Evaluating people's accessibility to public parks using Geographic Information Systems: A case study in Ames, Iowa

by

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This thesis has been prepared for the partial fulfillment of the Master's Degree in Community and Regional Planning. It represents series of steps taken to understand the concepts of Geographic Information system and how such systems could be used in public decision making such as providing equitable public park facilities in a city.

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ABSTRACT

Research on urban service delivery, such as transportation services, medical services, park and recreation services, employment services, etc. has proliferated during past few decades. These research deals with who are the disadvantaged, where they are located and what type of characteristics do they have in terms of socio-economic and demographic profiles. This study gives particular attention to empirical studies and presents a method for drawing conclusions about spatial equity in distribution of services. The methodology presented is a step by step approach of using Geographic Information System (GIS) and Spatial Analysis that is easy for adoption by any public authority. A case study of the spatial distribution of neighborhood and community parks in Ames, Iowa is presented here. In addition to the traditional methods such as container approach (counting the number of facilities in an aerial unit), radius method (buffering a standard walkable area around the park), and creating thiessen polygon as service area of parks, the study considers a potential measure of distance to the nearest park as indicators of accessibility.

Local indicators of spatial association within exploratory spatial data analysis are used to study the spatial distribution of need and accessibility. Raster Analysis is performed to identify neighborhoods in Ames that have high need and high accessibility and high need and low accessibility. The future locations of the parks are then evaluated. The results from the analysis show that there are some neighborhoods in Ames, where the need for public parks is higher, but the accessibility to parks is low. These are the critical areas that public decision makers need to focus on. Similarly, there are neighborhoods with higher needs and having higher accessibility to parks. These are the areas where Ames Park and Recreation Department has provided adequate park facilities. The future locations of the parks in the South, and Southwest of Ames are effective as some neighborhoods in these parts of Ames have been identified as having high need for park but currently have low accessibility to parks.

CHAPTER I: INTRODUCTION

1.1 BACKGROUND

Parks and Recreational facilities are essential to communities because they serve the dual purpose of providing leisure facilities for the residents as well as maintaining the ecological environment. Such elements make good use of urban land and improve the quality of life of the residents. Parks can provide residential opportunities and attractive views for residents and, at the same time, impact residential property values and the environment. Proximity to different types of parks has a significant effect on housing prices, that is, value of housing varies with respect to the park size and amenities in the vicinity (Espey & Owusu, 2001). Parks and recreational services should be easily accessible to people regardless of their location, financial resources and limitations or physical ability (Nicholls, 2001). However, park location is mostly the function of land suitability and availability rather than an assessment of need and accessibility of the residents in the area.

The importance of the provision of public parks and other open space in urban areas was first recognized by planners in the nineteenth century. People like Fredrick Law Olmstead and Ebenezer Howard emphasized the need for open spaces and parks in the design of cities. This concept of parks and open space has been growing forward. Parks were advocated by Olmsted and Howard as a means of refreshment of the mind and nerves which most city dwellers greatly needed. Today, the advantages of urban open space have been more specifically identified and the benefits of parks and open spaces serve to increase both the ecological stability and the social livability of urban areas. Such facilities are, therefore, typically regarded as desirable components of metropolitan regions (Nicholls, 2001).

Planners are now beginning to use accessibility measures as a way of evaluating the availability and quality of public services, such as parks and recreation, transportation and health services, at the neighborhood level (Handy & Clifton, 2001). Sister (2006) states that "while the benefits and values of parks are well recognized, such resources are not always equitably distributed across communities" (p.2).

Studies about accessibility and equity in distribution of public facilities help us understand whether there is adequate supply of urban services in certain areas. Such studies can then inform decision makers and impact decisions about where to locate new services for disadvantaged populations living in neighborhoods that are less equipped with urban services such as parks. According to Apparicio and Séguin (2005), easy access to public resources can make a considerable difference in peoples' daily lives. They state that proximity to facilities like a municipal library, a community center or a well equipped park can make a difference to the daily living condition of a neighborhood's residents.

Many cities now have an objective to provide an ideal system of parks, natural resources and recreational opportunities to their citizens. Theoretically, parks should be easily reachable from every neighborhood and usable by all citizens. However, cities seldom provide this kind of equity in their park and recreation plans; instead park distribution is subjected to land availability and funding acquisition (Williams, 1981). Therefore, there is a growing need to examine accessibility to parks and recreation plans in order to verify their equity and distribution. Study of accessibility is important because policymakers need to emphasize such critical issues. It is important for public service providers to ensure that all people have access to recreational services in their area. Future developments need to be planned by considering the need for and accessibility to public facilities in communities.

Sister (2006) in her study illustrates the need for examining the "supply of parks and park resources and how these match up to the need/demand of the population" (p. 2) for addressing the existing inequities as well as implementing equity in distribution for future locations.

Thus, research on urban service delivery, such as transportation services, medical services, park and recreation services, employment services, etc. has proliferated during past few decades. These research deal mostly with who gets what and why, who are the disadvantaged, where are they located and what type of characteristics do they have in terms of socio-economic and demographic profile. The study presented here gives particular attention to empirical studies and illustrates a method for drawing conclusions about spatial equity in distribution of park services. Through an application on the Parks System in Ames, Iowa, the study demonstrates the use of Geographic Information Systems (GIS) in measuring the accessibility and need for public parks in a city. The study offers measures for accessibility and need for the public parks in Ames, and identifies the poorly served areas with a high need for parks, and areas with high need as well as high accessibility. The results are then discussed along with the Parks Master Plan of Ames, and the future locations.

1.2 ACCESSIBILITY AND EQUITY

Although parks and open space are now considered fundamental to the livability of cities and neighborhoods, "in many U.S. cities there exists a widely perceived deficit of parkland" (Wolch *et al,* 2005, p.4). Geographical unevenness in the distribution of such amenities is now recognized as a major problem in planning by urban geographers and community planners as well as urban residents. Such unevenness in distribution is considered to be an important indicator of environmental injustice. Studies and research on accessibility are now more focused towards understanding the social and cultural dimensions of accessibility in addition to the physical dimensions emphasized in earlier studies (Lindsey *et al,* 2005).

Many authors and researchers dealing with accessibility and equity in distribution of services have defined accessibility in their studies. Lindsey *et al*, (2001) states that "equity and accessibility can be defined in a number of different ways, and the definitions that are chosen may influence the outcomes of the investigation" (p. 334). Talen (2003) defines accessibility as the ease with which a resident can reach a given destination and service to satisfy their different needs. According to Handy and Clifton (2001), accessibility reflects the ease of reaching needed or desired activities and thus reflects characteristics of both the land use system, where activities are located and the transportation system, how the location of activities are linked. Zhu *et al,* (2005) states that accessibility is concerned with the opportunity that an individual at a given location possess to participate in a particular activity or set of activities.

Accessibility analysis has a wide range of application, particularly in planning public facilities and services as well as planning for medical, residential and other services. Talen (2003) illustrates that these days, because of the growing interest towards accessibility measurements and the importance of social equity, "accessibility is not conceptualized as an issue of private mobility but rather is taken as a community wide public problem" (p.181).

Accessibility can be measured in variety of ways. Accessibility is usually measured in terms of travel distance, time, cost or a combination of all. Accessibility is assumed to be higher when less time and money is spent in travel and more activities are reached in a given amount of time (Zhu *et al*, 2005). Table 1 presents different accessibility measurement approaches that are commonly used by researchers in planning. Talen (2003) states that at the neighborhood scale, accessibility is evaluated on the basis of walking distance to destinations such as parks, schools and retail outlets. Even though many park and recreation plans still apply the traditional population area method, scholars argue that this approach does not consider the social and economic characteristics of locations (Talen, 1998; Nicholls and Shafer, 2001).

Table 1: Accessibility measurement variations: approaches (Talen, 2003)

Approach	**Definition**
Container	The number of facilities contained within a given unit (e.g. census tracts)
Coverage	The number of facilities within a given distance from a point of origin.
Minimum distance	The distance between a point of origin and the nearest facility
Travel Cost	The average distance between a point of origin and all facilities
Gravity	An index in which the sum of all facilities (weighted by size) is divided by the 'frictional effect' of distance.

Nicholls (2001) states that "levels of access to public parks are an important indicator of the effectiveness of their provision" (p. 201) and the equity provided by their location is a central concern of public recreation providers. However, Talen (1997) argues that the question of whether or not such facilities are distributed equally remains unresolved. That is why emphasis has been placed upon the researchers to ensure that there is an equitable distribution of social resources and to define equity (Apparicio & Seguin, 2005).

The need for places that people feel comfortable using is now recognized as central to both effective urban planning and the detailed design of the public realm. The concept of "socially just communities" introduced by Beatley and Brower (1993) emphasizes equal concern for all the citizens irrespective of their socioeconomic status. Thus "a socially just or equitable community is one in which all individuals and groups are treated fairly" (Beatley and Brower, 1993, p.18). Specifically, it requires that all the citizens receive access to an acceptable minimum level of basic public facilities and services (Nicholls, 2001).

In the last thirty years, scholars have presented a range of research, papers and reviews analyzing the accessibility of particular services in specific cities (Nicholls, 2001; Talen, 1997). All of these studies have provided useful insights to the application of public accessibility. While some of these studies have concentrated on the location of facilities and levels of access to them, others have delved into the analysis of their distribution in relation to the socioeconomic and demographic characteristics of the population they serve.

However, because of the variety of methods used and differing results, such studies cannot be generalized or compared. As "the issue of equity is likely to become more important as the population continues to increase and public resource become scarce" (Wicks, 1987, p.9), attempts to derive a proper methodology to measure the equity concept are thus required. Talen (1997) states that "while research dealing with urban service delivery has proliferated during the last few decades, few studies have directly linked the spatial distribution of facilities, in the form of accessibility measures, with the spatial distribution of population subgroups in an effort to assess equity issues" (p. 521).

Though the use of GIS in public planning and management has increased over the past decade, Nicholls (2001) argues that "its adoption within the field of leisure services appears to have been relatively limited" (p. 201). Wicks *et al.* (1993) highlight some potential applications of GIS for park management and planning; however, they assert that the lack of enough literature about GIS use in leisure studies dictates the need for further research of such potentials. Nedovic Budic' *et al* (1999) focus on explaining the methods available within a GIS environment to assess the levels of accessibility and equity of urban leisure facilities. The authors compare the straight line and network measure of distance on the interpretation of their results. Talen (1997) offers a methodological approach as well as an empirical assessment of equitability in facility distribution. Utilizing data on parks in Pueblo, Colorado and Macon, Georgia, Talen analyzes the equitability of park distribution by comparing the spatial clustering of park access scores with spatial clustering of selected socioeconomic variables. Werner (1998) examines the equity implications of cutting a public bus route in Ramsey County, Minnesota, in terms of the characteristics of the portion of population effected.

Kwan *et al,* (2003) reflect on some of the recent advances in accessibility research and how they could be implied for future studies on accessibility and social equity. Thus, there has been some research and attempts to define accessibility, distributional equity, and social justice in terms of distribution of public services. Different methods and definitions have been derived for analyzing these critical issues. Use of GIS for accessibility measurement is also now becoming prominent. These issues are dealt with in detail in the Literature Review chapter of the study.

1.3 RESEARCH ATTEMPTS

Though there has been some research on accessibility and equity in service distribution, the subject still needs proper research and literature in terms of application of the use of Geographic Information Systems (Nicholls, 2001). Geospatial technologies, such as the software ArcGIS, can be helpful in understanding how current and future parks do, or might, serve the public. In this study, emphasis is placed on the use of the GIS and its spatial capabilities in evaluating accessibility of public services. Although studies have been conducted to identify the disadvantaged and the reasons behind variations in level of service provision, only few studies have attempted to illustrate where such distributional inequity is located and how it is related over space. This study is an application of ideas from spatial analysis and represents an approach to the study of equity in distribution of park facilities in a city.

This study attempts to answer following questions: 1) what is the spatial distribution of the access and the needs for public parks in the city of Ames? The hypothesis here is that if there are areas with higher need for public parks, then such areas have higher accessibility to the parks. 2) Do residents of Ames with higher need for public park facilities have sufficient and equal access to park services provided by the city of Ames? The hypothesis here is that if the need for public parks is higher in an area, then the public authorities are providing higher accessibility. 3) Which parts of the city of Ames lack proper park services? The hypothesis in this case is that if there are areas in the city with higher need and lower accessibility, then such areas lack proper park services. 4) Whether the future park services allocated in the Parks Master Plan serves the higher need areas or not? The hypothesis here is that if there is a high need for parks in certain areas then the future parks are located in those areas.

While looking for answers to these specific research questions the main aim of the study is to find out the areas that have high need and high accessibility. In addition, areas that lack minimum level of accessibility standards to parks but have high need for parks are identified. The findings are then used to evaluate the future locations of the parks and see whether the Ames Parks Master Plan supports the idea of the spatial equity in the distribution of park facilities.

1.4 ORGANIZATION OF THE STUDY

As discussed above, we still need proper literature that analyzes equity in terms of spatial perspective and deals with the access and equity as spatial phenomenon; i.e. distribution of facilities in space, levels of access to them and their locations relative to the spatial distribution of different demographic and socioeconomic subsets of community (Nicholls, 2001, p. 208). The evaluation of access is deemed significant by Talen (1998) for the consideration of spatial equity issues like who has access to a particular good or service and whether there is any pattern to these varying levels of access. Talen (2003) states that distance based analysis helps address questions of discrimination in access provision (p. 182). This study also utilizes the distance based approach in defining service areas and measuring access and demographic variables are interpreted to derive need. The general research framework for the study is presented in Figure 1.

This study is an attempt to present a step by step approach of the use of Geographic Information Systems to identify areas of high needs and high accessibility and high needs and lower accessibility. The next chapter discusses the evolution of parks and open spaces, and how the concept of equity and accessibility in distribution of parks emerged in the planning field. The chapter also reviews the notion of accessibility and equity of public services as it relates to public planning and presents some empirical studies performed.

The third chapter presents the case study area, i.e. the City of Ames, Iowa. The study area in terms of its physical, cultural and demographic composition is outlined. The current and future land use for the City of Ames is also presented. The present condition of the parks and recreation in Ames in terms of number of facilities, level of service, types of parks and uses are also detailed. The location designated for future parks and the Park Master Plan are also discussed.

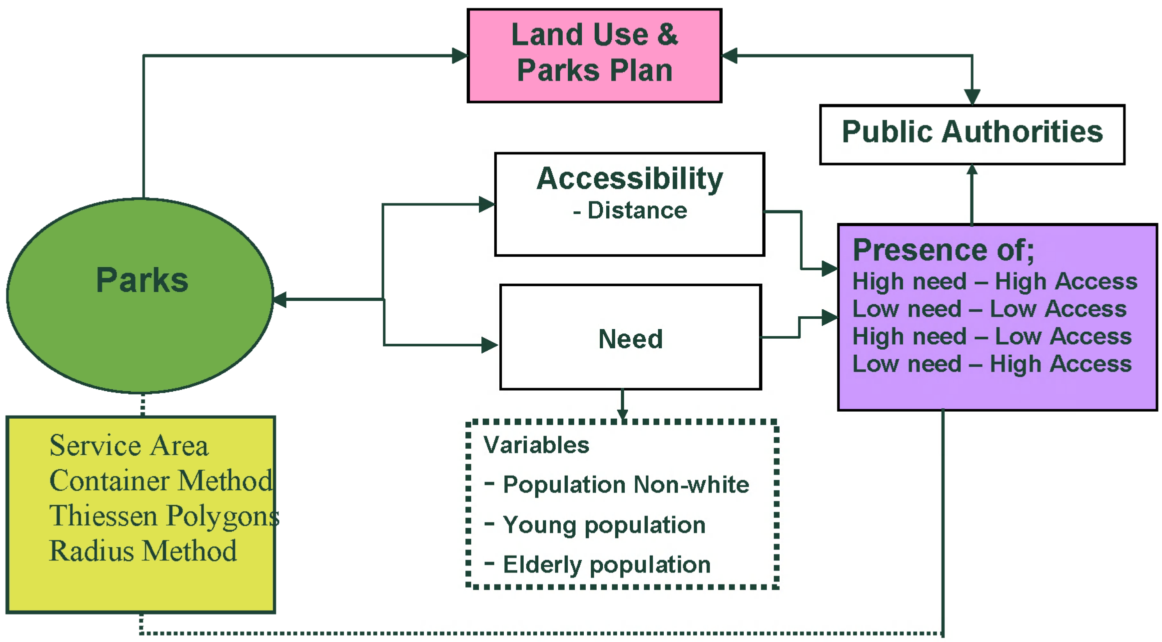

Figure 1: Research Framework

The fourth chapter presents the methods applicable in defining service areas for parks. The population and housing units served by the parks using different service area methods are computed and compared. The findings are used to discuss the pros and cons of the methods.

