DEPARTMENT OF PLANNING, PUBLIC POLICY, AND MANAGEMENT

Walkability Assessment of the Trainsong Neighborhood in Eugene, Oregon

Community and Regional Planning Masters Exit Project

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6/11/2013

Abstract

In this report I use the methods from Cerin et al. (2007) to perform a GIS-based walkability assessment of the Trainsong Neighborhood in Eugene, Oregon. I also performed a physical walking assessment of the Trainsong Neighborhood in order to compare the results from the GIS assessment with the current physical state of the neighborhood. I determined that the neighborhood had a high enough density to support walkability, but the street network and land use mix types were not sufficient and there are major physical barriers to walkability in the neighborhood. I suggest that the City of Eugene improve pedestrian connects between streets and sections of the neighborhood and provide incentives to small businesses in locating within the residential areas of the neighborhood. More broadly, I found that the Cerin et al. assessment is better used for multiple comparison studies as opposed to a single neighborhood assessment and that using only a small selection of indicators is insufficient to predict the walkability of a neighborhood given the complexity of the issues.

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Chapter 1 Introduction

Over the last decade the population of the United States has increased from 281.4 million people to 308.7 million people (United States Census Bureau 2011). Western states have seen the highest rate of population growth. These areas of growth have mostly been seen in the urban areas, where four-fifths of the country's population lives (United States Census Bureau 2011). This increase has put a strain on the resources of local and state government agencies to supply services for their citizens. This is especially true as populations have increased the most in the suburban areas directly outside city limits while still using city public services (Kasarda 1972).

This increase in population has not only put a strain on governmental resources, but has also made its impact on the natural environment. The EPA has identified personal automobiles as, "the single greatest polluter, as emissions from millions of vehicles on the road add up." (U.S. Environmental Protection Agency Office of Mobile Sources n.d.). Another consequence of this increase in urban populations is traffic congestion (Department of Transportation Federal Highway Administration 2005). In a composite study by the Federal Highway Administration (FHWA) in 2005, bottlenecks were the cause of forty percent of the congestion occurring on roads. Bottlenecks are described by the FHWA as places where the volume of traffic is too high for the physical capacity of the road to handle. Congestion in cities can have a negative impact on the economic health of the city (Hartgen and Fields 2009) as delays in employee and resource distribution are significantly increased.

The question of how to accommodate population growth with pollution concerns and traffic congestion impacts has been one with which human communities have always had to contend (Ehrlich and Lui 1997). Wherever large numbers of humans occur, these same problems also occur. One method that is currently being considered by the Community Planning profession is that of the walkable neighborhood concept (L. D. Frank 2000). The walkable neighborhood concept revolves around the idea of creating neighborhoods where an individual's entire daily needs can be met within walking distance of their residence. The goal is to reduce the number of motor vehicle trips made per day. The benefits of this type of neighborhood design is that it reduces pollution from vehicle emissions, allows for a more efficient use of land resources, decreases traffic congestion, and can have a positive effect on overall physical health as people become more physically active.

There are four general indicators that have been established for measuring how well areas can function as walkable neighborhoods. Chanam Lee and Anne Moudon describe them in their 2006 article, “The 3Ds + R: Quantifying land use and urban form correlates of walking” (Lee and Moudon 2006). They list the following four categories into which most walkability indicators fall: destinations, distance, density, and route. Destinations are used as an indicator for walkability because they are what prompt people to leave their homes. When people make trips from their homes, they are most likely to go to the nearest destination that meets the reason for that trip. By increasing the number of destination types within walking distance, it also increases the likelihood that a person will walk to that destination instead of driving. Distance plays an important role for the same reason. The majority of people are only likely to walk at most between ten and twenty minutes to reach a destination (L. D. Frank 2000). The third of Lee and Moudon’s “Ds” is density of both population and destinations. Businesses, as destinations, must have a high enough client population to support their economic viability. Businesses that cater to pedestrians must then have enough pedestrians living (or working) within walking distance of them to be economically viable. There must also be a variety of businesses within walking distance of the client population in order to meet the wide variety of daily needs for that population. These types of destinations are: cafes, religious institutions, community centers, convenience stores, grocery stores, department stores, hardware stores, doctor’s offices, libraries, parks, post offices, restaurants, and pubs/bars (King, et al. 2003). The number of available routes to these destinations is also an indicator category. It is the measure of how direct the path is that a pedestrian can take in order to reach a destination. More direct routes are easier and often include shorter distances than complex routes.

These walkability indicator categories can be measured using both quantitative and qualitative methods (Moudon, et al. 2006). In this paper I am proposing to use a walkability assessment tool developed by Cerin, et al. (2007) that is based on indicators that can be represented by spatial data models and analyzed in a geographical information system (GIS). GIS is a method of using specialized software applications to store, organize, and analyze data that can be connected with a geographical location. The indicators that I am using in this assessment are ones that have been shown to correspond with self-reported measures (Cerin, Leslie and Bauman, Applying GIS in Physical Activity Research: Community 'Walkability' and Walking Behaviors 2007). This assessment will be applied to the Trainsong Neighborhood of Eugene, Oregon in order to see how well the assessment can be applied to small urban areas and how it can be used by local governments to make land use decisions in order to promote walkable neighborhoods. It is paired with a walking assessment that I did afterwards in order to compare how an assessment based on a GIS analysis done with a few indicators reflects the actual walking experience within the neighborhood.

This paper is organized as follows. In Chapter 2 I review the major relevant professional and scholarly literature concerning walkable neighborhoods. Chapter 3 is a description of the methods I used for the GIS-based assessment and the walking assessment. In Chapter 4 I present the results of my research. And in Chapter 5 I provide the conclusions from my assessments and recommendations for the City of Eugene and for research on walkability.

Chapter 2 Literature Review

Walkable communities are not a new concept. All communities were walkable by necessity before the prevalence of the automobile at the start of the last century (Southworth and Owens, The Evolving Metropolis 1993). The popularity of the first automobiles was made possible by their affordability to middle class Americans. This allowed the mass movement of middle and upper class Americans out of the crowded cities where air pollution caused by the Industrial Revolution was creating health hazards (Brimblecombe 1967). The automobile allowed residents for the first time to live farther away from their workplace and reduced the need for walking to access goods and services. The increase in automobile use influenced the design layout of the road networks that connected people to places and allowed destinations to be spread out over wider areas (see Figure 1). This was the beginning of the classical modernism movement that shifted how western society viewed space and brought in auto-oriented development into the design of communities during the 20th century. This was also during an important and prolific phase of American infrastructure and community development after World War II. Much of this development is oriented for automobile use, which is often conflicting with pedestrian use needs (Forsyth and Southworth 2008).

	Gridiron (c. 1900)	Fragmented parallel (c. 1950)	Warped parallel (c. 1960)	Loops and lollipops (c. 1970)	Lollipops on a stick (c. 1980)
Street patterns					

Figure 1:The gradual evolution of street network design from 1900-1980 (Southworth and Owens, The evolving metropolis: Studies of community, neighborhood, and street form at the urban edge 1993).

The past few decades have shown a gradual shift in the planning field towards more pedestrian friendly communities (Forsyth and Southworth 2008) as urban planners face increasing problems with traffic congestion and air quality concerns in densely populated cities. This shift is part of the larger movement within development planning called New Urbanism (LeGates and Stout 2011). This trend focuses on applying form based design elements to solve the problems that community planners and architects witnessed in post WWII neighborhoods.

The problem that New Urbanism addresses is, "…the clutter and aimlessness of much development since the mid-twentieth century…" (Porter 2008, 25).

The New Urbanism movement was officially founded in 1993 with the establishment of the Charter of New Urbanism laid out by the Congress for a New Urbanism (CNU) (LeGates and Stout 2011, 356). The CNU was originally composed of urban planners and architects who wanted to see the future of development focused on ecologically sound principles. There are twenty nine principles within the Charter of New Urbanism. The Charter recognizes that the principles behind New Urbanism are based on physical design elements and that these alone do not provide solutions for social and economic problems (Congress for the New Urbanism 2001). The Charter advocates for the restructuring of public policy and development practices in order to support:

- Neighborhoods with diverse populations and uses
- Communities designed for pedestrians, transit, and automobiles
- Public spaces and institutions should be universally accessible and provide physical definition to cities and towns
- The architecture and landscape design of urban places should define them and celebrate their local cultural and natural history. (Congress for the New Urbanism 2011)

The Charter's twenty-nine principles are meant to guide public policy, development practice, and urban planning and design. Of these, ten of them are directly related to promoting walkable neighborhoods through physical landscape design. These are:

1. Development patterns should not blur or eradicate the edges of the metropolis. Infill development within existing urban areas conserves environmental resources, economic investment, and social fabric, while reclaiming marginal and abandoned areas. Metropolitan regions should develop strategies to encourage such infill development over peripheral expansion.
2. The physical organization of the region should be supported by a framework of transportation alternatives. Transit, pedestrian, and bicycle systems should maximize access and mobility throughout the region while reducing dependence upon the automobile.

3. Neighborhoods should be compact, pedestrian-friendly, and mixed-use. Districts generally emphasize a special single use, and should follow the principles of neighborhood design when possible. Corridors are regional connectors of neighborhoods and districts; they range from boulevards and rail lines to rivers and parkways.
4. Many activities of daily living should occur within walking distance, allowing independence to those who do not drive, especially the elderly and the young. Interconnected networks of streets should be designed to encourage walking, reduce the number and length of automobile trips, and conserve energy.
5. Appropriate building densities and land uses should be within walking distance of transit stops, permitting public transit to become a viable alternative to the automobile.
6. Concentrations of civic, institutional, and commercial activities should be embedded in neighborhoods and districts, not isolated in remote, single-use complexes. Schools should be sized and located to enable children to walk or bicycle to them.
7. A range of parks, from tot-lots and village greens to ball fields and community gardens, should be distributed within neighborhoods. Conservation areas and open lands should be used to define and connect different neighborhoods and districts.
8. The revitalization of urban places depends on safety and security. The design of streets and buildings should reinforce safe environments, but not at the expense of accessibility and openness.
9. In the contemporary metropolis, development must adequately accommodate automobiles. It should do so in ways that respect the pedestrian and form of public space.
10. Streets and squares should be safe, comfortable, and interesting to the pedestrian. Properly configured, they encourage walking and enable neighbors to know each other and protect their communities.

