Connectivity measures are almost identical in both neighborhoods. Both neighborhood developments do not have a single cul-de-sac in the street network and all of the streets are connected without any dead ends. This means that they both have a perfect 1.0 score in terms of internal connectivity. New Urban planned neighborhoods make conscious efforts to avoid creating a poorly connected road network, so this score is to be expected.

External connectivity also presents very similar results. Mueller has a ratio of 0.011 external connections per acre while Stapleton has a slightly better ratio of 0.012 connections per acre. This result is particularly interesting due to the fact that Stapleton appears to have much better external access at first glance. An examination of Image 4 reveals that Stapleton has 41 different neighborhood access points. Mueller only has 8 at present build-out. However, the fact that Stapleton is so much larger makes the ratios for each neighborhood almost identical. Thus, Stapleton only performs marginally better in this connectivity measure.

Residential houses per block measures the total number of blocks in a neighborhoods compared to the number of housing units supported by the block network. Both Mueller and Stapleton perform similarly in this measure. This result makes sense given the high residential density of each neighborhood and the highly-connected street networks. Mueller performs slightly better because it has fewer large, non-residential blocks; which increase the mean houses per block measure.

Additionally, both neighborhoods were measured for average block size. This measure removes the road area from the total area and then divides that area by the number of blocks. It is important to note that this measure takes into account area of all neighborhood blocks, not just residential blocks. This is a critical distinction because both neighborhoods contain large blocks of parkland as well as large blocks of big box commercial. These large land masses raise the neighborhood averages significantly. As the results show, Stapleton performs much better in this measure. Stapleton has an average area of 6 acres while Mueller has an average of just over 13. This appears to be a dramatic difference on paper; however, the important factor is the build-out of each project. Mueller still has two very large tracts of land that will be subdivided into much smaller blocks over the next several years. Once these new, smaller blocks are created the average area should drop significantly. However, we can only measure what is already built and Stapleton outperforms Mueller in this indicator.

## 5.2. Areas for Further Study

After conducting the analysis in this report, some critical caveats and limitations emerged. These limitations offer important opportunities for future study that would greatly enhance the findings of this report. Improved data, standardization of indicators, and a study after Mueller is completed are the three areas that offer the most need for expansion.

Data limitations are a major issue in conducting any spatial analysis. In the case of this project, the limitations were a result of the relative newness of each development. While both Austin and Denver do a good job of keeping up-to-date in their GIS departments, the best data available is from 2011. This is not a major problem for Stapleton because it is a more mature project. In fact, the project is almost at full build-out and should be there in the next 2-3 years. However, this was a major obstacle for analysis of Mueller. Land uses and lots data are only available as of 2010. The specific ways in which the age of the data limited the analysis of each indicator is not entirely known; however, it is clear that the most up-to-date land use data does not match the vision outlined in the Mueller master plan. Similarly, there were issues related to the ongoing construction in Mueller. The author created shapefiles for building footprints in order to conduct the analysis. This was a necessity because as of 2006 (the latest building data for the city), Mueller was almost an empty field. Similar data issues limited the number of indicators that could be accurately compared. Based on the data issues, future research could include an update of important GIS datasets for the City of Austin. This would allow for a more comprehensive comparison of the two sites.

Additionally, there is a need for more comprehensive data in the surrounding towns to Denver. Stapleton sits on the edge of Denver and Aurora, Colorado. Denver has significantly more comprehensive GIS data than does Aurora. While Stapleton is entirely located in Denver, the adjacent areas are important for any thorough analysis. In particular, these data limitations hinder accessibility measures. The author was able to piece together data from a variety of jurisdictions in order to conduct this analysis;

however, Denver would benefit from a more thorough collaboration with Aurora in order to analyze Stapleton in greater depth.

A second area for further research will be a follow-up study on these two sites once Mueller reaches full build-out. Currently, Mueller is in the middle of a multi-phase development plan. Nearly 1/3 of the residential units planned have been completed. However, there are plans for more single family units, multi-family, and a mixed-use town center. If these phases are completed, it will affect the outcomes of all indicator measures. In particular, the downtown center will be a critical change to the neighborhood. A neighborhood center will provide more retail access and likely include extensions to the local transportation network. It is not possible to know if the project will be fully built as planned, changed to a degree, or never finished. However, it is safe to assume that a follow-up analysis upon completion will provide a more holistic comparison of the two projects.