The fifth chapter defines accessibility and need index and presents a method for calculating these indexes using GIS. Need Index and Accessibility Index for Ames Park system are derived and mapped. The results are discussed.

The sixth chapter presents Spatial Analysis techniques for evaluating park accessibility and spatial equity by looking at the spatial relationships between need and accessibility. Two different spatial methods are used; Exploratory Spatial Data Analysis (ESDA) and Raster Analysis. Results using both of these techniques are discussed to identify areas that have high need and high accessibility and high need and low accessibility.

The last chapter presents the conclusions of the study and discusses the future locations of the parks in Ames. The Ames Land use plan and the Parks Master Plan are also discussed. Recommendations that highlight the implications of this study in public facilities planning are provided. Limitations of the study as well as its future implications are discussed.

This study is not meant to create, derive or implement a completely new methodology for evaluating accessibility. Rather, this study explores and tests some of the accessibility measures and presents an easy step-by-step approach for testing the spatial attributes like accessibility and need using the GIS and ESDA.

CHAPTER II:LITERATURE REVIEW

This chapter presents the historical development of the accessibility and equity concepts in parks and recreation services, defines the types of parks and recreation services and presents empirical studies in the field. Past studies that have contributed to the development of the concepts of accessibility and equity of a park system are also referenced in this chapter. Some empirical studies that have used the spatial analysis capability of the Geographic Information System in accessibility analysis are cited. These past works help in determining a proper framework for carrying out the study.

2.1. HISTORICAL DEVELOPMENT

Parks and Recreation Area means any mini park, neighborhood park, community park, regional park, public open space or swimming pool or aquatics facility whether enclosed or open which is open to the public for either active or passive recreation. In cities across the United States and in Europe, people are transforming neighborhood land into community green spaces designed to address the unique recreational needs of the neighborhoods (Francis, Cashdan, Paxson, 1984). This shows the growing interest of neighborhoods toward open green spaces and parks, and the increase in quality and quantity of such public places. Concurrently people are recognizing the psychological and ecological importance of green spaces, parks and recreation areas in everyday life.

Urban open space has many historical precedents. The development of parks and urban open spaces can be linked back to the history when the idea of planning cities was just emerging. The first cities were constructed at least 5,000 years ago (Pokharel, 1990). People chose to live in cities because cities with their density and diversity, offered a more diverse and cultivated lifestyle. Even the early concepts of city planning placed greater emphasis on a center, or a public space which determined the growth of the city and its physical shape. Some early cities such as Mesopotamian, Egyptian, Greek and Roman cities emphasized the center which was mostly occupied by a temple, a ziggurat, a palace, a public square, a basilica and it was termed as a public space. Thus, the need for public open space has always been the emphasis while designing neighborhoods and cities.

The idea of planning entire communities prior to their construction is an ancient one (*Planned Communities; Part I*). According to *Greenbelt: History of a New Town,* one of the earliest such cities on record is Miletus, Greece, which was built in the 4th century B.C. Various planned communities, both theoretical and actual, were conceived throughout the Middle Ages and the Renaissance. Following the great fire of London in 1666, architect Christopher Wren created a new master plan for the city that incorporated parkland and urban space. With the origin in the New England commons, the public park took on a central role in land use planning in nineteenth century America.

Influenced by the public open space movement in England, Frederick Law Olmsted, the founder of landscape architecture, firmly established park planning in the United States with his plans for Central and Prospects parks in New York City in the mid-nineteenth century. Fredrick Law Olmsted and his team created Central Park in New York City in 1850 which became a breathing space and playground for the crowded masses of the city. The success of Central Park led to the creation of other parks in Boston and Philadelphia. Olmsted went on to plan major park systems for Boston, Chicago and several other cities as large green areas that would become "the lungs of the city" (Francis, Cashdan, Paxson, 1984). Parks designed by Olmsted set the standards for parks throughout America. Around the same time, Joseph Lee was establishing children's playgrounds in Boston. These inner city playgrounds became the example for other cities in developing urban recreational facilities.

Several 18th century cities, including Washington D.C., New York City, and St. Petersburg, Russia, were built according to comprehensive planning. The Garden City Movement, considered as one of the important planning concepts in planning literature and practice, arose in 19th century England as a reaction to the pollution and crowding of the Industrial Revolution and introduced a new dimension to city planning; the concept of environmental sustainability. With the advance of the City Beautiful Movement in the early 20th century, neighborhood parks also became a part of the landscape of the American town and city (Cranz, 1982). Playgrounds were proposed as refuge for city children and as a result, many cities established park departments to manage and develop the growing number of parks, playgrounds, gymnasiums, and public swimming pools. Subsequently, public open space has become a central part of the public landscape of all communities (Heckscher, 1977).

Thus, the American park, recreation and conservation movement was born in both the teeming inner cities of the late 1800s and in the vast, beautiful, unspoiled wilderness of the West. The need for open space in the cities, the preservation of the natural wonders, and the need for recreation in urban areas led to the development of the city and national parks. The park, recreation, and conservation programs and areas and their rise in the landscape can be credited back to Frederick Law Olmsted, Joseph Lee and John Muir (Mertes, 1995). Their contributions resulted in an effort to provide recreation and park facilities for the public as well as the conservation of natural areas.

2.3 DEVELOPMENT OF PARK STANDARDS

With the developments of parks and playgrounds, concepts of minimum standards started emerging. The Playground Association of America developed a plan for Washington D.C., to provide playgrounds, recreation centers and athletic fields. Every school district was to have at least one acre of land for each 2000 children (Mertes, 1995). This recommendation of the Playground Association became one of the first recorded recreation space standards.

George Butler of the National Recreation Association established recommended space standards for playgrounds in neighborhoods of different population. He suggested a standard of 10 acres of park and open space per 1,000 population within each city, plus an equal area in parkways, large parks, forests and the like, either within or adjacent to the city. At the same time, naturalist John Muir led the forest conservation and national park movements in the United States. His efforts led to the setting aside of 148 million acres of forest reserves and in 1890, the establishment of Yosemite and Sequoia National Parks (Mertes, 1995).

The National Recreation and Park Association (NRPA) have been involved in developing recommended guidelines and standards for parks, recreation and open space for the last 30 years (Mertes, 1995). In 1971, NRPA published the *National Park, Recreation and Open Space Standards*, which guided the park and recreation field during the growth years of the 1970s. A team effort was applied to publish *Recreation, Park and Open Space Standards and Guidelines in 1983*, which stressed that the standards be viewed as a guide that addressed minimum, not maximum, goals to be achieved (Mertes, 1995). The 1980's saw an increase in federal, state and local funding for parks, recreation and open space: the Urban Park and Recovery Program, the Land and Water Conservation Fund, the Intermodal Surface Transportation Efficiency Act of 1990, the National Trails Act and State Open Space Programs. Also, the growth of the greenways movement brought renewed funds and public support for acquiring and developing parks, recreational facilities and open space.

The NRPA standards provide a model for applying a systems approach to the planning for parks, recreation, open space, and pathways. This approach includes a level of service guideline that is based on needs, facilities driven and land measured. The challenges facing the park and recreation profession in the future necessitate a revolution in planning philosophy, concepts and methodologies. At the very heart of the public service is the need to provide adequate and quality park and recreation facilities that truly meet the needs of the public and is accessible to all (Mertes, 1995). With the change and growing concept of equity and accessibility in the service distribution, the parks and recreation planning field needs identification, analysis, promotion and response to the changes in society.

Green Space, greenways, parks, open space, green corridors, trails and natural reserves have now become definitive terms used in modern community designs. These are the growing tools for creating environmentally sound communities. They provide a convenient setting for a broad variety of leisure and recreational activities, as well as enhancing the image and perceived value of the community. Urban parks and green space can serve the needs and interests of all kinds of people and many subgroups of the population; young and old, groups and individuals, affluent and poor, male and female, athletic or not, and all ethnic and cultural groups (Altman & Zube, 1989), while at the same time maintaining an individual identity of a place, community or a city. This wide appeal makes such space a tremendous asset to the quality of urban life in a social and behavioral sense as well as a physical sense. Presently, the most common of the open space that dominate the community planning, mostly the physical structures of communities are: plazas, private yards, mini parks, community gardens, wetland preserves, neighborhood parks and playgrounds, community parks, regional parks, conservancy lands, institutional grounds, trail corridors, parkways and shorelines. However, only the public parks are considered for this study.

2.4 CLASSIFICATION OF PARKS

National Recreation, Park and Open Space Association (1983) have classified parks into basically four general classifications. They are regional parks, community parks, neighborhood parks and mini parks. Each park system serves different functions according to their definition. Besides these four basic classifications, there are other parks and open spaces that facilitate special uses or need. Special use covers a broad range of parks and recreation facilities oriented toward single purpose use. Similarly, natural resource areas are lands set aside for preservation of significant natural resources, remnant landscapes, open space and visual aesthetics. The general classification of Parks, Open Space and Pathways is presented in the Table 2.

Thus, while mini parks address limited recreational needs, neighborhood parks are the basic unit of the park system and serve the recreational and social focus of the neighborhood. Community parks serve a broader purpose than neighborhood parks and serve the dual purpose of recreation as well as preservation.

Table 2: Parks, Open Space, and Pathways Classification Table

Parks and Open Space Classifications			
Classification	**General Description**	**Location Criteria**	**Size Criteria**
Mini Park	Used to address limited, isolated or unique recreational needs.	Less than a ¼ mile distance in residential setting.	Between 2500 sq. ft. and one acre in size.
Neighborhood Park	Neighborhood park is the basic unit of the park system and serves as the recreational and social focus of neighborhood on informal active and passive recreation.	¼ mile to ½ mile distance and uninterrupted by non residential roads and other physical barriers.	5 acres is considered minimum size. 5 to 10 acre is optimal.
School Park	Depending on the circumstances, combining parks with school sites can fulfill the space requirements for other classes of parks, such as neighborhood, community, sports complex and special use.	Determined by the location of school district property.	Variable – depends on function.
Community Park	Serves broader purpose than neighborhood park. Focus is on meeting community based recreation needs, as well as preserving unique landscapes and open spaces.	Determined by the quality and suitability of the site. Usually serves two or more neighborhoods and ½ to 3 mile distance.	As needed to accommodate desired uses. Usually between 30 and 50 acres.
Large Urban Park	Large urban parks serve a broader purpose than community parks and are used when community and neighborhood parks are not adequate to serve the needs of the community. Focus is on meeting community based recreational needs, as well as preserving unique landscapes and open spaces.	Determined by the quality and suitability of the site. Usually serves the entire community.	As needed to accommodate desired uses. Usually a minimum of 50 acres with 75 or more acres being optimal.
Natural Resource Areas	Lands set aside for preservation of significant natural resources, remnant landscapes, open space, and visual aesthetics/buffering.	Resource availability and opportunity.	Variable
Greenways	Effectively tie park systems components together to form a continuous park environment.	Resource availability and opportunity.	Variable
Sports Complex	Consolidates heavily programmed athletic fields and associated facilities to larger and fewer sites strategically located throughout the community.	Strategically located community-wide facilities.	Determined by project demand. Usually a minimum of 25 acres with 40-80 acres being optimal.
Special Use	Covers a broad range of parks and recreation facilities oriented toward single-purpose use.	Variable – dependent on specific use.	Variable.

Regional parks are large parks that are distinguished from, yet supplement and enhance, County and municipal park systems. They seek to preserve and protect regionally significant areas of particular ecological, scenic and historic value and provide recreational facilities to serve users throughout the region. In this study, only the mini parks, neighborhood parks and community parks are considered. There general description is provided below.

Mini Park

Mini Park is the smallest park classification. These parks are located within walking distance of the area serviced, and they provide limited recreational needs. Their small size requires intense development, and little to no buffer between the park and adjacent land users is provided.

The standards for mini park development are as follows:

Service Area:	¼ mile radius to serve walk-in recreation needs of surrounding populations.
Acreage/Population Ratio:	0.5 acres per 1,000 persons
Desirable Size:	2500 sq.ft. to 1 acre
Typical Facilities:	Playground Picnic Tables with Grills (not under shelter) ½ Basketball Courts Benches or Bench Swings Open Play Area, Landscaped Public Use Area Scenic Overlook

Where municipal jurisdiction is available, mini parks are typically developed by the municipalities.

Neighborhood Park

Neighborhood parks provide the basic unit of the park system. These parks are usually located within walking distance of the area serviced, and they provide a variety of activities of interest to all age groups. While their small size requires intense development, fifty percent of each site should remain undisturbed to serve as a buffer between the park and adjacent land users.

The standards for neighborhood park development are as follows:

Service Area:	¾ to ½ mile radius to serve walk-in recreation needs of surrounding populations.
Acreage/Population Ratio:	2 acres per 1,000 persons
Desirable Size:	5-10 acres
Typical Facilities:	Playground Picnic Shelters with Grill Court Games, Picnic Tables with Grills (not under shelter) Informal Play Field, Benches or Bench Swings Volleyball, 50% of Site to Remain Undeveloped Trails/Walkways, Parking (7-10 spaces)

Where municipal jurisdiction is available, neighborhood parks are typically developed by the municipality.

Community Park

Community parks provide for the recreation needs of several neighborhoods or large sections of the community. A range of facilities is typically provided and may support tournament competition for athletic and league sports or passive recreation. These parks also present opportunities for nontraditional types of recreation. Fifty percent of the community park site should be developed for only passive recreation; these relatively undisturbed areas may serve as buffers around the park and/or act as buffers between active facilities. Community park sites should have varying topography and vegetative communities. Forested areas should have a variety of tree species. Cleared areas should be present for siting active recreational facilities. One or more natural water feature(s), such as a lake, river, or creek is desirable in community parks. Parkland should also be contiguous and strategically located in order to be accessible to all users within the neighborhoods it serves (Mertes, 1995).

Development of these parks should be based upon the following standards:

Service Area**:**	.5 - 3 mile radius.
Acreage/Population Ratio**:**	2.5 acres per 1,000 persons.
Desirable Range:	30-50 acres.
Typical Facilities:	Recreation Center Picnic Tables with Grills
	Basketball Courts Benches or Bench Swings
	Tennis Court (lighted) Nature Trails
	Baseball/Softball Fields (lighted)
	Restroom/Concessions
	Multi-purpose Fields Parking
	Soccer Fields (lighted) Playgrounds
	Swimming Pool Volleyball Courts
	Amphitheater Disc Golf
	Observation Decks Lakes

Picnic Shelter, Paddle Boat/Canoe Harbor

Picnic Shelter with Grills, Fishing Piers/Boat Docks

50% of the community park site should remain undeveloped for passive recreation/open space. Specialty facilities may be added to, or substituted for, other facilities depending on community needs or special site characteristics. Development of community parks may fall within the responsibility of the municipality or the County agency.

2.5 EMPIRICAL STUDIES

As stated earlier, regardless of the type and size of parks, nowadays, there is a growing need to provide adequate services and facilities that meet the varying needs of the public and are accessible to all. Issues of distributional equity and accessibility have hit the field. Nicholls (2001) asserts that "traditional studies of accessibility approach the equity concept from purely geometric perspective" where the aim is to maximize the efficiency of the distribution networks and to minimize planning cost (p. 202). However, Nicholls (2001) argues that these kinds of value free models can result in significant discrimination against certain groups and areas. Thus he emphasizes the importance of identifying the social and economic dimensions of accessibility as they relate to users instead of concentrating solely on geometry and system profits.

Past researchers have defined equity as a term that refers to the fairness or justice of a situation or distribution. It is the question of who gets what and who ought to get what. However, as Nicholls (2001) says equity is a subjective concept, open to multiple interpretations. Lucy (1981) and Crompton *et al.* (1988) suggest useful guides for defining equity. They identify four major classes of equity with regard to the allocation of resources;

(i) equality, (ii) compensatory or need, (iii) demand/preferences, (iv) market (willingness to pay). Nicholls (2001) adopts the compensatory or need based approach to the equitable provision of public leisure and defines least advantaged according to the socio-economic characteristics of age, income, race and population density of residence. The groups considered most in need with regards to the provision of public leisure services and facilities were thus, the young, the elderly, minorities and those living in areas of higher population density. This study also follows the need based approach emphasizing the equitable provision of public parks based on needs of people.