(Congress for the New Urbanism 2001)

These ten principles address the need for including walking infrastructure design when planning developments and the encouragement of mixing destinations and residences within a close enough proximity to make walking a feasible method of travel. The CNU recognize that this charter provides only physical solutions and that these alone are not sufficient to solve all of the social and economic problems that urban areas have to contend with. However, they believe that providing a coherent and supportive framework is a critical component of a comprehensive plan to face these challenges (Congress for the New Urbanism 2001).

Proponents of New Urbanism, such as Peter Calthrope and William Fulton, stress the importance of building communities at a human scale, including conservation design elements, and diversity in types of use and populations (Calthorpe and Fulton 2011). Building at a human scale is done to, "…shift away from top-down social programs, from characterless housing projects, and from more and more remote institutions." (Calthorpe and Fulton 2011, 363). Including conservation design elements into the planning process reduces the amount and cost of land, energy, and material resources used in developments. Diversity in the types of land uses and populations is especially important because it brings destinations closer to the people who use them and then these shared institutions can foster a sense of community among all of its members.

The social implications of population diversity is the most controversial of New Urbanisms claims because it is not uncommon for neighborhoods in the United States to be segregated by age groups (M. Doyle 1977-1978), income (Ross, Nobrega and Dunn 2001), and race (Massey 1994). This becomes an especially troublesome problem for New Urbanism because this planning approach only provides suggestions on creating a change in physical environments to foster diversity and not on creating a change in social environment. Segregation is heavily influenced by self-selection behaviors (Iceland, Weinberg and Steinmetz 2002). This criticism of addressing only the physical environment is one that is repeated by many of the New Urbanisms detractors. David Harvey points out that New Urbanism falls into the trap of presuming that spatial order can be used as a vehicle for controlling social processes (Harvey 1997). Harvey also criticizes New Urbanism's lack of will to take on the politics of economy and power that drives social processes like segregation. Ignoring these processes in favor of the built form, Harvey says, "…new urbanism cannot get to the crux of urban impoverishment and decay." (Harvey 1997, 2) Instead the developments that are created out of the New Urbanism movement are developments that can be lacking in social diversity with regards to income since New Urbanist developments often raise housing prices (Song and Knaap 2003) and do not always include low income housing (Calthorpe and Fulton 2011). Jill Grant points out that New Urbanism creates a physically distinct form that will appeal to certain types of people, who will then select to live there. While this does help to foster a strong sense of community, it can also undermine social integration on a larger scale as certain groups are excluded who did not (or could not) select to live in a New Urbanist development (Grant 2007).

Within New Urbanism there are two subcategories that offer different strategies for achieving New Urbanism goals: Transit Oriented Design (TOD) and Traditional Neighborhood Design (TND). The focus of TOD is to create close-knit pedestrian-friendly urban or suburban developments. TND has largely been supported by Andrés Duany and Elizabeth Plater-Zyberk (Duany and Plater-Zyberk 1992) and is a movement to bring back the neighborhood design layouts of the pre-automobile era of the early 20th century. The hallmark of these layouts is that they are designed for mixed-use pedestrian spaces that are planned as a whole community and not piecemealed together. This latter requirement can be difficult to achieve since it requires construction of large developments by a single developer who can plan a community and ensure that the plan is implemented. Currently existing communities find it difficult to achieve this design since they must rely on spot development and infill to make significant changes to their built environment and preservation of existing structures (Porter 2008, 204). Both TOD and TND work together to encompass the principles of New Urbanism and not all New Urbanist developments fall into the same traps that New Urbanist critics have accused them of. Some of the New Urbanist projects in the Minneapolis-St. Paul region have shown a range of success at supporting a mix of social classes and have been built in both “green” field spaces and infill (Trudeau and Malloy 2011). The concern with “green” field development is that it contributes to urban sprawl by developing new land that is generally outside of the built urban areas. This is directly opposed to the Congress of New Urbanisms Charter, which encourages increasing urban densities and conserving resources such as land.

Interest in New Urbanism has not been limited to the field of urban planning and architecture. Economists, geographers, and even the health profession take an interest in this movement because of the impacts that it has had on these other fields. The health field in particular has begun to support the ideal of New Urbanism because walkable neighborhoods have been shown to be positively associate with increases in physical activity, lower rates of obesity, and lower emissions of air pollutants (Frank, Sallis, et al. 2006) (King, et al. 2003). The down side of this is that there are few points of agreement on what the best indictors are to use in identifying walkable neighborhoods and the struggle against the values of classical modernism that created automobile-oriented communities from the last century.

Most of the research that has been done to date on walkable communities has focused on comparative studies to find out which communities perform better for pedestrians. For the purpose of this report I will call this type of study a comparison-within study. A common strategy for these types of studies is to compare structures within the built environment of each community with self-reported walking behaviors of residents surveyed within that community. These results are then compared between the communities to discover which community has a higher population of pedestrians and which aspects of the physical environment encourage walking in one community over the other. There are many indicators of walkability that are used for the built environment, and not all of these comparison-within studies use the same combination of indicators. There are also different strategies that can be used to measure a few of the indicators. The comparison-within basis for these studies and the inconsistent use of indicators are a source of problems for creating a useful walkability assessment tool.

One of the main goals of research should be to create useful knowledge that informs society about a topic (Booth, Colomb and Williams 2008). The results of comparison-within studies are difficult to apply to specific communities because their results are based in the context of another community. These results can only provide information on which community is more walkable than the other. It does not give information on how a community is performing overall at promoting walkability. This makes comparison-within studies less useful to agencies who only need, or want, to asses a single community. In addition to this, the comparison-within studies do not create baseline data that informs researchers of what state the walkability indicators must be in to encourage walking behavior. They can only give better-or-worse assessments in context with another community.

The lack in use of a consistent set of indicators across research projects is the other barrier within the current state of research to creating a useful walking assessment tool for urban areas. There are a wide variety of indicators, and ways to measure them, that are used by different research groups studying walkable neighborhoods. This makes it difficult, if not impossible, to compare the results between studies because they are not using the same measurements. For example, a study that measures walkability by assessing population density, intersection density, and commercial density cannot be easily compared to a study using population density, miles of sidewalk infrastructure, and street tree density. This lack of comparability between studies is a barrier to analyzing the results of all of this work to draw general conclusions of how to promote walking behavior and the roles each indicator plays in this. The role of importance for each walkability indicator would be useful in creating a hierarchy of importance within the range of indicator types. This would be useful in determining which indicators should be used in an assessment and where to prioritize suggestions for making changes in the built environment to promote walking behavior. The result of the lack of a consistent measurements and their importance is that there is not yet a working model for walkable neighborhoods.

There are few indicators that have become more commonly used in walkability studies done in the U.S. and internationally despite the lack of consensus on how to perform walkability studies. Population density is by far the most commonly used indicator (Cerin, Leslie and Bauman, Applying GIS in Physical Activity Research: Community 'Walkability' and Walking Behaviors 2007) (Cervero and Kockelman 1997) (Frank and Pivo 1994) (Frank, Schmid, et al. 2005) (Owen, Cerin, et al. 2007). This highlights its importance to walkability and has even generated enough research that a threshold has been determined for its effectiveness at promoting walking behavior (Frank, Schmid, et al. 2005). The measurement used for population density in most of the research done for walkability has been the ratio of dwelling units per land area in residential use. Land use mix is the next most frequently used indicator (Moudon, et al. 2006) (Cervero and Kockelman 1997) (Owen, Cerin, et al. 2007). The most common measure that is reported for this indicator is a complex calculation called an Entropy Index that was developed by Lawrence D. Frank and Gary Pivo (Frank and Pivo 1994). It is a measure of how well mixed commercial, residential, recreational, and industrial land uses are. One important condition of this measure that is still being debated is how each of these land use types independently impacts community walkability.

Each research paper lists a different series of commercial development as being important destinations or barriers to promoting walking behavior. There are a few that are mostly agreed upon, such as grocery stores (Moudon, et al. 2006). But others are either ill-defined or there is conflicting evidence as to whether they act as a barrier or as a destination for pedestrians. An example of the latter are schools which can be important destinations for day-to-day trips (Cervero, Sarmiento, et al. 2009) but can also act as barriers to pedestrians because they are so large and when there are more than five of them within one kilometer of an particular residence (Moudon, et al. 2006). In addition, while transportation infrastructure is measured in all of the research, the indicators used vary. Rout directness, street connectivity, average block length, and average block size are all commonly used though not always in conjunction with each other (Cervero, Sarmiento, et al. 2009) (Turner, et al. 2011) (Larco 2009) (Owen, Cerin, et al. 2007) (Smith, et al. 2008) (Moudon, et al. 2006). Street connectivity itself can be measured in different ways, though most commonly it is measured by using intersection density (Smith, et al. 2008) (Larco 2009) (Owen, Cerin, et al. 2007). The list of indicators for walkability is long, confusing, and unclear in the level of relevance.