Finally, the analysis and findings also reveal that there is still a great deal of work to be done with indicators. A literature review revealed that there are many different approaches to indicators that measure essentially the same characteristics of urban form. Literature used for this analysis even showed variety in the calculation of individual measures between two reports by the same author. Much of this has to do with the current lack of availability of robust data. However, it seems that if indicators are to become widely accepted, there must be more agreement on how to measure them. Tools are currently being built and tested that do this, yet it is certainly a field that could benefit future analysis.

### 5.3. Conclusions

This report set out to compare Mueller and Stapleton based on the goals of sustainable urbanism. The comparison used a series of neighborhood-scale planning indicators. This analysis revealed several important things about each neighborhood, as well as about the analysis conducted.

One of the most meaningful conclusions from this analysis is the importance of scale. Mueller and Stapleton are two projects of very different sizes. Mueller is approximately 713 acres while Stapleton is approximately 3680 acres. When conducting the spatial analysis it became clear that this had an effect on some of the measures. In particular, the accessibility measures have a lot to do with scale. Mueller has a very high level of transit access from a very small number of bus stops that pass through the neighborhood. Stapleton has similar access, yet significantly more stops and route options. A similar pattern exists for Commercial establishment access. Stapleton and Mueller both have Big Box shopping centers of a similar size; however, one such center provides significantly more commercial access to the smaller Mueller. Additionally, Stapleton has a massive network of parks throughout the entire site. These provide an impressive level of access at 86%, yet this is lower than the access in Mueller from a few, smaller parks and open spaces. Scale has much less of an effect on diversity of land use, density, and connectivity. These measures translate well to neighborhoods of any size.

A second notable conclusion is the importance of compact and clustered residential development to all of the indicators addressed in this paper. Mueller currently has a clustered pattern of residential development. The clustering of residential buildings leads to better indicator access measures than was initially expected. Clustering allows for fewer amenities to reach more residents. Stapleton has a similarly compact development pattern; however the form is less clustered. Residential development in Stapleton follows a pattern of larger blocks with a rigorous grid. Thus, it appears that clustered development patterns may tell even more about the ability of a neighborhood to meet sustainability goals than density measures alone.

Additionally, this report reveals that we will learn much more about sustainability in Mueller once the project is completed. Mueller is only in the early phases of development. The project is yet to tackle mixed-use buildings, multifamily homes, and the neighborhood center. These are the three most controversial phases and the phases that have the most bearing on neighborhood sustainability. If these phases are all completed, the development may perform very differently that it does as currently built.

This paper has already noted that while there are specific site plans for the continued development of the site, all of this is subject to change. Changes may be made based on the market, financing, and any number of other unforeseen future conditions. Thus, it is not possible to accurately project what the future will look like. However, it is clear that comparing Mueller and Stapleton at full build-out will lead to a more robust comparison of sustainability in the two neighborhoods.

The analysis also reveals some of the limitations of a quantitative approach to measuring neighborhood sustainability. Many of the raw numbers make the two developments appear to perform similarly in important sustainability measures. However, these numbers do not account for the quality of amenities and neighborhood assets. This displays the importance of some amount of qualitative neighborhood analysis as a companion to the quantitative indicators. Including this component will provide a more nuanced comparison of neighborhood sustainability.

Finally, this analysis shows that Mueller is doing a very good job of meeting the objectives of a sustainable urban neighborhood. Stapleton is an award-winning example of a sustainable urban development. The plan has been heralded by New Urban planners as a high-quality example of sustainable development and it has served as a model for more recent development, including Mueller. Despite the high praise and recognition of Stapleton, Mueller currently performs better in a number of important sustainable neighborhood indicators. Mueller has currently exceeded the high bar set by Stapleton in a number of critical early indicators. Thus, although Mueller is not complete, the current comparison to Stapleton is very favorable. If Mueller can continue to develop as planned, it should compare well with Stapleton upon completion and stand as a model for future efforts at sustainable urban infill.

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# VITA

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