As Nicholls states (2001), till date few authors have integrated evaluation of accessibility and equity in a single study. That is why she focuses on the measurement of each of these issues before combining her analysis. The most basic standard with regards to the provision of urban parks is the NRPA's recommendation that 10 acres (4.1 hectares) of open space be available per 1000 residents. Many cities calculate this ratio to obtain a broad picture of the adequacy of their level of supply (Nicholls, 2001). Some of the cities apply another method, where they divide an urban area into smaller zones and calculate the amount of parkland available to residents within each of these units. This is the container approach as argued by Talen and Anselin (1998) which assumes the benefits of services provided are allocated only to residents within the predefined zone in which they are situated and that no spatial externalities to surrounding areas occur.

Some researchers have, however, used the spatial dimension and defined access as each park's service area, represented by a buffer drawn around the facility with a radius equivalent to the maximum desired distance of users from it. The distance can be determined according to NRPA's public park and open space classification scheme which recommends the ideal location and size of various types of open space relative to the surrounding population (Nicholls, 2001). Lindsey *et al,* (2001) used the buffer approach in measuring equity of access to greenways, defining equity as proximity using the concept of buffers in defining park service area, that is, a specified radius around parks deemed to be within some "accessible distance". Hodgart (1978) described this kind of approach as the coverage model of accessibility where residents are said to be covered by, i.e. have access to, a park if they are located within the specified maximum distance from it, but are assumed to have inadequate access if they are not. This method assumes a straight line distance between services and residences. However, in reality potential users cannot travel in straight lines. They move against the public rights of way and have to avoid barriers to travel such as railway lines and rivers which make the actual travel distance almost always greater than the direct distance (Nicholls, 2001).

The configuration of a park and the points of its access, as well as the actual distance, are important factors not considered by the traditional radius methods. Nicholls (2001) suggests an alternate approach to overcome these problems based on the measurement of distance along the roads and other public rights of way surrounding parks. Such method calculates as closely as possible the actual routes that users are likely to follow between their residences and designated points of access to facilities. This network analysis approach is more realistic and responds to the disadvantages of the radius method.

Using "equity maps", Talen (1998) presented a framework for investigating spatial equity and demonstrated the use of GIS as an exploratory tool to uncover and assess current and potential future equity patterns. Highlighting the importance of accessibility measures in equity studies, Nicholls (2001) presented an approach utilizing simple GIS commands to refine the measurement of accessibility to, and thereby equity, in the distribution of park resources. She utilized the concept of buffers and street networks within GIS and incorporated travel cost times in order to better estimate park accessibility. GIS was also used in integrating various spatial and socioeconomic data.

Sister (2001) states that access and equity are spatial issues and thus tools within GIS can be used for examination of these social issues. She examined park congestion rates (i.e., the size of population served by a park) across the Southern California Region on a per park basis. Utilizing tools within GIS and the concept of Thiessen polygons, service areas are delineated so that each park at the center is assumed to serve the population within the bounds of such polygons. The study shows the utility of spatial analysis tools in GIS as well as the concept of Thiessen polygons in elucidating existing inequities in park access.

Murray and Davis (2001) present an approach for identifying areas in need of public transport based upon the use of socio-demographic and economic information of the study area. Then they relate the public transport need to the levels of access to service. Using the GIS and multi-criteria techniques, socio-demographic and economic factors are integrated in order to determine public transport need. This allows need to be compared to the current levels of suitable access to public transport. This study is important in accessibility analysis, as it forms the basis of other studies such as Talen's (2003) that uses the notion of accessibility index and need index. Murray and Davis (2001) also help define the disadvantaged or the persons that are needy, or more in need than others, for such public services.

Wachs *et al,* (1973) presents discussion of ways in which accessibility to urban services constitutes an important measure of the quality of living and how accessibility might therefore be included as an important component of a social aspect of any city or a region. A conceptual framework for measuring accessibility in terms of the ease with which citizens may reach a variety of opportunities for employment and services is derived for evaluating transportation and regional plans. It differs from other approaches which are based on travel volumes and travel times that are currently employed in urban transportation planning and evaluation.

A study by Apparacio and Seguin (2005) first evaluates the accessibility of various urban resources using spatial data analysis in Geographical Information Systems and then develops an indicator of the accessibility of services and facilities for each public housing project using multivariate data analysis. Another study by Swift *et al*, (1997) describes a method using GIS to statistically determine the impacts of land use change, demographics change, and political conditions on the accessibility of quality recreation in San Gabriel Valley communities.

Previous studies of spatial equity have been of two kinds; outcome and process. Outcome studies have focused on the distribution of various resources relative to the socio economic characteristics of residents. Process studies have in contrast been less concerned with who is or is not impacted by inequity and more with the reasons underlying distribution of resources (Nicholls, 2001). This study presented here also is based on outcome. Nicholls (2001) asserts that the outcome of the distribution of public leisure services in terms of variation between different socio-economic groups, rather than the processes underlying this distribution, is important. However, there still remains a lack of analysis of the spatial aspect of equity, i.e. the study of relationships between the spatial distributions of facilities or services and the spatially referenced socio economic characteristics of the population they serve. Though studies have been conducted, most of them use the container approach to access and equity.

This study utilizes these concepts in measuring service areas and accessibility and need and demonstrates much simpler methods in terms of computation and interpretation. Utilizing the straight line distance method, levels of accessibility across the city is identified and then the spatial equity and its relationship to the demographic variables are assessed. This involves comparing characteristics of residents with high and low accessibility. The main objective in evaluating the parks systems is to examine the current provisions of parks in order to identify those people who do not have sufficient public parks facilities, but may need the services. These are the people who are referred to as the disadvantaged in the study.

The next chapter details out the study area, the demographic profile of the study area and the variables used.

CHAPTER III: THE STUDY AREA

In this chapter, the study area is presented. The study area is discussed in terms of growth influences, projections and land use. The current Land use plan of the area is presented. The existing parks and open spaces available within the study area, types of parks, the future projections for parks and open space and the future locations of parks are also discussed. This chapter also presents the summary of the variables used for the study through charts, tables, maps, etc. The data sources are the U.S. Census Bureau, The Office of Social and Economic Trend Analysis (SETA) and the City of Ames, Iowa. The GIS data have been obtained from the City of Ames and Iowa Geographic Map Server (ISU GIS Facility) and the Iowa Department of Natural Resources – Natural Resources Geographic Information Systems Library.

3.1 THE CITY OF AMES

The study area chosen for this study is the City of Ames, Iowa. It encompasses 22 square miles and covers 0.04 percent of the state territory. The location map for the City of Ames is presented in Figure 2. The total population of the city is 50,731 in 2000, whereas for the State of Iowa, it is 2,926,324. The population percent change from 1990 to 2000 for the city was 7.1 percent, whereas for the state of Iowa, it was 5.4 percent. About 14.6 percent of the population is under 18 years of age and about 7.7 percent of the population is 65 years old and over. The detailed table for the population demographics for the City of Ames and the State of Iowa are presented in Table 3.

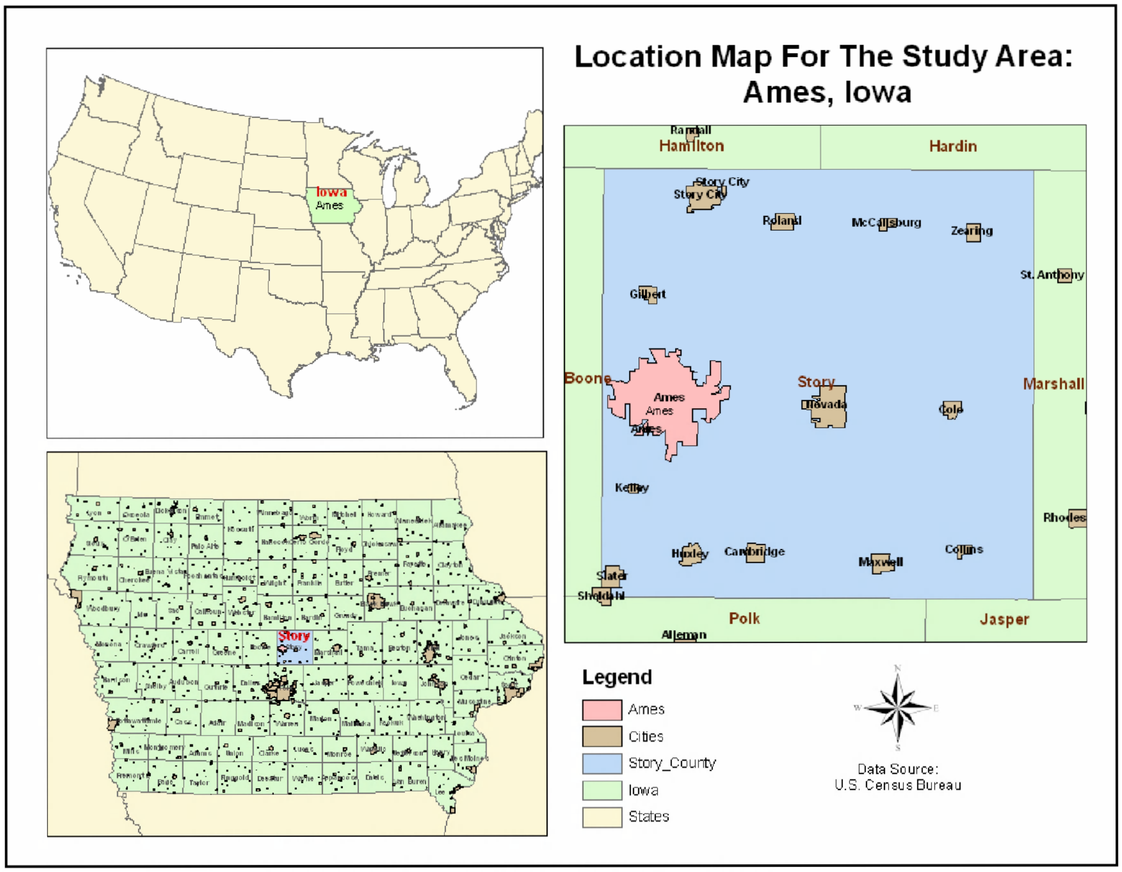

Figure 2: The Location Map for the City of Ames, Iowa

Table 3: Demographic Profile of the City of Ames, Iowa

Comparison of City of Ames to State of Iowa			
S.N	*Variable*	*City of Ames, Iowa*	*State of Iowa*
1	Land Area	22 sq. miles	55,869 sq. miles
2	Person per Sq. Mile	2,352.30	52.4 person per sq. mile
3	Total Population (2000)	50,731	2,926,324
4	Population, percent change, 1990 to 2000	7.10%	5.40%
5	Persons under 18 years old, percent, 2000	14.60%	25.10%
6	Persons 65 years old and over, percent, 2000	7.70%	14.90%
7	Non-White persons, percent 2000	12.70%	6.10%
8	Housing units, 2000	18,757	1,232,511
9	Median value of owner-occupied housing units, 2000	$130,900	$82,500
10	Households, 2000	18,085	1,149,276
11	Median household income, 1999	$36,042	$39,469
12	Persons below poverty, percent, 1999	20.4%	9.10%
Data Source: U.S. Census Bureau, State and County Quick Facts			

The city of Ames is within the Story County jurisdiction. Story County has a total of 2,537 census blocks with a total population of 79,981. Of these census blocks, City of Ames contains about 732 census blocks. Some land in the city is affiliated with the Iowa State University, so the total population for these census blocks is reported as zero. These blocks are avoided from our sample of census blocks. The geographic areas of our sample and the census blocks are displayed in Figure 3. In total, 563 blocks are selected for the study.

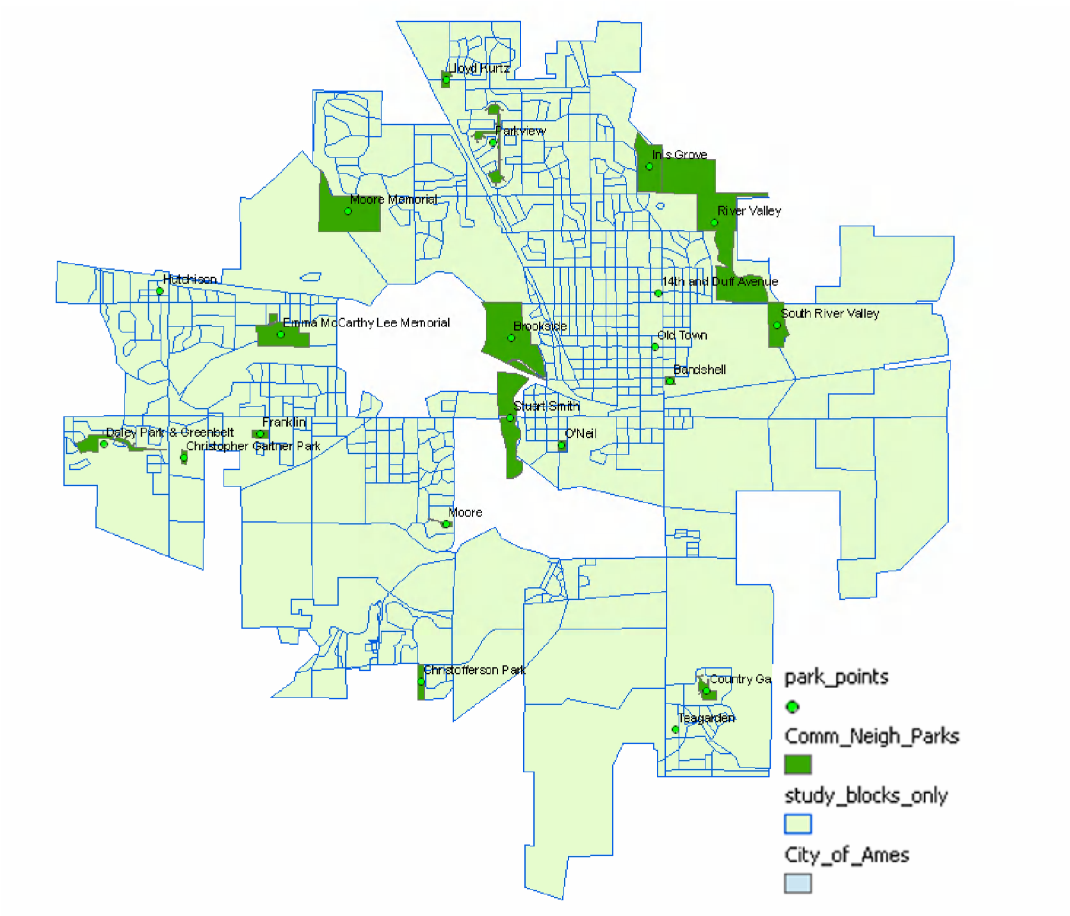

Figure 3: Census Blocks considered in the study

3.2 GROWTH FACTORS

The Land Use Policy Plan for the City of Ames (1997) characterizes the City as a community with relatively high densities (i.e. about 2,352.3 person per square mile – Census

2000) and potentially creative spaces. Ames residents and other visitors can experience the opportunities associated with a major urban setting while also enjoying the benefits of a smaller community. The community seeks to enhance the quality of life for its residents by maintaining this character. Through planning for growth opportunities, the connection and integration of people, places and activities, it is desired to create a sense of place in Ames (Land Use Policy Plan, Ames, Iowa, 1997).

The presence of Interstate 35 links Ames with Des Moines providing convenient access and creating new growth and diversification. Since its incorporation in 1869, Ames has experienced major expansion of its boundaries in accommodating growth. Since 1930, Ames has increased its land area by 400 percent, adding approximately 9,300 acres through annexation. That is why a planning area has been designated for addressing growth opportunities and development compatibility for the city. As of 1994, the Planning Area, exclusive of the city, encompassed an area of 43,837 acres (Land Use Policy Plan, Ames, Iowa, 1997).

Ames is the largest population and economic center within Story County. Population within the City of Ames and the unincorporated planning area is projected to grow from approximately 50,000 in 1990 to between 65,000 and 67,000 by the year 2030. The population increase is 15,000 to 17,000 or 30 to 34 percent. The annual rate of growth is 0.7 percent to 0.8 percent, which represents an increase from the rate of growth between 1980 and 1990 (Land Use Policy Plan, Ames, Iowa, 1997). Total housing within the City of Ames and the unincorporated Planning Area is projected to grow from approximately 17,200 units in 1990 to between 25,000 and 25,800 by the year 2030. Of the approximately 10,271 acres within the City of Ames currently, all but 1,096 acres of agriculture and 250 acres of vacant classification are permanently utilized. Land for the projected growth through the year 2030 will come mostly from the approximate 43,837 acres of unincorporated land within the planning area.