The physical infrastructure ideals of New Urbanism call for cities that are easier and more efficient for pedestrians to navigate. The Charter for New Urbanism gives some general guidelines for what these walkable urban areas look like but it falls short of providing specifics on important details such as exactly how dense street network should be or how many feet long should city block be. It has been up to researcher to build a physical model of what kind of urban street environment will succeed in promoting walking behavior in city residents and visitors. The current state of research in this area is still in the beginning phases of settling on measurements for constructing this model for walkable neighborhoods. There are a few measurements that have emerged that can be used for simplistic modeling purposes. An important barrier to implementing this ideal is that urban areas have already been built to the auto-oriented designs of the last century. Promoting walkable infrastructure in these places requires retrofitting the infrastructure that is already in place. This can be an expensive process for cities who need to make the most out of their budgets. The walkability assessment that I have tested is based on these emerging model measurements and is intended to provide smaller municipalities with a means to assess how well their current infrastructure in a specific neighborhood is performing at promoting walking behavior. The results of this research will inform the municipality on how to assess the neighborhoods how to use the results to enhance the walkability in their neighborhoods.

Chapter 3 Methods

Case Study Background

The Trainsong Neighborhood is located just northeast of Eugene's downtown area (see Figure 1). Highway 99N creates the eastern boundary of the neighborhood and Northwest Expressway creates the western boundary. The western section is also dominated by the presence of busy railroad lines that create a wide barrier to the west of the neighborhood. The neighborhood contains a mix of zoning types (see Appendix B: Trainsong Neighborhood Zones). The zones found in the neighborhood are agricultural, community commercial, heavy industrial, light-medium industrial, limited high-density residential, low-density residential, and medium-density residential. Most of the heavy industrial lands contain the areas that have the railways on them.

Trainsong Neighborhood in Eugene, Oregon

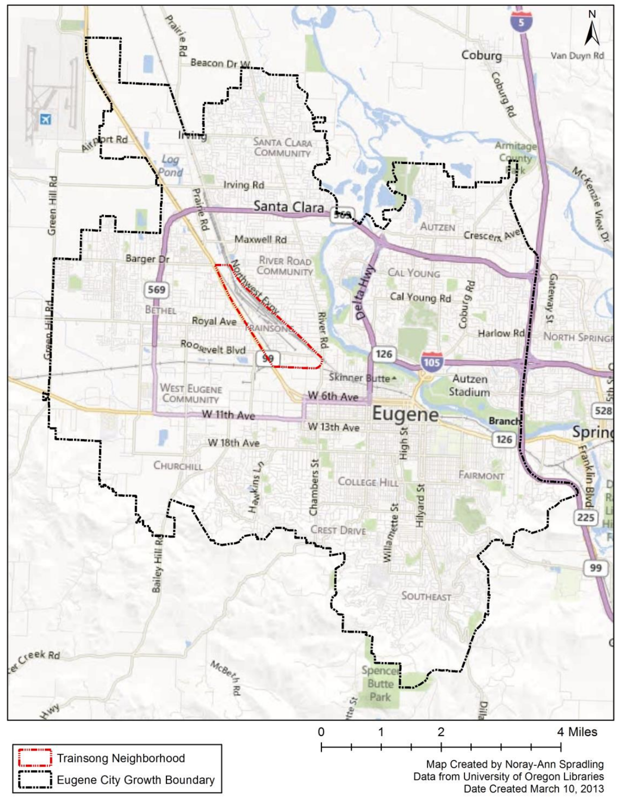

Figure 2 The Trainsong Neighborhood is located northwest of the center of Eugene, Oregon. See Appendix A for a larger image of this map.

According to the 2011 Neighborhood Analysis Report by the city's Neighborhood Services, 1,569 people live within the neighborhood boundaries (Flormoe, et al. 2011). The Hispanic or Latino population make up 20% of the overall population of the neighborhood while the Non-Hispanic or Latin population makes up the other 80%.There is a fairly even distribution of ages and genders within the neighborhood, though the largest group of housing types is single person households. The majority of residents have between a high school degree, an associate's degree, or a bachelor's degree. Seventy one percent of the housing is renter occupied and there have been few new housing units built since 2000. The 2010 U.S. Census identified this census block group as having a median household income of $30,882-34,999 (between 2009 and 2010). Of the renters in this neighborhood, 49% are considered housing burdened. This is using the guidelines from the U.S. Department of Housing and Urban Development which define a housing burdened household as one that pays 30% or more of their annual income on housing (U.S. Department of Housing and Urban Development 2013). Of those who own their houses in the Trainsong Neighborhood, 44% are considered housing burdened. The percent of households that fall below the poverty line is 28% (Flormoe, et al. 2011). With regards to using alternate transportation, only 10% said that they bike or walk to work. The majority of these commutes took 34 minutes or less.

GIS Application

The framework for the GIS section of the walkability assessment that I am using comes from Ester Cerin et al.'s article "Applying GIS in Physical Activity Research: Community 'Walkability' and Walking Behaviors" (2007). In their paper they examined how well certain GIS-based walkability indicators corresponded with measures done with self-reporting. I've chosen to use the GIS indicators from the Cerin et al. article to perform a walkability assessment for the Trainsong because this article shows that there is a moderate to strong association between these GIS indicators and the self-reported measures for determining walkability. The data that I will be analyzing are the tax lot and street network data files that were provided for Lane County from the University of Oregon Library. These two data sets are from 2011, a time since which there has been insignificant development in the Trainsong Neighborhood..

The walkability indicators chosen for this assessment are: intersection density, population density, destination density, and the mix of land use types. Cerin et al. describes the intersection density as a ratio the number of true intersections to the overall study area. They did not give a definition of 'true' intersections, which they use in this article. Other studies have defined intersections for this purpose to be 3-, 4-, and 5-way intersections (Doyle, et al. 2006). The latter definition was chosen because it gave clear guidelines for the purpose of this study. With respect to Lee and Moudon's 3Ds+R theory, the intersection density is a way of calculating distances and route because the intersection density can provide information on:

1. *Shorter Trips*: increases in street connectivity also increase the number of route choices and 'shortcuts' that a pedestrian make when planning how to reach a destination. By allowing a greater number of rout choices, by allowing more streets to take, rout lengths can be shortened since pedestrians don't have to go around as many areas.
2. *Block Length*: more intersections mean that blocks are broken up by more streets, which leads to shorter block lengths.
3. *Destination and/or Population Density*: in areas with a higher intersection density block lengths are generally shorter. This means that the land use is being used at a higher intensity for different types of uses because one use generally only takes up a block or less of space. By increasing the number of blocks in an area, the density of uses can also be increased.

Intersection density is not used to address any of these three things together, but it has been shown to have a strong positive association with walkability (Doyle, et al. 2006). Intersection density was obtained by using Google Maps to count the number of intersections and to ensure the accuracy of the shapefile that recorded usable streets. Some of the streets in the street shapefile from the University of Oregon Libraries had streets listed that were on private property and not open to public use. These streets were not used in the assessment because they were on private property and not formally used by pedestrians. This map can be seen in Appendix C. The density of street intersections was calculated by finding the total number of intersections per area of the neighborhood.

The second indicator that was used from Cerin et al. is a calculation for population density. This calculation is measured in dwelling units per acre of land in residential use. Measuring dwelling unit density in the neighborhood facilitates calculating the distribution of land in residential use and how intensely that land is being. This is part of the density measure referenced in Lee and Moudon's 3D+R. The first step in determining the population density was to identify the tax lots in residential use from the tax lot data set. Images of the neighborhood from Google Earth (Google 2012) were used to verify the use type of tax lots that had a nonstandard classification in the data set. The second step was to determine the intensity of use for these residential lots. Properties that had a single home were counted as having one residential unit. The units of other classifications were counted based on the definitions of this classification in the city of Eugene’s Land Use Code (City of Eugene 1971). Some of the properties required further investigation in order to determine the type and intensity of their use. For these I did an internet search of the addresses to verify how the land was being used. For example, this was how I identified the number of apartment units as part of the calculation of residential density. A map of the resulting distribution of residential units can be seen in Appendix D: Trainsong Dwelling Unit Density. To determine the ratio of units per acres in residential the total number of units were divided by the total number of acres in residential use. This became the measure used for population density.

The fourth indicator from Cerin et al. was not one that had information that was directly accessible. It was a measure of destination density that used the, “average retail ratio of the retail gross floor space to the land area.” (Cerin, Leslie and Bauman, Applying GIS in Physical Activity Research: Community 'Walkability' and Walking Behaviors 2007, 76). The floor area for all of the retail spaces was not provided in the tax lot data. Instead, I used the overall land area for retail per overall land area in the neighborhood. The lots that were in retail use were determined the same way as the residential uses. The commercial uses selected for this purpose were the types of destinations that attract pedestrians (King, et al. 2003). This excluded auto-oriented businesses from the walkability assessment because they do not act as attractor destinations for pedestrians (Moudon, et al. 2006). The Trainsong Neighborhood contains uses such as food stores, restaurants, taverns, and retail stores (see Appendix E: Trainsong Commercial Density). The commercial density was calculated by dividing the total acreage of land in retail use by the total number of acres in the neighborhood. This number was also later used in my calculation for the Entropy Index.

The Entropy Index was the final indicator used from Cerin et al. (2007), and was developed by Lawrence Frank and Gary Pivo in 1994 to determine the homogeneity/heterogeneity of land use mix for a given area (Frank and Pivo 1994). It is important for there to be a mix of use types so that residential uses aren’t segregated form destinations. In this way it is connected to both distance and route from Lee and Moudon’s 3Ds+R determination. Since the destination options are more scattered throughout the neighborhood, the likelihood that one is nearby to any given residence increases overall. This makes destinations more accessible to residents if they wish to walk. Heterogeneous mixes of land use types have been shown to have a positive associating with walkability (Frank and Pivo 1994). To calculate the mix of land use types, all of the acres in the neighborhood were first divided into one of five land use types. The land use types were the same as those used by Cerin et al. (2007): residential, commercial, industrial, recreational, and other. The acreage of each of these types was then divided by the total acreage of the neighborhood in order to determine the ratio of each land use type to the total area. This was already performed for residential and commercial, so I used the same methods to determine industrial, recreational, and everything left over went into ‘other’ category. These calculations were then applied Frank and Pivo’s Entropy Index:

$$\text{Entropy} = -\frac{\sum k(p_k \ln p_k)}{\ln N}$$

In this index, *k* a land use category; *p* is the proportion that I calculated for each category previously; and *N* is the number of land use categories that I used. This Entropy Index is rated on a scale of 0 to 1 where 1 is maximum heterogeneity and 0 is maximum homogeneity. Appendix F: Mix of Use Types shows the mix of uses by type within the Trainsong Neighborhood.

The software used for these calculations was ArcGIS 10 (esri 2011) and Microsoft Excel 2010 (Microsoft 2010). The maps were created in ArcGIS 10.

Walking Tour Application

The next stage of the Trainsong Neighborhood walkability assessment was a walking tour of the area. The goal of this tour was to compare the results from the GIS section of the assessment to what a pedestrian would experience physically walking through the neighborhood. To do this assessment I planned a walking route that would pass through a sampling of the residential neighborhood (See Appendix G for a map of the route). I focused on the residential area of the neighborhood in order to test out how easily local residents could walk from their homes to destinations. During this tour I looked for evidence of the previously identified walking indicators that were either present or absent from the physical design of the neighborhood. The walking tour was done on a warm and sunny Monday afternoon on April 22, 2013. These indicators were based on observations and personal perceptions that are considered to be an important part of the aesthetic and safety appeal to walkable neighborhoods. Neighborhood perceptions are often included in walkability assessments in the literature because they have an impact on walking behavior (K. Gebel, A. E. Bauman, et al. 2010). The observational indicators that I used in my walking assessment were based on both subjective and objective values that have been used in previous research projects (K. Gebel, A. E. Bauman, et al. 2010) (Echeverria, Diez-Roux and Link 2004) (Owen, Humpel, et al. 2004).

The following is a list of the indicators that I used in the walking assessment:

- The presence of sidewalks: were there sidewalks on the roads that we saw while traveling through the neighborhood? *Objective value*
- Observed land use types in relation to land use types recorded in the tax lot data: was the land being used in the same manner that was recorded in the tax lot data? *Objective value*
- The presence of informal pedestrian trails: were there trails made by heavy foot traffic that had worn a path through the vegetation? *Objective value*
- Pedestrian street crossings: were there marked places where pedestrians had the right-of-way to cross the street safely? *Objective value*
- Street connectivity: how many dead-ends or loops were there that made traveling in a straight path or taking short-cuts difficult or impossible? *Objective value*
- Street trees: were there trees along the roadway that provided overhead cover, a barrier between pedestrians and vehicle traffic, and/or an aesthetically pleasing view? O*bjective value and subjective value*
- The feel of the speed of traffic flow: was traffic moving uncomfortably fast along the streets where we were walking? *Subjective value*
- Visual appeal: did the surroundings in the neighborhood reflect a diversity of sights that were interesting? Was the view blocked or obstructed by sights such as blank walls, unsightly fences, or large parking areas? *Subjective value*
- Physical safety concerns: were there threatening situations caused by the physical environment (poor road conditions, overhanging tree limbs, etc.), unattended animals, and individuals with a threatening demeanor. *Subjective value*

Chapter 4 Results

This chapter covers the results of the GIS application assessment and the walking tour application assessment of the Trainsong Neighborhood. The results of the GIS application describe how each of the indicators (population density, intersection density, commercial density, and land use mix) performed for the Trainsong Neighborhood data. The results of the walking tour application cover what walking through the neighborhood revealed about the walkability of the Trainsong Neighborhood.

GIS Application

Population Density:

Then population density that I calculated for the Trainsong Neighborhood was about seven residential units per acre. The threshold measure for population density is 6 residential units per residential acre or more (Frank, Schmid, et al. 2005). Neighborhoods with less than 6 units per acre are not considered to be walkable neighborhoods. In this case the Trainsong Neighborhood is just barely on the walkable scale with regards to population density.

Intersection Density:

The resulting intersection density from this study shows that there are only 0.0000012 intersections per acre in the Trainsong Neighborhood. The threshold for intersections is greater than or equal to 30 intersections per km^2 (Frank, Schmid, et al. 2005), which equates to 0.1214 intersections per acre. Using this standard, Trainsong Neighborhood is severely lacking a high enough intersection density to be considered a walkable neighborhood.

Commercial Density:

The density of commercial use per acre of the Trainsong Neighborhood was 0.02703 acres in commercial use per acre of the neighborhood. This seems like a very small number, and there were only 8 retail areas that I identified in the whole neighborhood as being likely destinations. However, without a threshold to be as standard commercial area density for walkable neighborhoods cannot easily be determined. Moudon et al.'s assessment of significant destinations that attract pedestrians identifies grocery stores, sit-down restaurants, and banks (Moudon, et al. 2006). Using this definition I surveyed the actual types of commercial businesses that are located within the neighborhood and found that there are 4 restaurants, but no grocery stores or banks. I don't consider the Trainsong Neighborhood as having an adequate level of commercial use given the lack of these two important destinations types.

Land-Use Mix:

The Entropy Index that I calculated was 0.54. If 0 is considered a completely homogenous mix of land use types and 1 is considered a completely heterogeneous mix of land use types, then the Trainsong Neighborhood falls on the slightly heterogeneous side. However, many of these land use types are neither destination types nor residential types. There is a significant amount of land that is either vacant or used for industrial purposes. While the industrial purposes may offer some destinations for work, the significant amount of vacant land does not. So even though this does offer some insight into land use mix, it might be good to find a way to account for this variable. This is especially important because much of this vacant land is the section of railroad tracks on the east side of the neighborhood. As seen in Appendix F: Trainsong Mix of Use Types, all of the commercial is along the west side and there are train tracks separating them from the majority of the residences. Another thing that this variable fails to take into account is the barriers that prevent certain land use types from being used by the neighborhood residents. An example of this are the railroad tracks that separate the commercial area running along Highway 99 N from the residential section of the neighborhood. These two areas cannot functionally be mixed together because there is little movement between them.

Walking Tour Application

The results from this walking tour show that route connectivity within the Trainsong Neighborhood is very low and the land use mix is mostly segregated into four sections. The neighborhood can generally be separated into three sections that based on walking accessibility. These sections include the commercial area along the west side the neighborhood, the residential area that composes most of the middle southern portion, the industrial area in the southern section, and the industrial/train yards in the northern eastern section of the neighborhood. The GIS section of the assessment shows that there is a high enough population density to support pedestrian oriented development, but there are few destinations to attract pedestrians that are accessible from the residential area of the neighborhood. The paths that residents would currently have to take to reach current commercial destinations in the neighborhood require a long route that includes walking down to Roosevelt Boulevard and then to Highway 99N. The railroad tracks that run parallel to Highway 99N through the middle of the neighborhood effectively cutoff easy pedestrian flow from residential areas in the east to the commercial areas in the western half of the neighborhood. There are no commercial uses within the main section of residential housing. The Trainsong Park abuts this set of railroad tracks and a few informal paths, such as the one shown in Figure 1, can be seen crossing from the park to the western side of the neighborhood. Unfortunately this is an unsafe crossing that passes through a large ditch and ends at a property that is in residential use. Informal networks of pedestrian paths that are not shown on the street network are difficult to map without intimate knowledge of the neighborhood. Because of this they are not factored in to this walkability assessment.

A similar, though formal pedestrian path also exists at the northern end of the Trainsong City Park where a path and bridge have been built to link the park with the parking lot of the Red Cross facility that is in the northern section of the neighborhood (See Figure 2). Across the street from the Red Cross is a sidewalk that runs down the east side of Bethel Drive from the Red Cross facility to Roosevelt Boulevard. This effectively makes a pedestrian network that links the park with the eastern section of the residential part of the neighborhood. While this is useful, there are no pedestrian crossings from the residential section of the neighborhood to the walking path on the western side of Bethel Drive. Figure 3 shows a typical access point along the walking path. This image shows that there is no pedestrian crossing and the access point is offset from the actual street intersections where pedestrians would be coming from. Figure 4 shows where pedestrians ignore the built access point for a more convenient informal access point.

The states of the roads in the Trainsong Neighborhood are rough and mostly lacking in sidewalks. Figure 5 shows a street that is typical of the residential section of the neighborhood. A lack of sidewalks in the neighborhood forces pedestrians walk with traffic in the street which can be unsafe and can be problematic for pedestrians who have a disability or are elderly.

The road networks within the body of residential neighborhoods should also have more connectivity. There are a few places where streets dead-end into cul-de-sacs, future development in this neighborhood should exclude the construction of cul-de-sacs or require pedestrian pathways at the back of the development that connect the cul-de-sac to streets on the other side.

Figure 3: An informal path on the west side Trainsong City Park. This path connects the residential section of the neighborhood with the commercial section that runs along Highway 99N. However, there is a residential use on the opposite side of the train tracks from the park.

Figure 4 A pedestrian bridge at the northern end of the Trainsong City Park that connects the park with the Red Cross facility.

Figure 6: An access point along the walking path that runs along the opposite side of Bethel Dr. from the residential area of the neighborhood. Note that this access point of offset from the street intersection in the upper left corner of the picture.