Based on a projected population of 65,000 to 67,000 and an accompanying 25,000 to 25,800 housing units, another 1,700 to 2,050 acres of residential area is required. The projection assumes an average density of approximately 6 dwelling units per gross acre. Based on the projected population increase for the planning area, another 800-900 acres of land is required for commercial growth. Based on the projected population increase for the collective planning area and the City's recreation standards, another 400-450 acres are required for parks and open space (Land Use Policy Plan, Ames, Iowa, 1997).

Because of these expected growths of the population and housing and the land use projections, the study of the accessibility and equity of parks distribution in Ames can be justified as important to provide equal services to Ames residents and maintain an equitable and easily accessible parks system as the city and the population continues to grow further.

3.3 AMES LAND USES

Existing Land Uses within the City: As of 1994, the City of Ames consisted of approximately 10,271 net acres, not including public right of way. Of the total area, 9,175 acres, or 89.3 percent were urban use. The remaining 1,096 acres were classified as agricultural. The residential use covered 2,834 acres of the city land. The commercial use covered 621 acres of the city land. Medical use covered 22 acres, industrial use covered 315 acres, and the Public / Quasi Public use covered 4,372 acres. Among the land use classification, Parks and Open Space covered 761 acres. 250 acres were classified as vacant and 1,096 acres were classified as agricultural land (Land Use Policy Plan, Ames, Iowa, 1997).

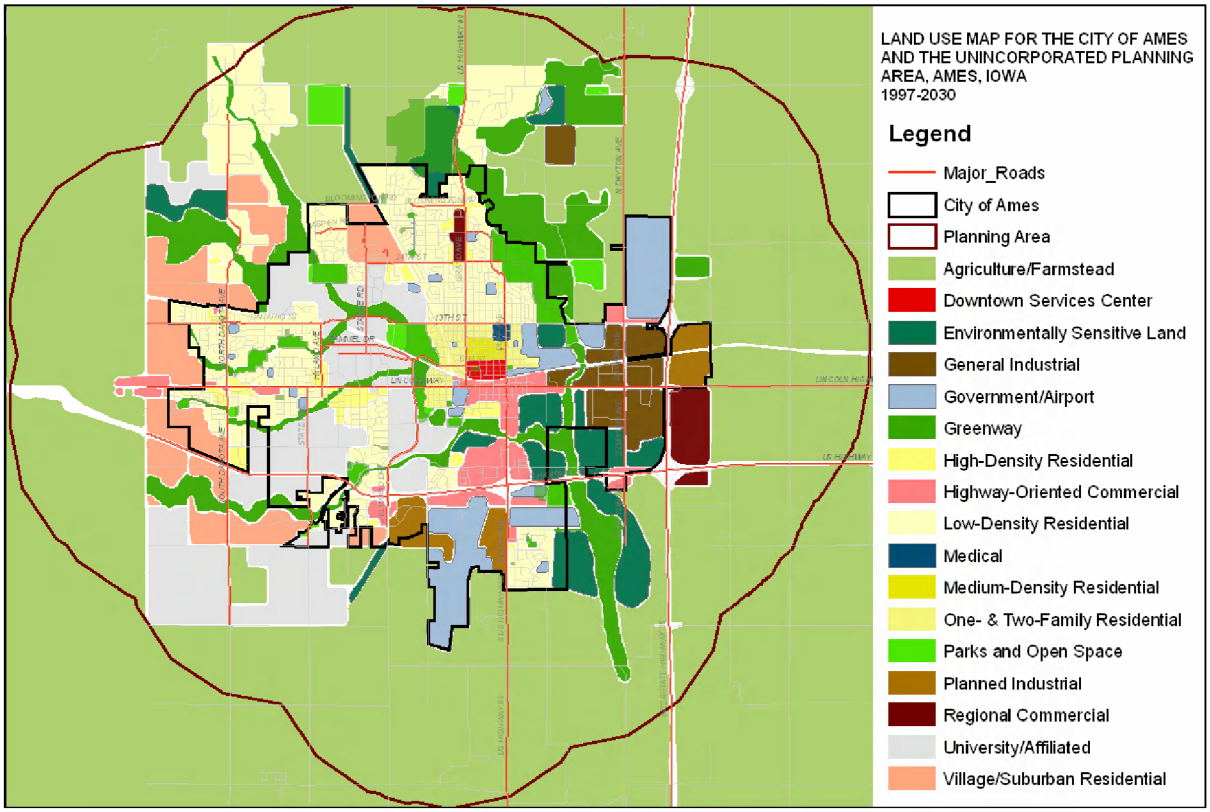

Figure 4: Land Use Map for the City of Ames, Iowa

Existing Land Uses within the Unincorporated Planning Area: In 1994, the unincorporated planning area consisted approximately of about 43,837 acres. 6,269 acres was classified as residential, 111 acres was classified as commercial, 537 acres was classified as industrial, 1,117 acres as Public/Quasi Public, 820 acres as Parks and Open Space, 757 acres as vacant and 34,226 acres as Agricultural (Land Use Policy Plan, Ames, Iowa, 1997). The Land Use Map for the City of Ames is presented in Figure 4.

Future Land Use Allocation for Parks and Open Spaces: According to the Land Use Policy Plan for Ames (1997) an additional 3,000 to 3,500 acres of land is required for the development of Ames based on projected growth by the year 2030. Based on the land use projections, additional acreages have been allocated for the major land uses, among which Parks and Open space covers a major part. An additional 400-450 acres are allocated for future parks and open space. Included are approximately 100-125 acres for a regional park, 100-125 acres for neighborhood parks and 200 acres for open space.

In order to facilitate planning changes, a more extensive classification system is recommended by the Land Use Policy Plan for future land use. Parks and Open space designation involves public-controlled areas for recreation. The term involves facilities and/or structured programs for a variety of recreational opportunities. The term "Open Space" refers to primarily undeveloped areas (maintained and natural) – for passive recreational opportunities. Future Park Zone designation involves the identification of general areas or zones wherein future parks may be located. The Land Use Map for the Ames Planning area presented in Figure 4 locates the extent of the land use classifications as envisioned for the city of Ames and the unincorporated planning area by the year 2030.

3.4 PARKS, RECREATION AND OPEN SPACE

The City of Ames has an exceptional parks and open space system and the development of the City of Ames Park Master Plan is the fulfillment of the vision of opportunities for Ames' future (Statement of Purpose, Park Master Plan). The Ames Park Master Plan outlines ways in which the City's Department of Parks and Recreation can enrich the quality of life for the Ames citizens to the year 2030 and beyond. The challenge for parks and recreation development for Ames does not derive from a need to address fundamental deficiencies associated with a weak system; instead the need is for assuring the maintenance of an excellent system in light of the continuing population growth. Supporting this idea of maintaining the effective system, this study is thus focused on the efficiency of the existing parks and future parks of the city of Ames, in terms of accessibility and equity which involves applying the accessibility measurement methods to the Ames Park system.

Operations: The City of Ames operates 32 facilities for the public provision of parks, recreation and open space. Both active and passive opportunities are provided through a decentralized system of essential facilities that are generally unstaffed. More specialized facilities are provided in centralized locations and supported by some staff. City owned facilities are available to the region's population and ISU students. The University provides extensive recreational facilities and programs for its students. Some of these facilities are available to the general public on a limited basis. City owned facilities are classified into five groups based on the type of provisions, size, and service area. The largest and most extensive type is the regional parks which is not included in this study. The Community parks are classified as parks with service area of 1 to 2 miles, with a size of 25 acres or more. Neighborhood parks are parks with service area of ¼ to ½ miles and size of 15 or more acres. Special uses are community centers, golf courses, swimming pools, ice rink and so one. These are also not considered for the study. Open Space and Woodlands are land set aside for conservation or passive use.

Level of Service (LOS): Standards for level of service involving parks, recreation and open space vary with the socio-economic, physiological and alternative provider characteristics of a community. LOS standards for parks, recreation and open space are based on three conditions; type, number and appropriateness of facilities, amount of land dedicated for active and passive recreation and accessibility of facilities. The LOS standards for the type, number, and appropriateness of the city's public facilities are similar to those recommended by the National Parks and Recreation Association. LOS standards for land area involving parks, recreation and open space are recommended as 5 acres per 1,000 population for the developed land and 5 acres per 1,000 populations for Woodlands/Open space. A developed park is designed for either passive or active usage with amenities incorporated at the site. Woodlands/Open space land is set aside to be left in a natural state.

Existing Parks and Open Space: According to the Land Use Policy Plan (1997), as of 1997, Ames provided approximately 230 acres of developed park land, excluding Homewood Golf Course. The plan states that based on the projected population of 65,000 to 67,000 by the year 2030, a total of 335 acres of developed park land would be required. The plan also highlights that all of Ames is served by an existing community park with the exception of the southeast area. It also mentions that areas to the north and northwest have limited availability to neighborhood parks. The plan emphasizes the need of neighborhood parks on the south of Highway 30 as the population and growth increases southward.

Currently, Ames has 1,178 acre of park land providing the city with 32 parks, including 6 community parks, 15 neighborhood parks, 5 specialized parks and 3 woodlands. The existing Parks and Recreation services in Ames, Iowa and in Story County are presented in Figure 5.

Ames also provides several recreational facilities including: a full service community center, playgrounds, hiking paths, indoor and outdoor swimming pools, golf courses and ice skating arena. According to the Land Use Policy Plan, most of the city's parkland are in natural woodland, water or open space. The percentage of undeveloped parkland is high because of the flood plains in and around Ames. With the opening of the Ada Hayden

Heritage Park, the city of Ames has more than three times the national standard of undeveloped park land.

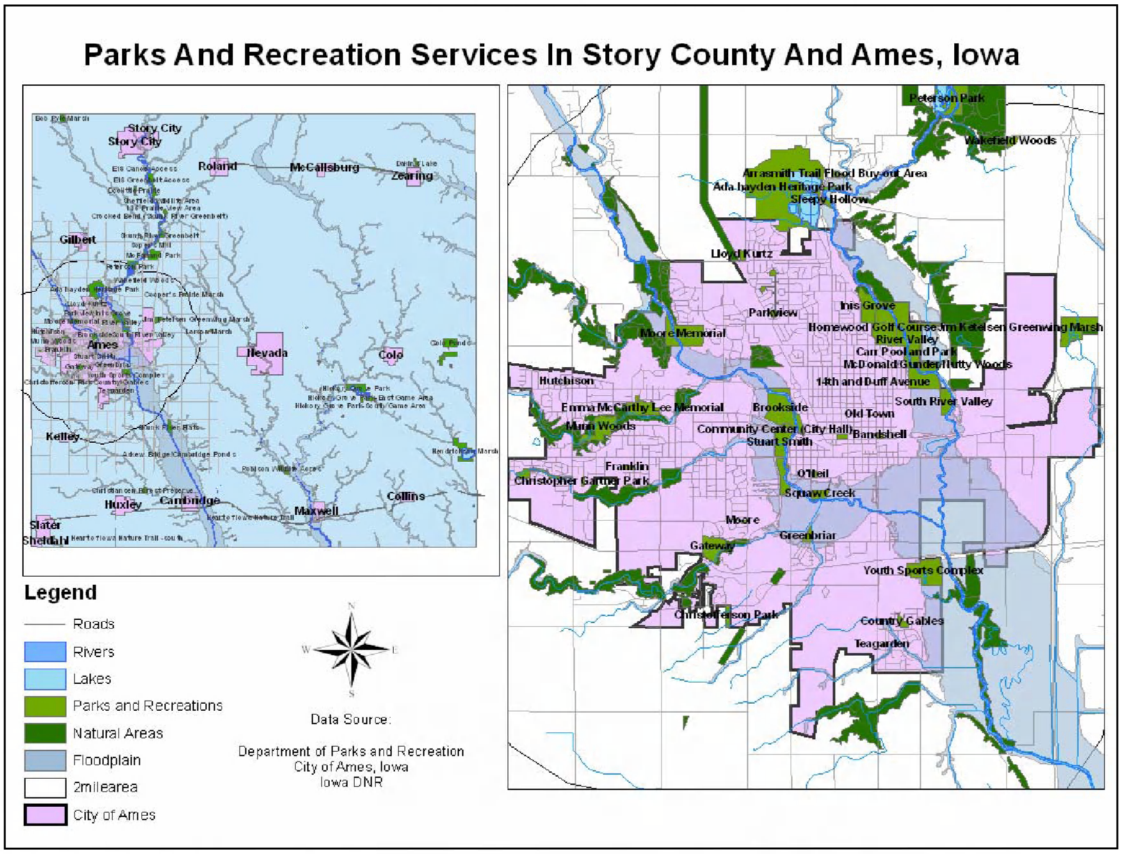

Figure 5: Parks and Recreation Services in Ames and Story County, Iowa

Augmenting the City's formal open space system are 109 acres of several properties, including the Gateway Administration Office, Community Center, Carr Pool, and Homewood Golf Course, which are used for more specialized recreational activities, and Moore Memorial includes 40 acres of cropland leased from ISU. Excluding this 109 acres and 131.3 acres of water, the system has a total of 981.2 park acres for a 2000 census population of 50,731. This calculates to 19.3 acres per 1,000 populations. Of this, 19.3 acres, Woodland/Open Space acre comprises 14.5 acre per 1,000 populations and developed acre comprise 4.8 acres per 1,000 populations. Table 4 illustrates the Existing Parks and Open Space for the City of Ames and classifies the land into developed and Woodland/Water/Open Space acres.

Table 4: Existing Parks and Open Space, City of Ames

PARKS	***Total Acres***	***Developed***	***Woodland/Water Open Space***
REGIONAL			
Ada Hayden Heritage	437.0	2.0	435.0
COMMUNITY PARKS/WOODLANDS			
Brookside	82.0	53.0	29.0
Emma McCarthy Lee	38.0	14.0	24.0
Inis Grove	42.0	21.0	21.0
Moore Memorial Park (*East side of river*)	50.0	22.0	28.0
River Valley Park (*North/South*)	77.0	52.0	25.0
Subtotal… … … … … … … … … … … … … …	*726.0*	*164.0*	*562.0*
NEIGHBORHOOD PARKS/WOODLANDS			
Bandshell	2.6	2.6	0
Business Area Parks	0.5	0.5	0
Christoffferson	7.29	4.0	3.29
Christropher Gartner	2.4	2.4	0
County Gables	14.3	6.3	8.0
Daley Park	10.0	10.0	0
14th and Duff	0.5	0.5	0
Franklin	4.5	4.5	0
Hutchison	1.0	1.0	0
Lloyd Kurtz	4.7	4.7	0
Moore	2.0	2.0	0
O'Neil	2.5	2.5	0
Parkview	12.0	12.0	0
Patio Homes West	2.0	2.0	0
Stuart Smith Park	41.0	28.0	13.0
Teagarden	1.0	1.0	0
Old Town	0.5	0.5	0
Subtotal… … … … … … … … … … … … … …	*108.8*	*84.5*	*24.3*
WOODLANDS & OPEN SPACE			
Carr Woods	21.0	0	21.0
Gateway Park	38.0	0	38.0
Gunder Woods	57.0	0	57.0
Homewood Woods	21.1	0	21.1
Railroad/Zumwalt	24.4	0	24.4
McDonald Woods	3.0	0	3.0
Munn Woods	40.0	0	40.0
Nutty Woods	24.4	0	24.4
Daley Greenbelt	5.5	0	5.5
Subtotal… … … … … … … … … … … … … …	*234.4*	*0*	*234.4*

Table 4 Continued.

ADDITIONAL PARKLAND			
Greenbriar	9.0	0	9.0
Clear Creek	5.0	0	5.0
Squaw Creek	17.5	0	17.5
Subtotal……………………………………	*31.5*	*0*	*31.5*
SPECIALIZED RECREATION FACILITIES			
Carr Pool/Park	6.0	6.0	0
Community Center	2.0	0	2.0
Gateway Administrative Complex	4.0	4.0	0
Homewood Golf Course	43.0	0	43.0
Moore Memorial *(Farm Land)*	40.0	0	40.0
Subtotal……………………………………	*95.0*	*10.0*	*85.0*
GRAND TOTALS	**1195.7**	**258.5**	**937.2**

Source: City of Ames, Parks and Recreation Department

There are different facilities present at different parks in Ames. These facilities include bus routes, covered shelters, picnic area, playground, restrooms, tennis courts, sand volley ball courts, ball fields, basketball courts, discgolf, open field space, wading pool, horseshoes, fishing, walking path, paved bike path, community gardens, ice skating, off street parking and so on. Figure 6 presents the classification of parks in Ames, Iowa as neighborhood parks, community parks, specialized parks and woodlands.