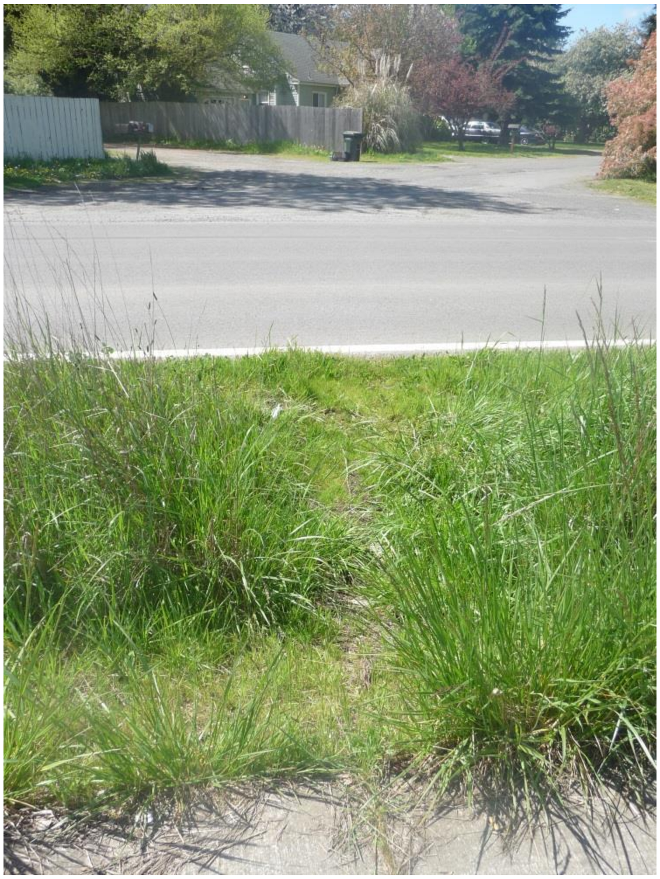

Figure 5: This is an informal pedestrian path where pedestrians are choosing a more convenient access point to the walking path along Bethel Dr.

An example of this can also be seen in Figure 5. There are many streets and allys such as this throughout the neighborhood. Some of these streets become dead ends sooner than this one. Another example that can be seen in Figure 5 is the poor condition that many of these streets were in. Figure 6 shows a section of the street along the pedestrian way that is beginning to crumble. Streets such as these are unappealing to pedestrian because these conditions are hazerdouse to walk over and the alternative is to either walk further into the street or onto private property. Elderly, disabled, or otherwise concerned pedestrians can be the most sensitve groups to conditions such as these that create unstable walking conditions.

Stable walking conditions and sidewalk infrastructure must also be coupled with protected pedestrain crossings to create a safe pedestrian atmosphere. The lack of protected street crossings was evident at every street intersection in the Trainsong Neighborhood. This was especially problematic when trying to cross Bethel Drive to access the pedestrian path. The pedestrian pathway that runs the length of Bethel Drive lacks formal pedestrian crossings to connect it with the residential neighborhood that it is supposed to serve. As mentioned before, there are some cut-outs along the path that act as access points, but these are all oddly offset from street intersections where pedestrians would be using them and there are no signals for vehicles that there may be pedestrians crossing in this location. This can be dangerouse since Bethel Drive is a fairly straght and narrow road with no shoulder and a speed limit of 35 mph (See Figure 7). In 2005 Proffessor Per Gårder, from the Department of Civil and Enviromental Engineering at the University of Main, analyzed pedestrian crash statistics in Main to determine if there were common features of the street environment that might indicate unsafe conditions for pedestrians (Gårder 2004). He found that serious pedestrian crashes most often occur in places where the roadway is wide, level, has no visual impedements, has no control devices, and the speed limit is 35+ mph. These are all features that describe Bethel Drive.

Likewise, Roosevelt Blvd also created a barrier to pedestrian circulation within the neighborhood because it has only one pedestrian street crossing (See Figure 8) and no stop lights along the one mile streatch from Highway 99N to River Road. This section of Roosevelt has heavy traffic that includes both passenger vehicles and industrial vehicles that service the industiral areas in the southern section of the neighborhood (See Figure 9). An intial drive through the southern industrial section of the neighborhood showed that it was too active with large trucks and machinery to be a safe walking environment for the walking assessment. This may be a walking destination for residents who live in the Trainsong Neighborhood, but there are only three safe access points for pedestrians to reach this part of the neighborhood.

Figure 8: The street intersection between Haig Street and Goodyear Street. Goodyear St. is in poor condition and there are no sidewalks. It also leads to a dead end.

Figure 7: An example of the poor condition of the street networks that can be hazardous to pedestrians. This image is of a spot on Wilkie St facing north.

Figure 7: Bethel Dr. is a straight road with a speed limit of 35 mph. Vehicles regularly go well above the speed limit and there are no pedestrian crossings for pedestrians to cross from the residential areas over to the pedestrian path on the opposite side of the road.

Figure 8: The only protected pedestrian crossing in the Trainsong Neighborhood is along Roosevelt Blvd.

Figure 9 The railroad crossing on Roosevelt near Highway 99N where pedestrians must cross the railroad tracks along with vehicles. This crossing creates an ambiguous section of the sidewalk since the sidewalk is forced down to the same level as the street. This leads to the feeling of walking in traffic across the railroad tracks.

Figure 10: This fence that abuts the pedestrian path along Bethel Dr. is unsightly and creates an uncomfortable environment for pedestrians.

The aesthetic appeal of walking through the Trainsong Neighborhood varied greatly depending on the area of the neighbohood. For the most part the residential area was vegetated with landscaping. Some of the streets were populated with more street trees than others. The down side of this was that a few of the trees grew too close to the road and forced pedestrians further out into the roadway. The pedestrian path along Bethel Drive has been planted with a variety of street trees. There are a few places along the path where unsightly structures create an unpleasent environment. The chainlink fence in Figure 10 is not only unsightly, but it also exposes an uninteresting view of an industrial yard, and can leaves only a few feet of space for pedestrians who are enclosed between a fence and a busy street.

In summary, the GIS-based application assessment revealed that the population density of the Trainsong Neighborhood is high enough to support a walkable neighborhood, but the other indicators (intersection density, commercial density, and land-use mix) do not. The walking tour application assessment revealed that the Trainsong Neighborhood is lacking in pedestrian infrastruture and safety considerations while still providing some aesthetic appeal.

Chapter 5 Conclusions & Recommendations

Recommendations for Walkability Assessments

Creating a walkability assessment requires a model of a walkable neighborhood to use as a standard for comparison. The model that I used, including threshold values and standards for commercial use types, worked adequately for assessing a small neighborhood, but including other indicators such as the ratio of sidewalks to road infrastructure would improve the model. Testing the model with both a GIS-based assessment and a walking assessment was critical for the success in this experiment. I recommend future assessors perform the walking assessment first in order to inform the GIS-based assessment, as it would help the practitioner decide which indicators should be used in the GIS-based assessment. It is important to narrow down the list of relevant indicators before starting the GIS-based assessment because the high volume of information that is available within GIS analysis can slow down the assessment process. The results of the GIS-based assessment should be used to bolster the results of the walking assessment. Another benefit of doing the walking assessment first is that can reveal what some of the limitations may be to the GIS-based assessment. This would have helped avoid problems like the one in this assessment involving the indicator for land-use mix.

The planning literature does not explicitly state a hierarchy of importance for the indicators to use in a walking assessment. However, I believe that Abraham Maslow’s Hierarchy of Needs (Maslow 1954) can give insight as to which indicators might be most effective in a walking assessment, and provide some guidelines for creating a hierarchy of importance. Maslow’s Hierarchy explains that humans are motivated in order of importance first by physiological needs; then by safety needs; belongingness and love needs; esteem needs; and, finally, self-actualization needs. Meeting the infrastructure requirements for these needs in order of importance is the most effective way for a municipality to motivate its residents to walk more. Based on Maslow’s hierarchy, the hierarchy of importance (1 being the most important and 5 being the least) for walking indicators would be:

1. Physiological needs for walking
    a. Sidewalks
    b. Close destinations: grocery stores, restaurants, coffee shops, banks, etc.

2. Safety needs for walking
    a. Safe pedestrian crossing areas
    b. Safety from crime
    c. Barriers between pedestrians and automobile traffic
    d. Slower traffic speeds
3. Belongingness and love needs for walking
    a. The walking culture of the neighborhood (do people view it as something normal that other people do in their neighborhood?)
    b. Welcoming environment of the street space (is it aesthetically pleasing?)
    c. Opportunities for neighbors to meet outside of their homes
4. Esteem needs for walking
    a. Pride in being a pedestrian
    b. Sense of accomplishment from walking to and from destinations
    c. Reward programs for people walking to and from destinations
5. Self-actualization
    a. The amount of pleasure that pedestrians derive from walking
    b. A sense of acceptance and fulfillment derived from walking

It is most important for municipalities to focus on the first two indicator groups in order to establish a healthy walking environment. These indicators should form the foundation of the first assessments in each neighborhood, and future community building efforts in these areas can help to encourage these indicator groups.

The walking assessment and GIS assessment would also be bolstered by including a survey of the neighborhood residents to uncover hidden barriers that may not be otherwise evident. The Neighborhood Environment Walkability Scale (Saelens and Sallis 2013) is a self-administered survey that has been tested and found to be effective for understanding the walking environment of the neighborhood from the outlook of the residents (Cerin, Saelens, et al. 2006) (K. Gebel, A. E. Bauman, et al. 2010) (Gebel, Bauman and Owen 2009). It is important for the municipality to survey the views of the residents because the residents have more experience in the neighborhood under a greater variety of conditions which may affect the overall walkability of the neighborhood.

Recommendations for the Trainsong Neighborhood

Both natural and governmental resources have been under pressure to keep up with the demands of population growth. In 2012, U.S. oil demand per day was 18.65 million barrels and it is expected to continue rising (Bird 2013). Last year alone, the Department of Transportation spent $73 billion dollars on road infrastructure that was largely focused on automobile use (Hargreaves 2013). This is less than half the total budget that is spent on transportation, the rest comes from state and local funding sources. The high cost of automobile use is not just limited to these two examples. Also factoring into this price tag should be the cost of automobile production, raw materials, and degradation of air quality.