It is Ames' objective to increase its parks and open space by a total of 400-450 acres by the year 2030. The Future Land Use Map identifies four future park zones. These park zones involve general locations wherein a new park site would be developed. The type of park to be associated with each zone is more emphasized by the city through the Park Master Plan. The Future Land Use Map also identifies a greenway system that encompasses portions of environmentally sensitive areas. Linking these greenways together with the City's existing parks and open space to create a greenway system is one of the visions for 2030.

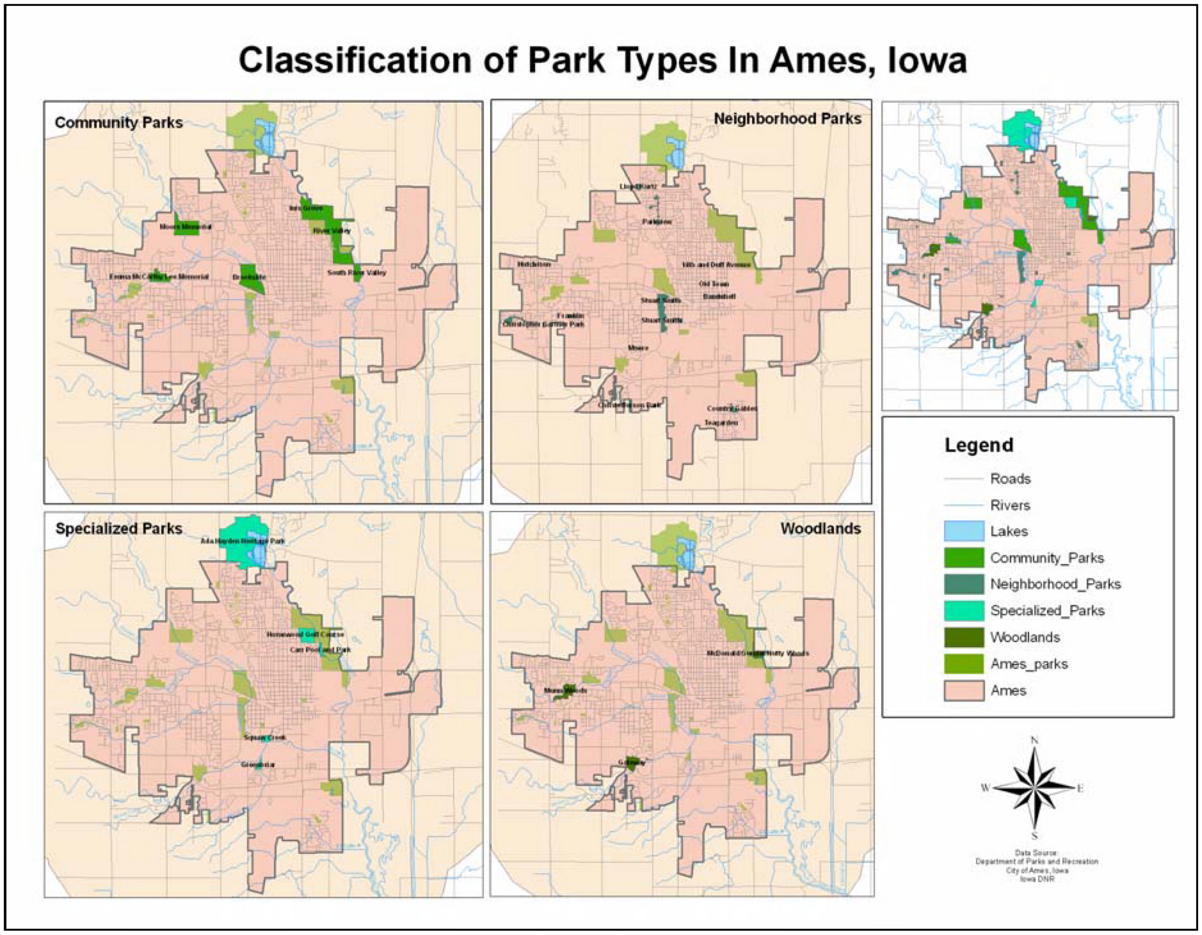

Figure 6: Classification of Park Services in Ames, Iowa

3.5 PARKS MASTER PLAN

The City of Ames and the Unincorporated Planning Area is expected to have an additional 15,000 to 17,000 residents by year 2030 according to the projections in the City's Land Use Policy Plan, 1997. The Parks Master Plan is based on using the estimate of 66,000 population for 2030; however, it is also flexible plan that can be modified to account for any variations in actual population growth (Statement of Purpose: Ames Park Master Plan). In order to maintain a similar level of park facilities currently enjoyed by city residents, the city must develop an additional 87 acres of developed space within the next twenty five years or by

2030. The city currently exceeds the recommended guideline for Woodlands/Open Space; however, due to its location within the existing community, this Woodlands/Open Space excess will not impact projected new growth areas and their needs. The future locations of the parks are presented in Figure 7.

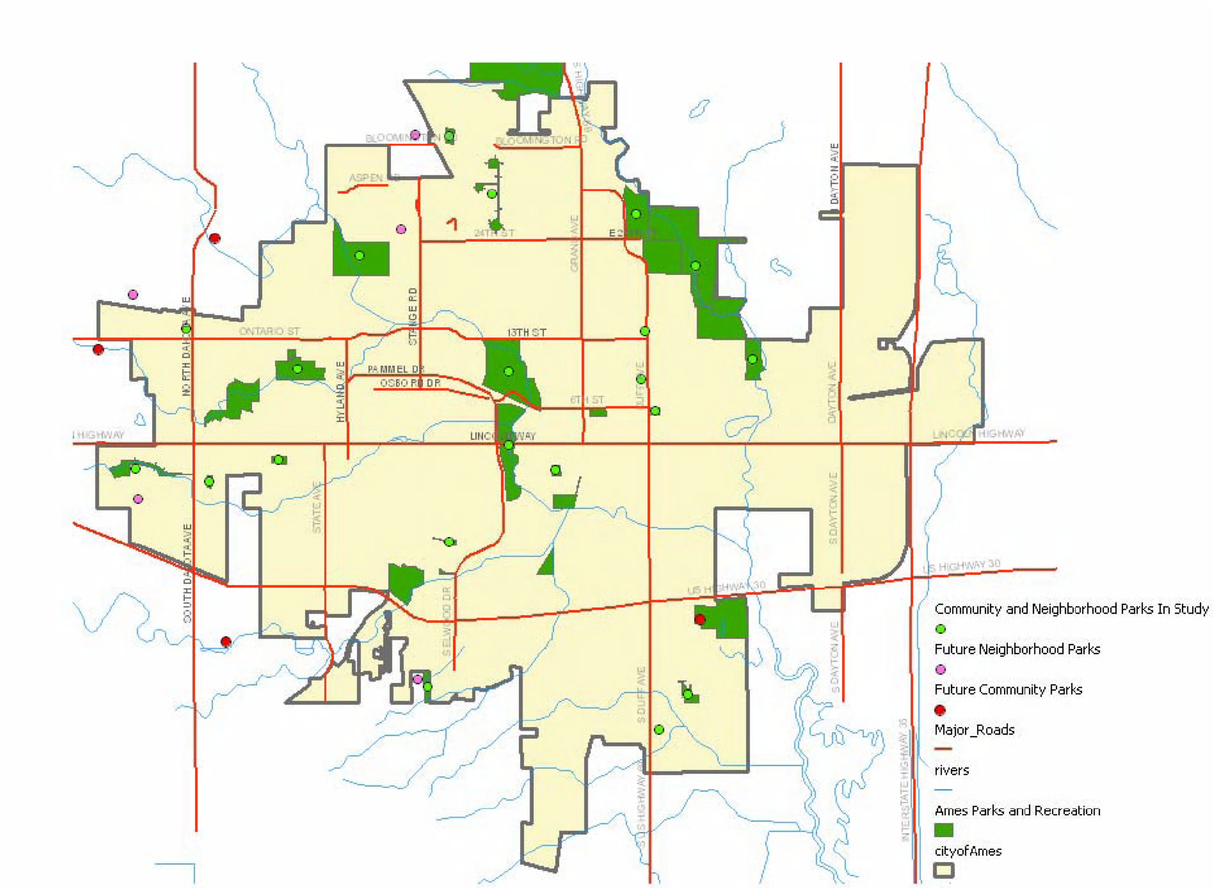

Figure 7: Future Park Locations

Currently, no Community Parks exists south of Lincoln Way, yet the Land Use Policy Plan forecasts that growth will be focused toward the south and west within the next several decades. This growth will dictate that new Community Parks be located in that area. As the City of Ames moves into the 21st Century, it is the challenge for the city to provide its residents with responsive, equitable and quality park services. Therefore, Ames Park Plan must be accessible to all citizens and equitable in terms of distribution. Through the accessibility and equity study, the Ames Park system can maintain its efficient status as well as encourage one of the finest and socially equitable park systems in the country. That is why this study will not only look at the accessibility and equity conditions of the existing parks, but also study if the future locations are appropriate according to the population growth and need. Recommendations for improving the Ames Park Master Plan can then be formulated.

3.5. DATA PREPARATION

First of all, the spatial data for the study area is organized. Geographic digital data and paper maps on Ames parks classified as mini, community and neighborhood parks are collected. Special parks and natural reserves are not considered in this study because of their regional characteristics. These data about park location, with their acreage and level of services, is obtained from the Ames Parks and Recreation Department. The shapefile (for using in ArcMap) for the Parks and Recreation services was obtained from the City of Ames and cleaned up in ArcMap to represent only those parks that are considered in this study. A total of 21 neighborhood and community parks are chosen for the study. The parks considered for this study are shown in Figure 8. The future location of parks is obtained from the Ames Parks Master Plan (paper maps) and City of Ames.

These shapefiles and datasets were cleaned and projected in ArcMap to represent the entity within the city of Ames boundary and the 2 mile planning area and to overlap them with each other. A shapefile is the name given within ArcMap to the geographical representation of a theme or layer of spatial information (Nicholls, 2001). In order for each separate layer to be superimposed correctly upon the others, each must be stored in the same geographic projection and co-ordinate system.

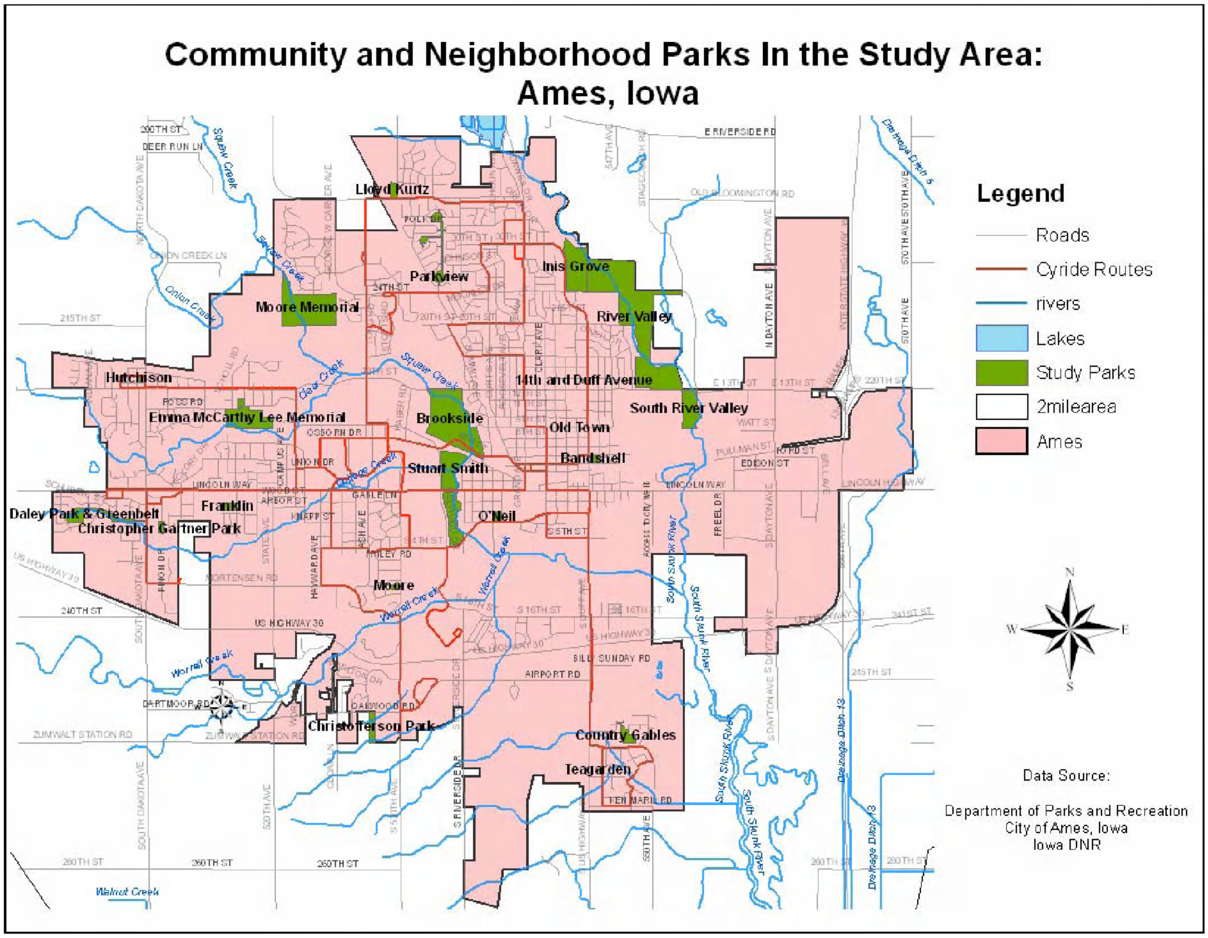

Figure 8: Community and neighborhood parks considered for the study

Variables Used: To analyze spatial equity, demographic data at census blocks level is obtained from the US Census Bureau. Mostly population that are elderly, the young, disabled, low income earners, unemployed, those of ethnic background do not have easy access to services (Morris 1981; Starrs and Perrins, 1989) are considered disadvantaged. Nicholls' (2001) utilized nine different variables in her equity analysis. The variables used were population density, percent non white, percent black, percent Hispanics, percent under age 18, percent over age 64, percent of housing unit's renter occupied, mean housing value (for owner occupied units) and mean contract rent (for rental units). Groups considered most likely to be in 'need' of better than average access to parks identified by past researchers are non-whites, those earning low incomes (approximated by those who rent as opposed to own their home, and those whose property or rental value is lower than average), the young and the elderly, and those residing in more densely populated areas and less likely to have access to a private garden (Nicholls, 2001).

The variables included in this study are total population for blocks, population non-whites living in the blocks and age group targeting people who are younger than 18 years and at or above 65 years. The percentage of non-white population, percentage of population below 18 years of age and percentage of population above or at 65 years of age are calculated. Data for variables like population in poverty (income) and percentage of households without vehicles are not available at the census blocks level. So, these variables could not be used for the study. The Minimum, Maximum, Sum, Mean and Standard Deviation for each of the variables used in the study are presented in Table 5.

Table 5: Summary Statistics of variables considered in the study

Distribution of Variables Considered in the Study							
S.N	*Variable*	*Count*	*Minimum*	*Maximum*	*Sum*	*Mean*	*Std.Dev*
1	Total Population	563	1	1,832	50,847	90.31	154.73
2	Population Non-White	563	0	416	6,414	11.39	31.6
3	Population under 18 Years of Age	563	0	202	7,438	13.21	19.41
4	Population above or at 65 Years of Age	563	0	253	3,936	6.99	16.01
Data Source: U.S. Census Bureau, Census 2000 Summary File (SF1), 100 Percent Data							

Spatial Unit of Analysis: Sister (2006) states that most of the work based on equity and access to parks catalogue existing park resources in communities and/or political jurisdictions (e.g. municipalities) and characterizes these sites in terms of demographic characteristics usually based on census data. Accessibility and need can be calculated, even down to the household level if desired, however, due to manageability, planning intent and privacy concerns, the actual unit of analysis is likely to be much larger in spatial scale (Murray and Davis, 2001). Talen (2003) states that planners usually want to consider the demographic and socioeconomic characteristics of a population in looking at access as they aim to assess the urban spatial patterns in terms of accessibility to services. The greater the level of disaggregation of data, the higher the level of precision in measuring access. Talen (2003) argues that though use of individual parcels may be most appropriate for analyzing urban spatial pattern, the disadvantage with using parcel level data is that demographic and socioeconomic attributes are not easily obtained for a given parcel. However, if a census geographic entity is used, such as a block, block group or census tract, demographic and socioeconomic characteristics for that entity can be used in the assessment of spatial equity (Talen, 2003). By using the census geography, the locations are compromised as centroids, but then socioeconomic characteristics aggregated by zone can be determined.

The unit of analysis is usually confined to the census tract level, or to neighborhoods or municipalities. For this study census blocks are considered. Using the block groups is not so efficient for this study, because of the large size of block groups in the periphery of the City of Ames, with greater portion of the area being outside the city limit, even outside the 2 mile planning area. Following Sister's (2006) argument that as the unit of analysis grows larger, the assumption of homogeneity within the units may not always hold true, the census blocks are considered as appropriate spatial unit for the analysis.

The next chapter presents the methods for deriving park service areas and calculates the population served by minimum level of accessibility

CHAPTER IV: DEFINING SERVICE AREAS

There are different accessibility measurement approaches for determining areas with good accessibility, which are already mentioned earlier in the Introduction. In this chapter, three different approaches for defining service areas for parks are used. As a first step in the analysis of access, points of origins and points of destinations are created. The points of origin are the centroids for each census blocks. The destination points are the centroids of the parks selected for the study. A simple function in ArcToolbox is used to create centroids for parks and blocks. Then the different approaches are applied respectively.

4.1 CONTAINER APPROACH

Container approach is one of the most widely used approaches in service area delineation. This measure simply counts the number of facilities within a given 'container', such as census block groups, census tract, political district, or municipal boundary (Talen, 2003). In this study, the blocks are considered as the container. The amount of park land available to residents within each block is determined by calculating the ratio of parkland area to the total population of the block group. This study, following Nicholls (2001), uses the most basic ratio for urban parks need, which is the NRPA's recommendation that 10 acres of open space should be available per 1000 residents at least.

In ArcGIS, the blocks that contain the parks centroids are selected and a new layer is made from the selected features. This new layer contains the blocks that have at least one park located inside them. Some of the blocks have more than one park inside their vicinity. Then the park acre is divided by the total population for each block to determine the parkland population ratio. For the blocks containing more than one park, the park acre is summed and divided by the total population.

4.2 THIESSEN POLYGONS

If it is assumed that everyone uses the nearest park at some uniform rate, then each person in the region can be assigned to a park. One way to accomplish this is by generating thiessen polygons around each of the parks identified in the study area. Considering that residents are more likely to utilize parks in closer proximity on a more regular basis, these thiessen polygons can be viewed as “park service areas”, with each park at the center servicing most of the population within the bounds of the Thiessen polygons (Sister, 2006). Here the assumption is that everyone within the bounds of any one polygon uses the park at its center, and that there is no reduction in park “desirability” or use with increasing distance within Thiessen polygons.

Thiessen Polygons are created for each park to determine the service area. Each park is represented by a point (centroid of the park) and polygons are generated to apportion these points to regions. Each region contains only one park. Each park within the region is closer to the residences inside that region (polygon) than to the residences outside the polygon in any other region. Each of these polygons represents the service area for individual parks.

For each park service area (i.e., thiessen polygon), corresponding population count from the Census Bureau Dataset is assigned, thus providing an estimate of the potential number of people each park is serving. The census blocks that fall inside these service area, are assumed to be served by that particular park. By joining the spatial location, the census blocks are assigned to each park service area and by summarizing the value, the total population that each service area serves is found. Thiessen polygons can be generated by using the <thiessen> command in ArcInfo. If ArcInfo is not available, Thiessen polygons can also be created with the help of a visual script. The script is available for downloading at http://arcscripts.esri.com/. The script should be customized first in the toolbar and then thiessen polygons can be created by using park points as the input layer and the city boundary as the extent. To estimate how many people are located within each park's service area, centroid of each polygon (census block) is used to decide the membership of the blocks to the service polygon. The Thiessen polygons are assigned to each centroid of the census blocks through spatial joining. Each point will be given the attribute of the polygon that it falls inside. Finally, the park information is joined to the census block using the attributes. This way it is possible to estimate how many people each park is serving in a summary table.

4.3 RADIUS METHOD

In this approach, access is defined according to each park's service area, represented by a circle drawn around the facility with a radius equivalent to the maximum desired walkable distance for the users. This distance is determined according to the NRPA's public park and open space classification scheme. It is assumed in this case, that users go to the nearest service available. It is also assumed that distance equal to or less than 1/2 mile is the walkable distance for users. Residents are said to be covered by, i.e. have access to a park if they are located within this specified 1/2 mile distance (Nicholls, 2001). The total population served by each circle can then be calculated by determining the census blocks that fall within the service area. Census Blocks are then classified as areas with good accessibility and low accessibility in terms of their distance between their centroids and the nearest parks service.

For this approach, it is necessary to establish some standards against which the citywide access data can be evaluated. In terms of minimum standards, planners have been able to establish some general principles about the willingness and ability of residents to walk to their destinations (Talen, 2003). Though there is some variation, usually the walking distance is defined as ¼ to ½ mile, depending on the destination type (Talen, 2003). Since this study is based on park accessibility, it is assumed that 0.5 mile is the walkable distance, i.e, people are willing to walk half mile to go to parks.

After delineating service areas covered by the parks, by each method, a comparison, the population served by the service area in each method can be compared and the populations that have easy access to parks are determined. Maps of census blocks that have easy accessibility to no accessibility of parks are created. Census blocks lying inside and outside service areas are identified. Population served by and underserved by the park system is computed in each method and the results compared. This provides an estimate of the number and characteristics of residents located within the service area.

4.4 APPLICATION

The methods of measuring accessibility and service areas for parks by container, thiessen polygons and straight line method are all applied to the set of parks in Ames. In the container approach, the census blocks which have at least one park in it is identified. Figure 9 displays those census blocks that contain at least one park in its vicinity. The amount of parkland available to residents within each of these blocks is calculated and compared to the NRPA's recommendation.

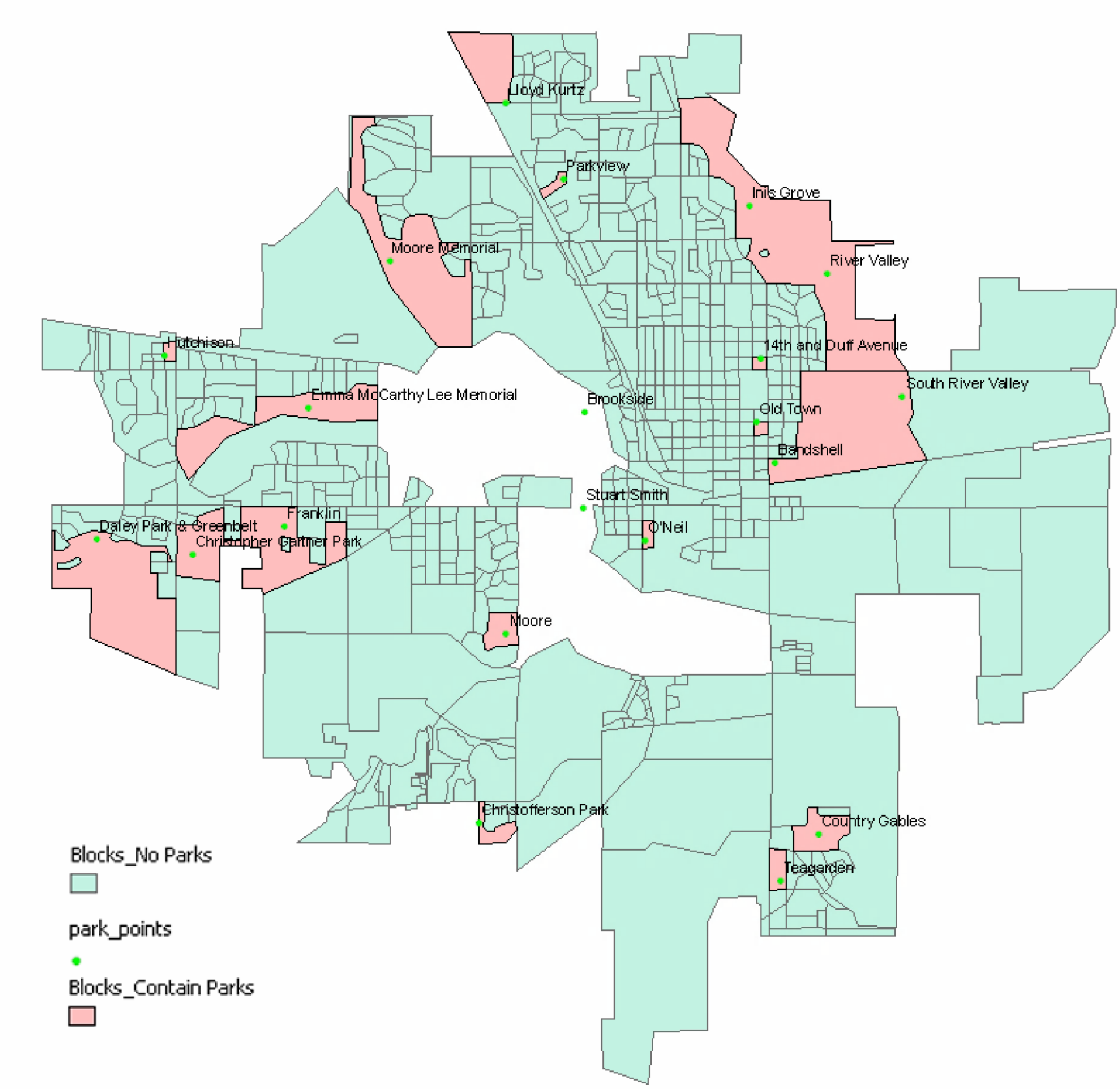

Figure 9: Park Service Area by Container Approach

Table 6 presents the summary of the total parkland available to residents within each of these blocks. According to NRPA's recommendation, 10 acres of park and open space should be available per 1000 resident. The ratio calculated from the container approach is then compared to this basic standard, to see how the block groups are doing in terms of service.

Table 6: Summary of the total parkland per 1000 people – Container Approach

Uni_id	**Tot_pop**	**Parks contained**	**Acres of parkland**	**Ratio of parkland to pop**
191690010001019	95	O'neil	2.9	30.56 per 1000
191690001002030	309	Moore Memorial	74.81	4130 per 1000
191690001002050	35	Llyod Kurtz	4.45	127per 1000
191690003001009	50	Parkview	3.35	67 per 1000
191690011004005	106	Moore	2	18.86 per 1000
191690013011012	513	Daley Park and Greenbelt	15.94	31.07 per 1000
191690013012003	477	Franklin	4.05	8.49 per 1000
191690013012007	594	Christopher Gartner Park	2.48	4.17 per 1000
191690013022011	214	County Gables	7.12	33.27 per 1000
191690013022014	109	Teagarden	0.5	4.58 per 1000
191690002001000	303	Inis Grove and River Valley	214.43	707 per 1000
191690002003017	26	14th and Duff Avenue	0.5	19.23 per 1000
191690006001002	55	Hutchison	0.7	12.72 per 1000
191690006004000	329	Emma McCarthy Lee Park	34.83	105.86 per 1000
191690009003001	308	Bandshell and South River Valley	26.03	84.51 per 1000
191690009004000	54	Old Town	0.26	4.81 per 1000
1916900130211012	230	Christofferson Park	7.01	30.47 per 1000
All other Blocks	47,040	No Parks	0	0
Total Population	50,847			

A total of 3,807 people have easy access to parks and out of 563 blocks, only 17 blocks are classified as the containers having access to parks using the container approach. All other blocks do not contain park, thus the amount of parkland per 1000 people is zero in their case. Thus they have no accessibility to parks if the container approach is applied. Out of the 17 blocks that contain parks, 4 of the blocks have the ratio of parkland to the total population below the NRPA's national standard of 10 acres of parkland per 1000 population. By using this approach, 47,040 people do not have any access to parks.

The problem with this approach is that it assumes that the benefits of services provided are allocated only to the residents within the predefined zone in which they are situated and that no spatial externalities to surrounding areas occur. Similarly, it assumes that residents of an area have sufficient access to that they will benefit from the services provided within it, an unrealistic expectation (Nicholls, 2001). However, this is not the ideal case. In this case, since blocks are the unit of analysis, using container approach for parkland calculation is not efficient. The parks are also utilized by other population outside the confined container of the block to which the park belongs. However, this is the most basic approach in accessibility measurement and can give the general idea of how the blocks are doing in terms of parks accessibility. This presents a simple and less calculative method for public authorities to understand their service distribution.

Figure 10 shows the Thiessen polygons generated around each park point such that any point within this polygon is nearest to the park it is assigned to.

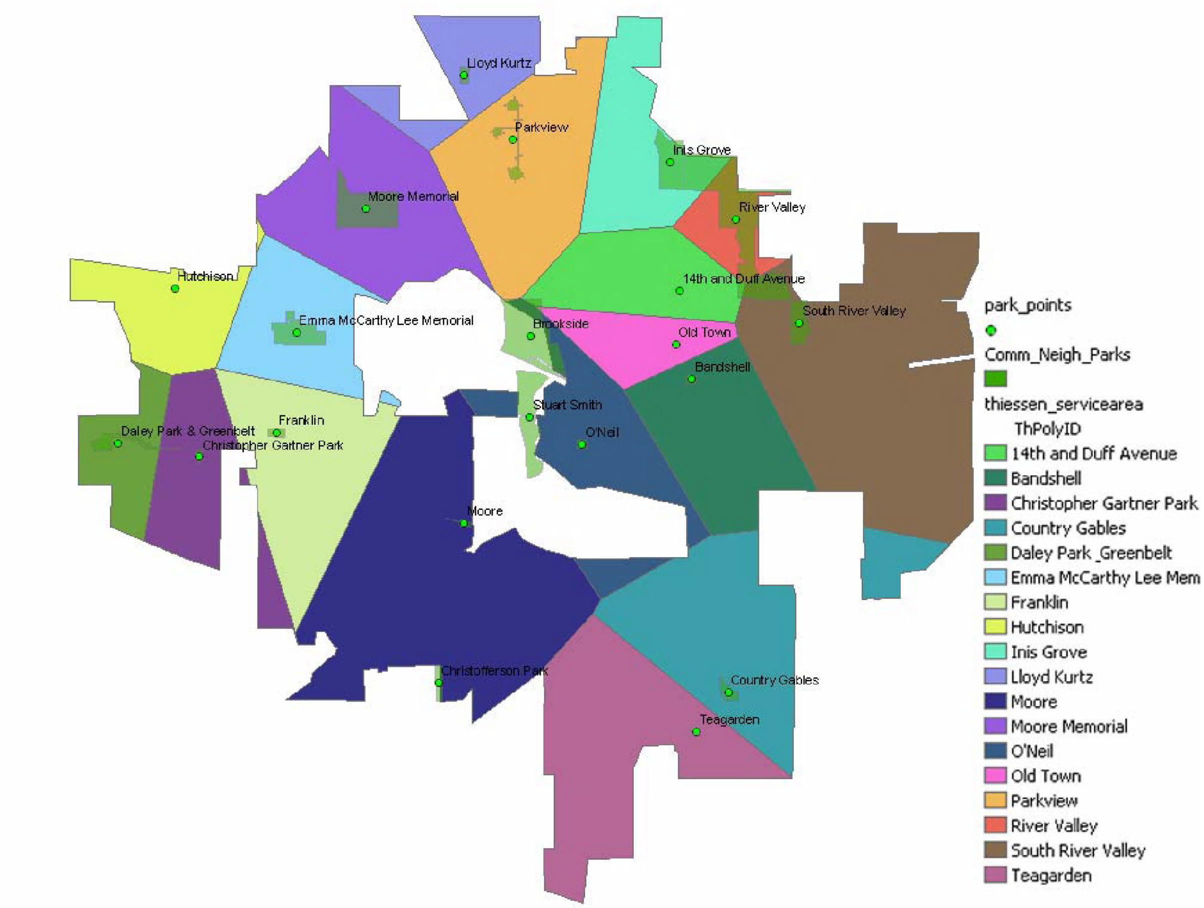

Figure 10: Thiessen Polygons as park service area generated around park points

Thiessen polygons are generated by using the <thiessen> command in ArcInfo. ArcInfo is the full version of the ArcGIS Software and contains many tools that are available only within the ArcInfo environment. The park points are used as the input layer for creating the service areas. The Park names will be the identification for each service polygon created by the Thiessen method. The extent of the service area is limited to the city boundary.