In the past twenty years there has been a growing focus on finding alternatives to fossil fuel consumption and automobile use (Holmes and van Hemert 2008) (Cervero and Kockelman, Travel demand and the 3Ds: Density, diversity, and design 1997). This has sparked the latest trend in the study and design of twenty minute neighborhoods, such as those seen in sections of Portland (City of Portland 2013) and other cities around the world (Owen, Cerin, et al. 2007). The City of Eugene has also recognized the value of supporting alternative transportation methods within the city. This can be seen in the effort put forth to create an extensive bicycling route throughout the city and an effort put forth to collaborate with the Lane Transit District to support public transit. Recently the city has begun to assess its walkability in a generalized Walkability Assessment (City of Eugene n.d.).

Unfortunately, the city does not have the resources to do an in-depth analysis of all of its neighborhoods and in order to determine how best to address the needs of each neighborhood. An analysis of the Trainsong Neighborhood is the start of this process of assessing the state of the city's neighborhoods, and make decisions about what can be done to encourage the development of walkable neighborhoods. This process is further hampered by the lack of consensus in the academic field on which walkability indicators should be used and in applying them to a single neighborhood and not in comparison with other neighborhoods. Currently identified indicators should be organized into a hierarchy of importance. The relationships among the indicators, as well as between indicators and their social and physical environment, should also receive more attention. An example of this is the problem in this assessment with the land use mix indicator. This indicator did not proved to not be as useful because there were major physical barriers isolating land use types in the neighborhood that were not taken into account when using the entropy index to determine the degree of land use mix. Despite this, there are still recommendations that can be made for the City of Eugene to improve the walkability of the Trainsong Neighborhood.

Current zoning in residential areas is a mix of Low-Density Residential (R1), Medium-Density Residential (R-2), and Limited High-Density Residential (R-3) (City of Eugene 1979). There are restrictions for allowing uses in these zones that are similar to those for Neighborhood Commercial Zoning (C-1). In R-1 zones they are permitted but require a Planned Unit Development (PUD) to be approved by the city (EC 9.2741(7)). These uses must be targeted for residences in the local area. In R-2 and R-3 zones this is also permitted with and approved PUD or with an approved conditional use permit (EC 9.2741(8)). There are more standards for approval in the R-2 and R-3 zones that address building and site design standards.

In order to encourage more of a land use mix to occur within the Trainsong Neighborhood, the city can make the process for applying for conditional use permits or PUDs easier. This effort would be targeted for uses that are pedestrian oriented and serve the needs of the local neighborhood populace. Commercial developments in the C-1 zones are subject to EC 9.2151(1) Small Business Incentives. The Eugene City Code excludes this in R-2 zones (EC 9.2741(8) (b)), but perhaps this can be expanded for use in residential areas in order to attract more small businesses. This should be especially targeted at new developments on sites that are currently vacant or being under used. There are many tax lots within the neighborhood that fall into these two categories.

The most critical change that needs to be made for the Trainsong Neighborhood is the inclusion of sidewalks, street repair, and safe pedestrian crossings within the neighborhood. Pedestrians are not likely to walk if they do not feel safe in the space that they are walking in. Adding safe crossings has been shown to increase pedestrian use (Turner, et al. 2011). Without the infrastructure to create that sense of safety, the other indicators for walkability will have little meaning.

Areas for Further Research

The area of research surrounding the concept of walkability has come a long way since New Urbanism adopted the concept in 1993. Researchers from multiple disciplines have worked together and independently to identify indicators in the physical environment that promote walking behavior. Some studies, such as the Cerin et al. study that I used as a basis here (Cerin, Leslie and Bauman, Applying GIS in Physical Activity Research: Community 'Walkability' and Walking Behaviors 2007), are comparison-within studies between two or more neighborhoods. This style of research requires that two neighborhoods undergo the assessment and the results of the study be reduced to deciles for comparison. Deciles are a form a descriptive statistics where nine values for each comparison group are divided into ten equal groups based on the distribution values. These results in each value can then be compared between the study groups.

Such studies are limited in ascertaining how neighborhoods perform in relation to each other and not their walkability as a whole. For example, performing such a study can only indicate if a neighborhood is more walkable than another, but how well the neighborhood functions as walkable area in general. It also requires performing multiple studies with comparable neighborhoods, which can be resource intensive and difficult to perform. For this reason comparison studies are not as helpful in creating walkability assessments that can be used on individual neighborhoods to identify areas of improvement that would encourage walking behavior. Devising recommendations for individual neighborhoods should be done using a single assessment that relies on indicators whose thresholds for inspiring walking behavior is known. The number of indicators that have thresholds is currently limited, as, for example, I was not able to find one for commercial density. Future research should be done to find more of these threshold points at which these indicators should be in order to influence walking behavior.

Another area of further exploration is how the indicators should be used and what their interactions with each other are. Some studies use many indicators (Pikora, et al. 2003) while other use just a few (Gebel, Bauman and Owen, Correlates of Non-Concordance between perceived and Objective Measures of Walkability 2009). The problem with using just a few indicators is that there has been little research done on how these indicators interact and which ones have more influence over the others. In ecology, there is a concept of keystone species, where the activities of one species in some way or another impact the survival of the entire ecosystem (Cain, Bowman and Hacker 2008). Identification of key stone indicators for walkability would make it easier for new groups to create studies and to allow better comparison between studies. Part of identifying these key stone indicators would also help in understanding how indicators interact with one another it was apparent in this study that there was a lack of understanding in how connectivity and land use mix were related. The land use mix result that I got for the Trainsong Neighborhood indicated that it was moderately well mixed, but this is not the case since there are major physical barriers that isolate the usage types (the railroads and Roosevelt Blvd.). My results may have been skewed had I not taken into consideration these barriers. There is opportunity within the research field to further explore how indicators interact and in what ways this should be included in walkability assessments.

While there is still a large amount of work to be done the research field in walkability has made good headway in the last twenty years. The identification of so many indicators, and the budding interest in finding thresholds for them has been encouraging. Another good sign is the diversity of fields that have taken an interest in this subject. Their interest opens up the possibilities for a cross disciplinary approach to walkability and highlights the range of benefits that walkable neighborhoods have to offer.