Figure 11 shows the block centroids as well as the thiessen service areas and presents the population distribution in these service areas.

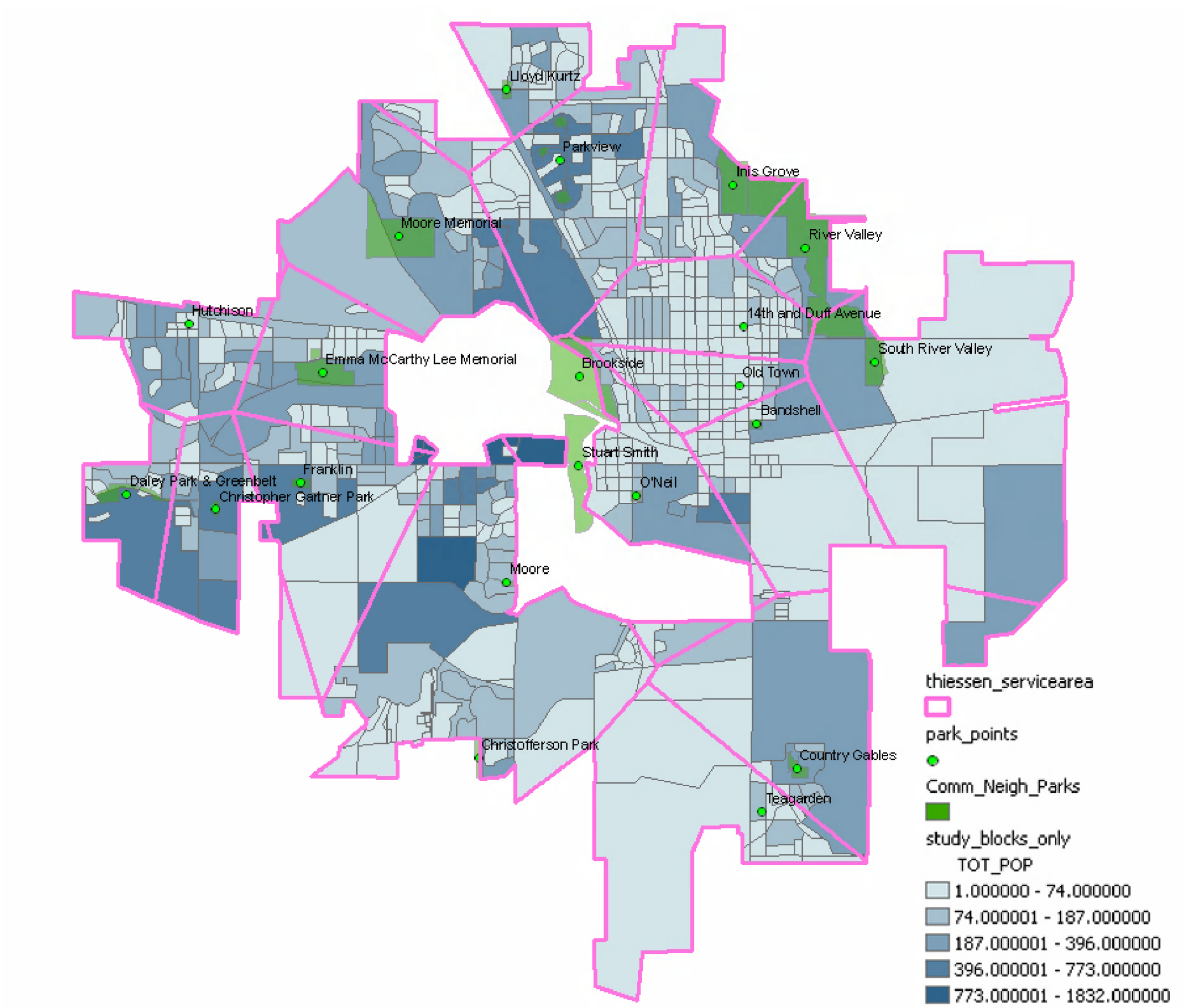

Figure 11: Block centroids and the population distribution of blocks

Through spatial joining each block within the polygons are then joined to the park service area they fall under. The park information is then joined to the blocks, such that each block is assigned to a park. The membership of the block to a park service area depends on where the park centroid falls. The blocks according to the park they are assigned to, are shown in Figure 12.

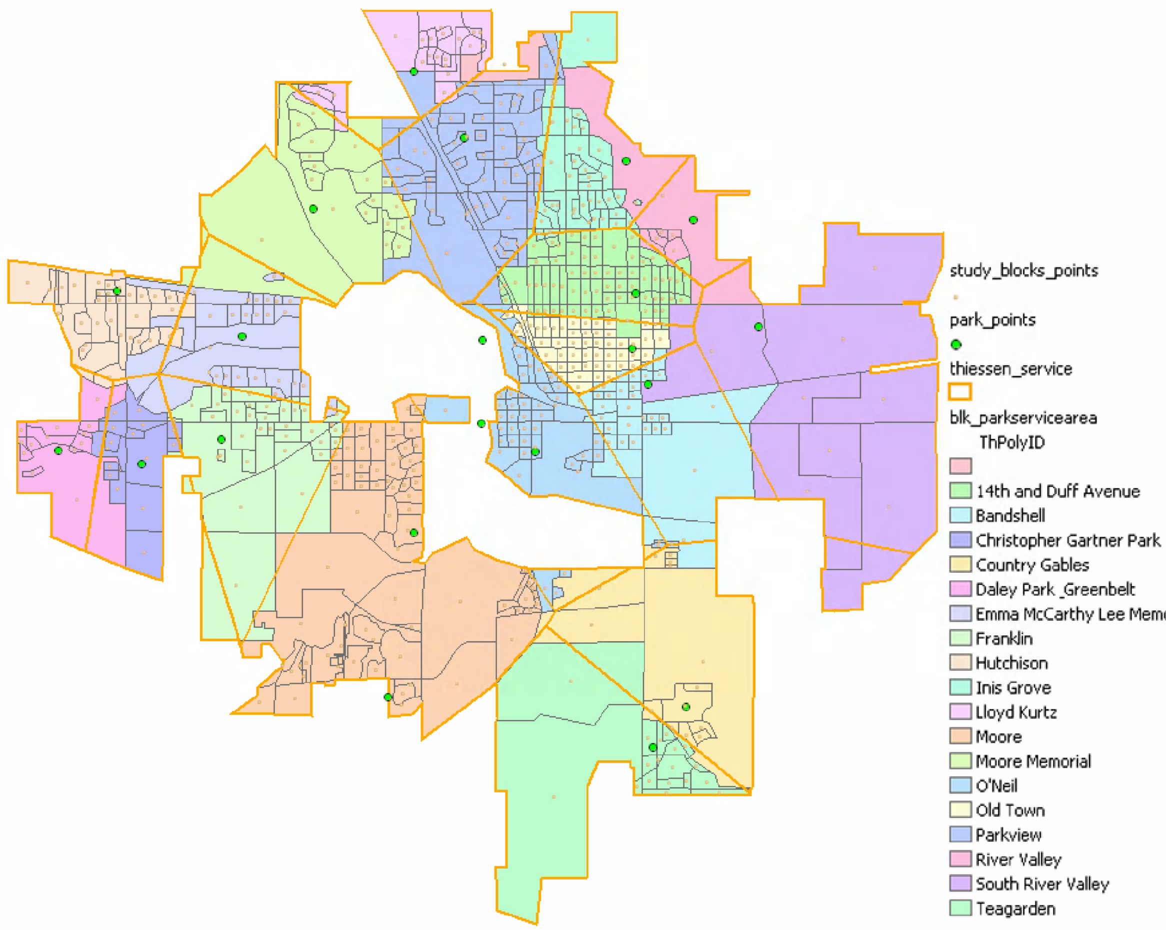

Figure 12: Blocks assigned to the park within Thiessen polygon

Finally a summary table can be created adding the total population served by the park. This method is much applicable than the container approach, as this method includes all the blocks within the city and assigns them to a park such that residents within that block has the most easy access to the park, as that park is the nearest location from anywhere within the block group. The summary table for the population is presented in Table 7. For example, Emma McCarthy Lee Memorial serves a total of 3,905 people and 1,128 housing units.

Table 7: Summary table for Population and Housing units served by the parks

OID	ThPolyID	Count_ThPolyID	Sum_TOT_HOU	Sum_TOT_POP
0		1	84	180
1	14th and Duff Avenue	65	1352	3150
2	Bandshell	33	907	1722
3	Christopher Gartner Park	15	1394	2975
4	Country Gables	14	572	1424
5	Daley Park & Greenbelt	13	427	1218
6	Emma McCarthy Lee Memorial	25	1128	3905
7	Franklin	33	1381	4293
8	Hutchison	32	1241	3148
9	Inis Grove	36	872	1920
10	Lloyd Kurtz	22	437	1140
11	Moore	71	2172	9619
12	Moore Memorial	19	1040	2917
13	O'Neil	47	1193	3892
14	Old Town	51	1071	2402
15	Parkview	54	2088	5042
16	River Valley	6	235	590
17	South River Valley	8	247	534
18	Teagarden	18	279	776

A total of 50,847 populations are served by the parks service. We can see the total population and the total housing units served by each park in the summary Table 7. This method also has some disadvantages. It assumes that people within the park service area defined by Thiessen polygon have access to that park and the park is the one nearest from the blocks, however it does not take into account the distance from the centroids of blocks to the parks. Some of the blocks might be at the far end of the thiessen polygons and thus the distance between the park and the block, though nearest park, might be above the acceptable walking distance.

The straight line technique or the radius method is implemented using the Buffer command under the ArcToolbox in ArcGIS. A distance of one half of one mile is specified, measured from the geographic center of each park, and circular buffers, representing each park's service area are created. Half mile distance is considered as the walkable distance or the distance that people are willing to walk to reach a park. The 0.5 mile buffers around each park represent the areas within the city that have good walkability or accessibility. Figure 13 depicts the buffers drawn around each park point with a radius of half mile.

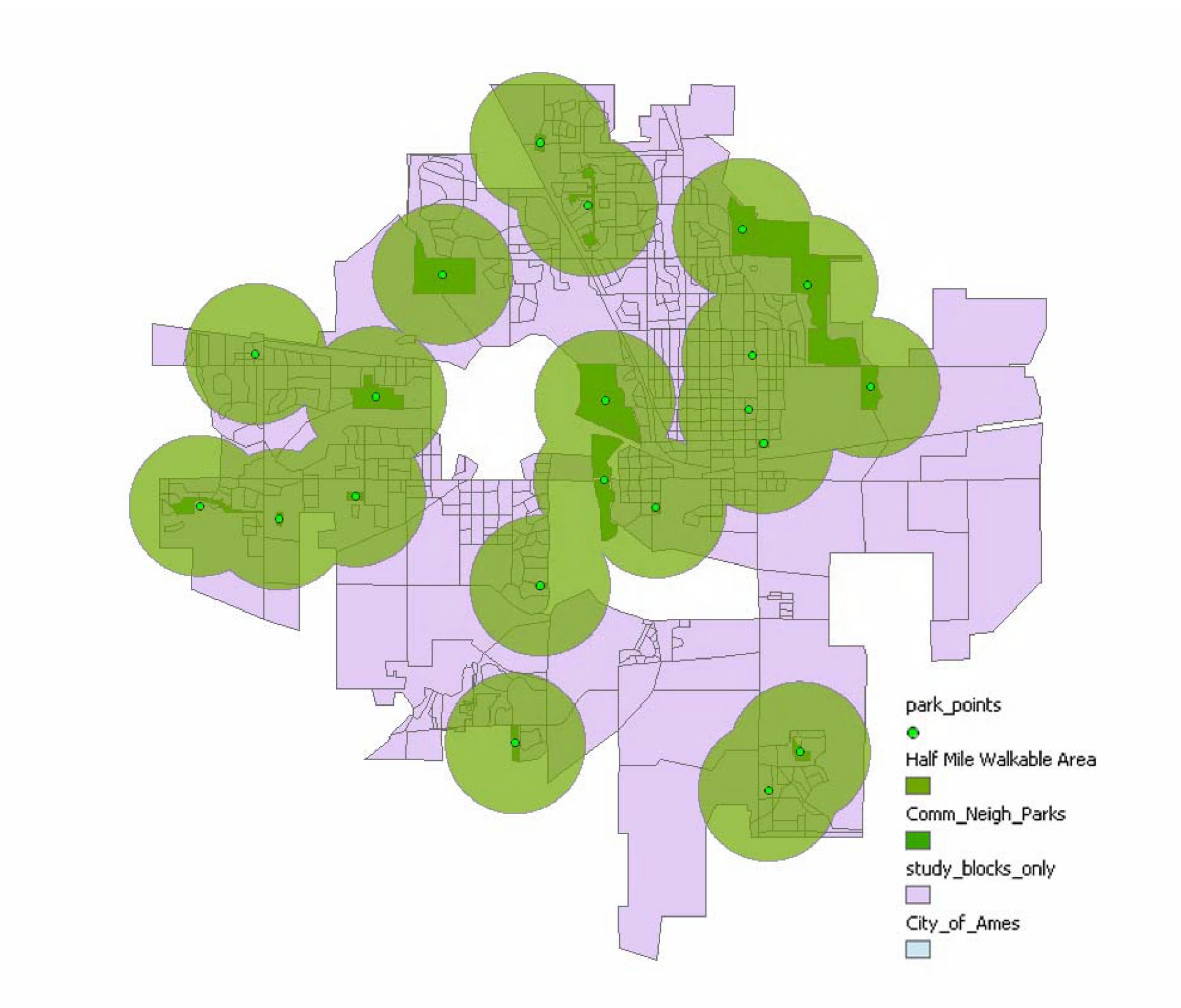

Figure 13: Half mile buffer created around each park as their service area

By using the selection function within ArcMap, census blocks lying inside and outside each service area defined by the distance are identified. Only the blocks that have their geographic center in these buffers are considered to be served by the parks (Nicholls, 2001). The total population within the blocks that are selected as best served by the park service area is then summed up to get the total population that has good accessibility to parks. 417 blocks are selected as the blocks served by the park service area defined by 0.5 mile radius. The total population of these blocks is 33,414 and the total housing units within this accessible area are 13,245. Figure 14 classifies the areas within the city as those with good accessibility to parks and those without good accessibility or no accessibility to parks.