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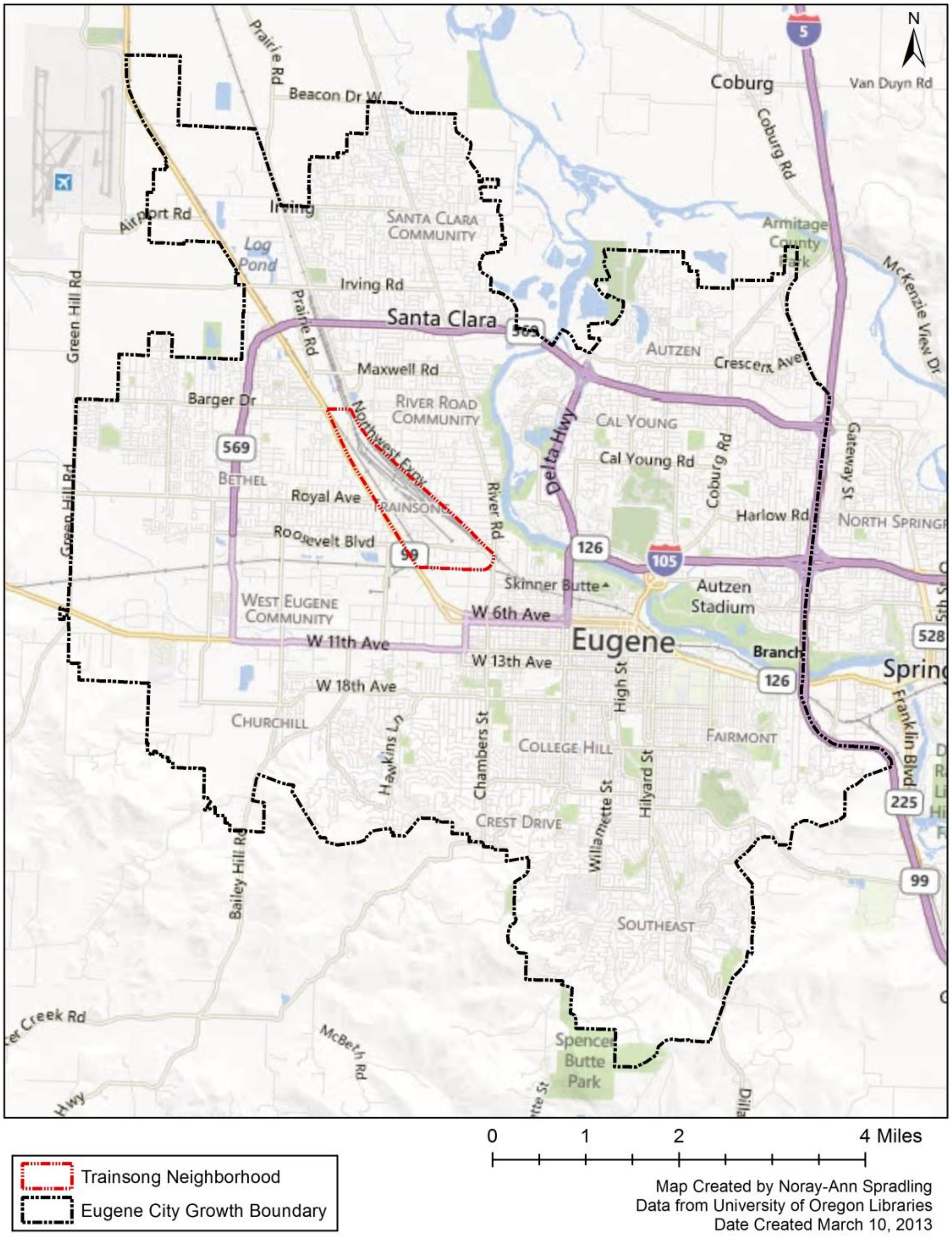
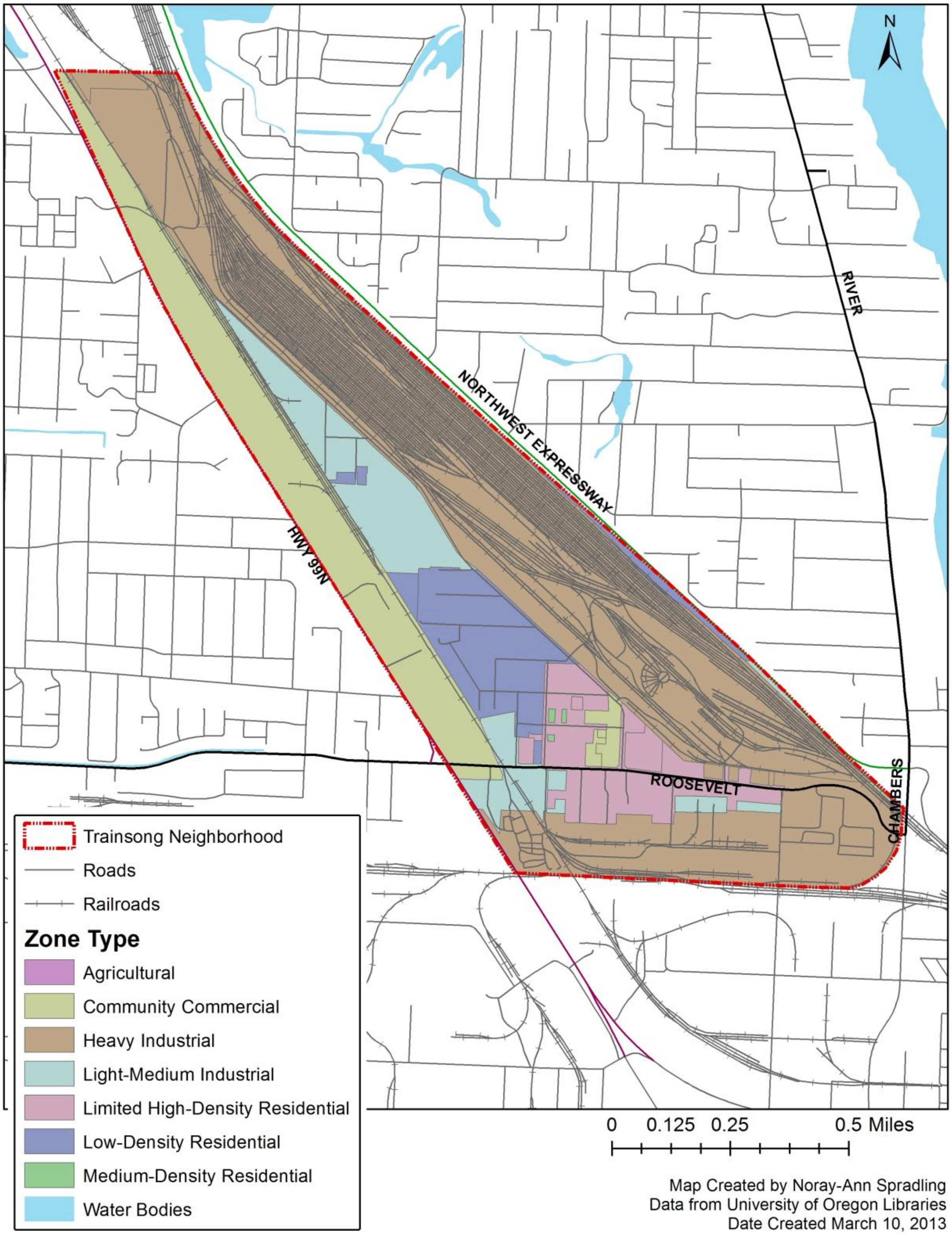
Appendices

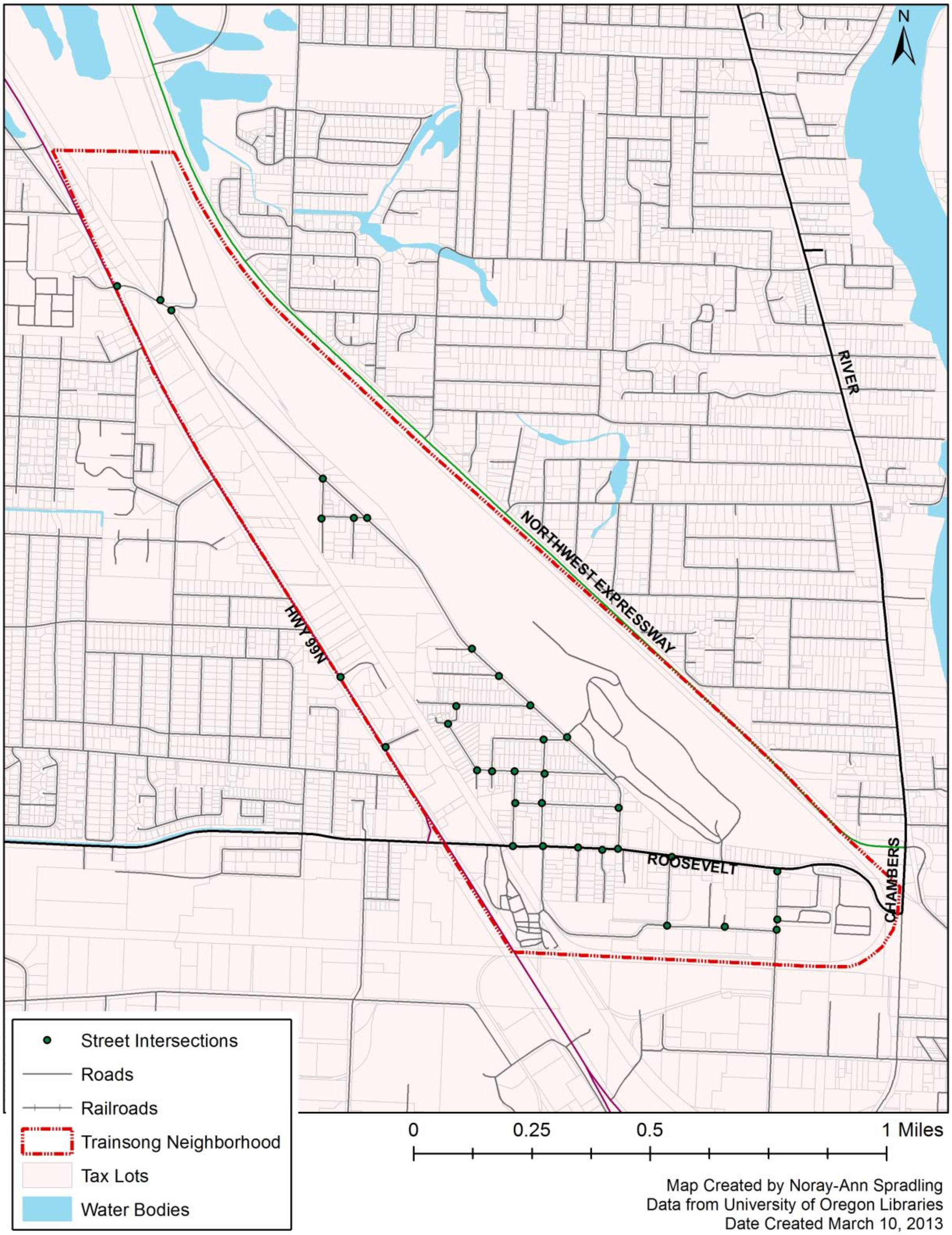
Appendix A: Trainsong Neighborhood in Eugene, Oregon



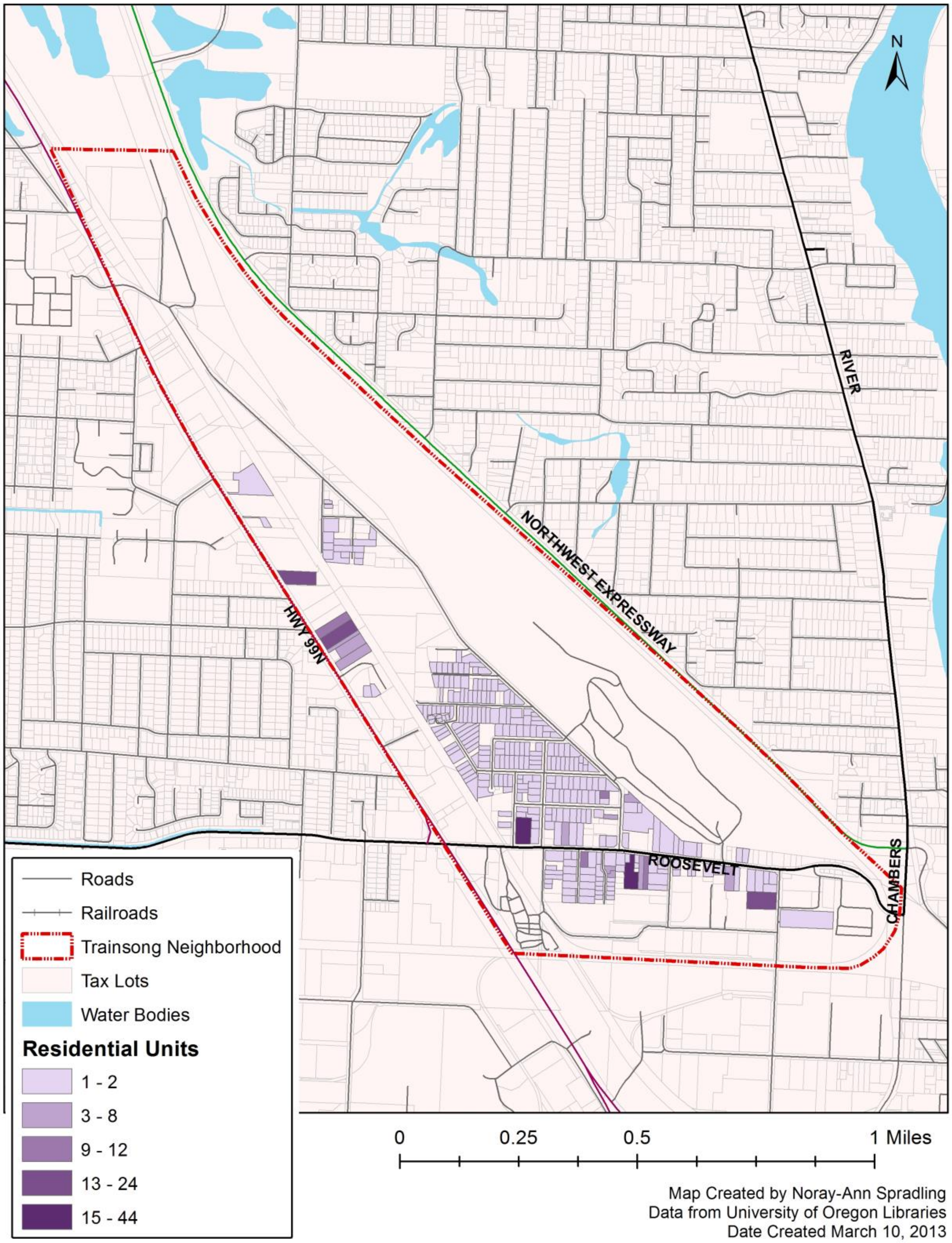
Appendix B: Trainsong Neighborhood Zones



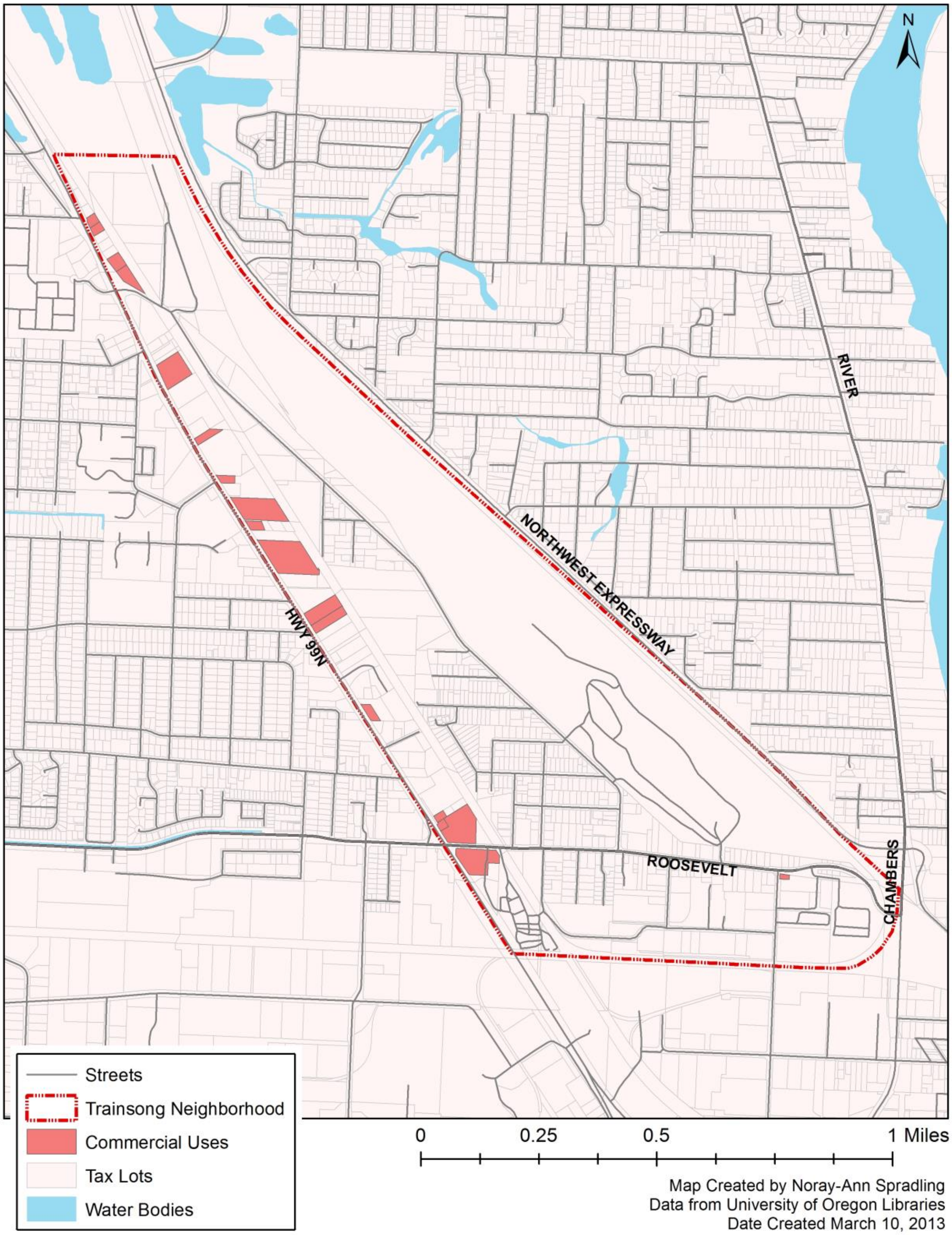
Appendix C: Trainsong Intersection Density



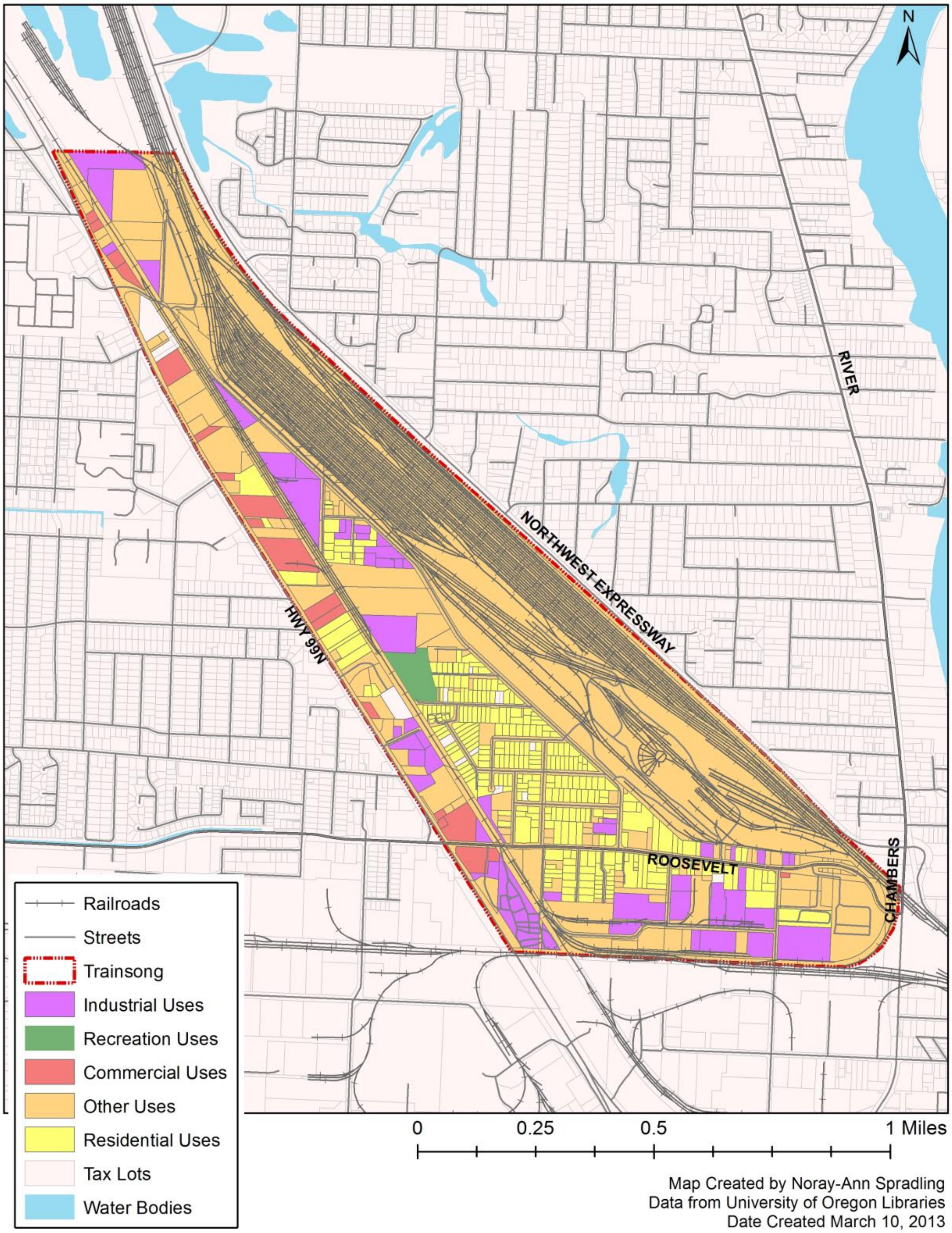
Appendix D: Trainsong Dwelling Unit Density



Appendix E: Trainsong Commercial Density



Appendix F: Trainsong Mix of Use Types



Appendix G: Trainsong Walking Tour Route