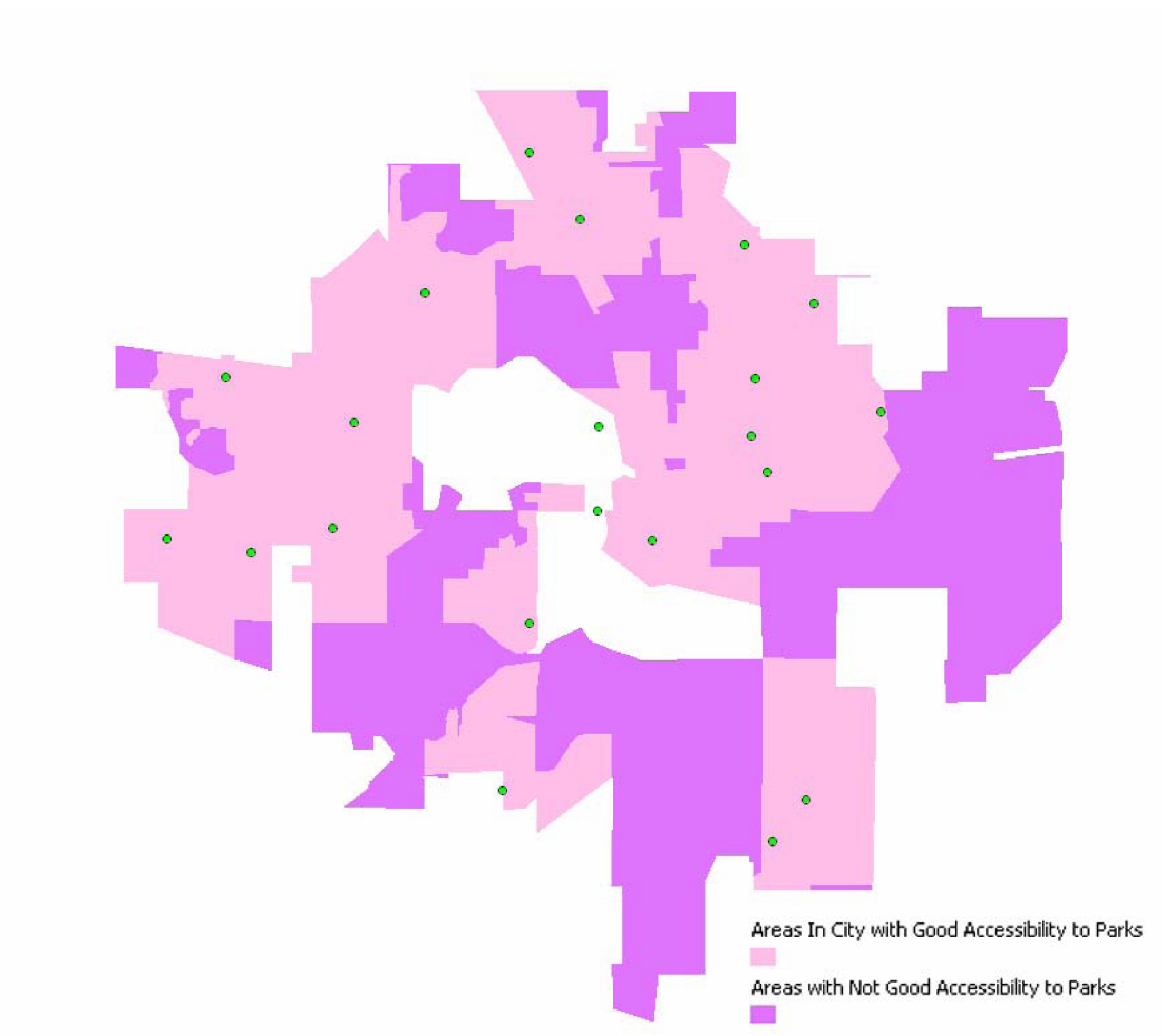

Figure 14: Areas within the city with Good Accessibility to parks using Radius method

Although it is known that this technique provide only an estimate of the true number and characteristics of residents located within the service areas, it is deemed accurate enough for the level of detail likely to be needed by a public leisure services department. The radius method is an example of the covering model of accessibility. Residents within the area have access to a park if they are located within the 0.5 mile distance of parks, but are deemed to have inadequate access if they are not.

This method does have advantages over the computation of ratios of parkland area to population, but several problems are also present. One of the disadvantage highlighted by Nicholls (2001) is that this method can provide only an approximate representation of a park's service area since it assumes 'as the crow flies' movement rather than actual distance between the parks and blocks because in reality potential users cannot travel in straight lines. They move instead along predefined public rights of way, the actual travel distance is always greater than the direct distance. The other disadvantage of this method is that it assumes parks to be open to access at all points along their boundaries, which is not always true. As the size of park increases and the distance between the center and its perimeter grows, underestimation of the service area becomes greater due to the inclusion of the park itself within this zone. The other disadvantage of the radius method is that it does not take into account the park's shape.

However, this method is widely used in planning arena in determining areas served by public services such as transportation, medical service, and parks and so on. Public authorities can easily implement this method if they have access to ArcGIS. The results will give the general idea of which areas have good services and which areas need more attention from public authorities.

4.5 DISCUSSION

Different methods for defining service areas for parks are applied and population and areas served by parks in each method is summarized. The Container approach as criticized by past authors is very vague as it only considers the population inside the block to be the only recipient of the service within the block, whereas in real situation, the service benefits within and outside the block. Only 16 blocks had accessibility to parks by this method while the ratio of parkland to population is lot higher than the National standards for most of the blocks. This may be because of the level of spatial unit of analysis that is use of census block.

The results from the Thiessen polygons are better compared to the container approach, because in this method, all the census blocks are assigned to their nearest park by drawing polygons. So, all population within the blocks is supposed to be served by the park. However, in reality, some of the census block will not have good access to park even within the thiessen polygons, because of their higher distance to parks. Thiessen method completely opts out the distance function in accessibility analysis and is thus only a method of determining the service area for parks and assigning each block to the nearest park service. But in the other hand it is also useful for park departments to see how each park is serving the community and to summarize how many people and housing units are being served by a particular park. This helps determine the importance of the park in that particular area and how it is being utilized by maximum public.

The radius method is best among these three methods applied in determining the service area for parks. The standard distance of 0.5 mile is the recommended distance for parks walkability by the NRPA, so the result based on this minimum distance is acceptable for the communities. About 74 percent of the blocks within the City are supposed to have good access to parks by this method. A half mile buffer of the parks covers almost the mostly populated blocks within the city and thus serves about 65 percent of the population within the city with good access to parks as per the National Recommendation. However, the results from this analysis cannot be deemed totally accurate since the distance is only measured in a straight line (not in actual street networks) and the shape and size of the park is not considered in this method. But, this method is simple and easy to carry out using ArcGIS and thus is an effective tool for planning authorities to generally see which areas in cities lack proper public services such as parks and recreation.

In the next chapter, accessibility and need indexes are defined and ArcGIS is used to derive them.

CHAPTER V: THE INDEXES

In this chapter, the accessibility index and the need index are defined and methods to derive them are described. The indexes are created applying the methods to the Ames Parks. Accessibility and need study requires making some assessment of the accessibility needs of the population. This can be done by calculating the percentage of children, elderly and minorities in the area under the study and making the assumption that, at a minimum the percentage of accessible blocks should be similar to the percentage of the population that could be characterized as having high need for access to parks (Talen, 2003).

Since, the purpose of the study is to look at the variation in access levels for different part of the city and to identify areas with low or high access, it is sensible to make evaluation of pedestrian level accessibility for discussing census blocks level variation of access. By using accessibility measures, one can calculate a neighborhood accessibility index. By using some demographic variables, need index is also calculated. Appropriate indexes developed by Murray and Davis (2001), are used for deriving accessibility and need.

5.1 ACCESSIBILITY INDEX

Potential need for services provides only one component of the analysis of social equity in service provision (Murray and Davis, 2001). An important component in equity analysis is the actual suitable access to these services. The next step in establishing whether there exists a park disadvantage in the given census blocks is to make a comparison of the index of potential need for public parks to a measure of suitable access. The following notation from Murray and Davis (2001) can be used to explain the accessibility index;

τ_i = is the neighborhood accessibility index,

N_i = set of units l in area *i;*

λ_{il} = proportion of population in the blocks (area i) found in neighborhood l;

d = distance between the block groups centroid and the nearest park;

S = minimum standard for access, in this case, 0.5 mile

By using this notation, the index of neighborhood access is defined as follows;

$$\tau_i = \sum_{l \in N_i} \lambda_{il} f(d_l, S) \qquad \text{..................} \ (1)$$

where,

$$f(d_l, S) = \begin{cases} 1 & \text{1 if } (d_l \le S) \\ 0 & \text{0 otherwise} \end{cases}$$

The variable τ_i gives the proportion of the population in the block that is at a minimum distance of 0.5 mile to the nearest park. This index is included only if that block reaches the minimum standard *S*, for access (within 0.5 mile).

In simple words, the accessibility index is composed of the population in the block divided by the total population of the city. This ratio is multiplied by a standard *S*. *S* can be 0 or 1 depending on the distance between the centroid of the block group and the nearest park. If the distance is equal or less than half mile, S is 1, if the distance is greater than half mile, S is zero.

The Accessibility index thus gives the proportion of the population in an area having at least minimum standards of accessibility. The higher the value of the index the better is the accessibility to the parks. This index then is interpreted using the interval scale approach as developed by Murray and Davis (2001). Scaling the index helps in standardizing the data as well as avoiding any values of zero which could impact the exploratory spatial data analysis in the later section. Thus, an index of suitable access coverage would be;

$\psi_i = \{^1_p\}$ where

1 is having good accessibility

p is having worst accessibility

The distribution of the Accessibility index is evaluated in order to appropriately classify the corresponding ψ_i ratings.

For determining the value of *S*, in this case we need to measure the shortest distance between the block centroid and the nearest park. Measurement of distance between two spatial locations can be based on several different metrics. A route can be based on the shortest straight line distance between destination and origin (the Euclidean distance). This is straightforward, but may not approximate actual travel behavior very well. A second approach is to calculate distance along the existing street network, factoring in such attributes as street direction. But the disadvantage is that this approach can be very computationally intensive (Talen, 2003). In this study, the shortest distance is measured between the centroids and the nearest park using the ArcGIS function. Only the Euclidean distance is considered. Once the shortest distance between the origin and the destination are computed, the access index can then be computed and scaled.

5.2 NEED INDEX

While accessibility index is based upon the distance between census blocks and parks, the need index is based on the sociological context of the census blocks. An index based approach for measuring need and evaluating equity issues depends on the variables included, use of processed or interpreted data, weightings used in combining variables and method used to combine variables, - linear or nonlinear (Murray and Davis, 2001).

Lynch (1981) states that access should vary accordingly to population characteristics such as gender, age, income and so on. Women, children, elderly and low income populations are more in need of easy access to services. Beyond the determination of variables to be used as indicators of need, weights could also be assigned. Construction of a need index involves determining what variables are to be used, whether the variables or indicators are equal in importance in determining a measure of need, and how the variables can be combined.

Need index can be deemed from variables such as percentage of population that is under 18 years of age, percentage of population above 65 years, average income of people, percentage of poor household, percentage of household without vehicle at home and so on. In an analysis by Murray and Davis (2001), the need index is constructed using socioeconomic indicators in order to identify suburbs that are potentially in need of public transport. The five indicators used are Young (individuals between 0-16 years), Aged (individuals 65 years and over), Low income earners (those with an income below 300 dollars per week), Households without automobiles and Disabled persons.

In this study because of the constraints on data at the block level, only three variables are used, population non white, population young (below 18 years of age) and population elderly (population at or above 65 years of age). The number of individuals associated with each of these variables is scaled by the total population of the study area. The variables are then scaled in a common scale for linear combinations to derive need index. A multivariate need index can be calculated simply as a linear function of a derived value for each need indicator (Murray and Davis, 2001).

Mathematically, the need index can be specified as;

i = index of geographic areas

j = index of indicators or variables;

w_j = importance weight of indicator j;

R_{ij} = derived value of indicator j in area i;

ϕ_i = measure of relative need.

This notation allows to formally define an index of need for parks as a function;

$$\phi_i = U(R_{il1}, R_{i2}........) \qquad ....(2)$$

Following Murray and Davis (2001), the multivariate need index can be calculated as simply a linear function of a derived value for each need indicator. The specific notation for the multivariate need index is the following;

$$\phi_i = \sum_j w_j R_{ij} \qquad .... (3)$$

In this study, unity weighting is applied to each of the indicator variables. This is done in order to reflect equal importance of each variable and avoid value judgments on the social significance of the indicators (Murray and Davis, 2001). If weights are not used, a derived value can be constructed based on where a particular value falls within a distribution. Each of the need variables could be arranged from high to low, corresponding to high need, low need and so on. Each block groups, then is assigned a score of 1,2,3, or 4, depending on where its value is located in the distribution. Interval values can be assigned in any number of classes and could be based on standard deviations, quantiles, natural breaks and so on

(Talen, 2003). As a general construct, R_{ij} may have the following values and associated interpretation;

$$R_{ij} = \{^{1}_{p}\} \text{where, 1 is least needy and p is most needy}$$

In this study, to create the need index of the variables each one is divided into three groups. Lower values are part of group one and receive a weight of 1. Medium values are part of group two and receive a weight of 2. Higher values are part of group three and receive weight of 3. Therefore high need is expressed by higher values and lower need is expressed by lower values.

Given ϕ_i, the index of potential need for parks and ψ_i the index of suitable access to public parks, the basis for evaluating equity issues in parks services distribution is now formed. After calculating the need index and accessibility index for the census block, need index maps and accessibility maps are created to demonstrate higher needs and lower needs, higher accessibility and lower accessibility.

5.3 APPLICATION

The shortest distance between the park points and blocks is calculated in the ArcGIS. This function takes the block centroids and then identifies the nearest park in terms of distance and measures the distance between them. The distance is then converted from feet to miles. Figure 15, presents the map which shows the distribution of block groups according to the shortest distance from their centroids to nearest park. The lighter areas shows the blocks that have parks nearby, as the color darkens, areas that have greater distance to parks are represented. The darker shades represent areas or blocks that do not have good accessibility to parks in terms of minimum distance when 0.5 mile is taken as the distance that people can walk up to park.

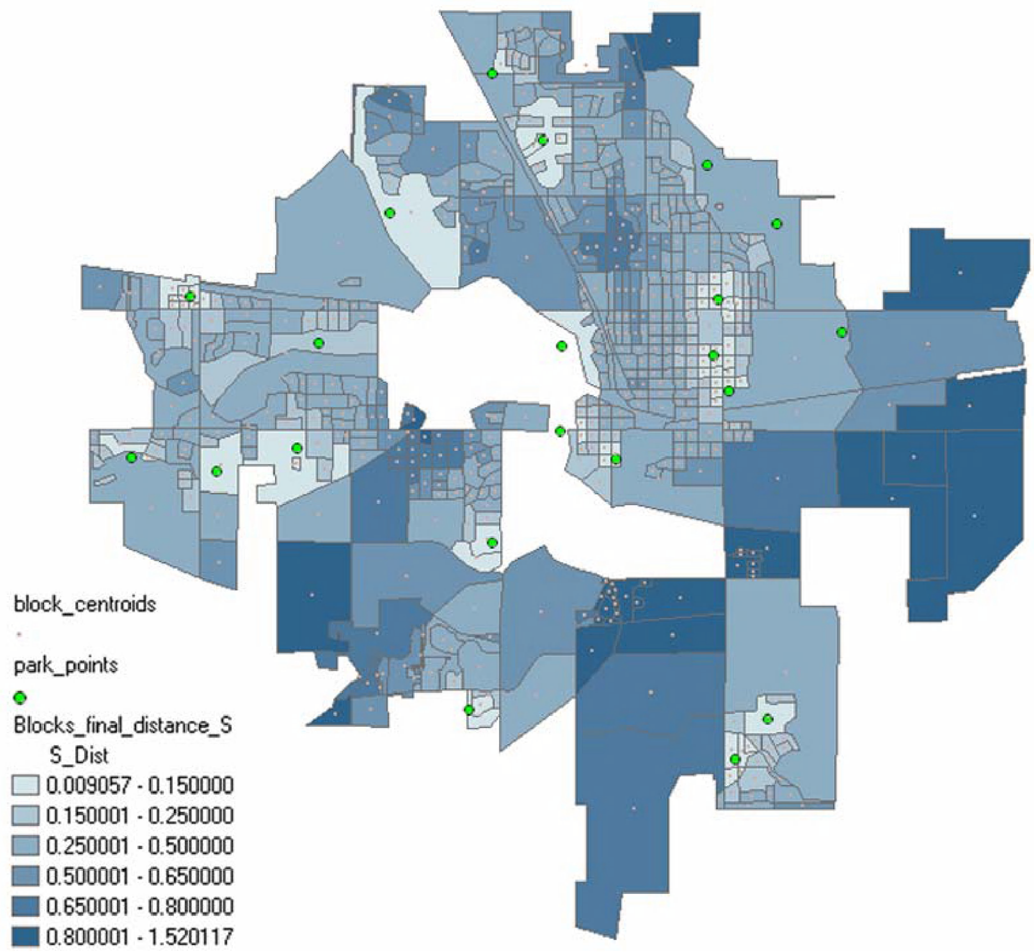

Figure 15: Distance between the block centroids and nearest park in miles

Once the shortest distance between the origin and the destination are computed, using the Euclidean distance, the access index can then be computed and scaled. The Standard [S] is calculated in ArcGIS where S is 1 if the shortest Distance (S_Dist) is less than 0.5 mile. If the shortest distance is greater than 0.5 mile then the value of S will be zero. That is blocks within these area do not even have minimum accessibility standards. The total population in the block is then divided by the total population of the study area. This ratio when multiplied by the [S] factor gives the Index of Accessibility. This Index of accessibility is raw and has to be standardized in order to perform exploratory spatial data analysis. Figure 16 shows the raw Accessibility index derived for the study area using the notation derived by Murray and Davis (2001).

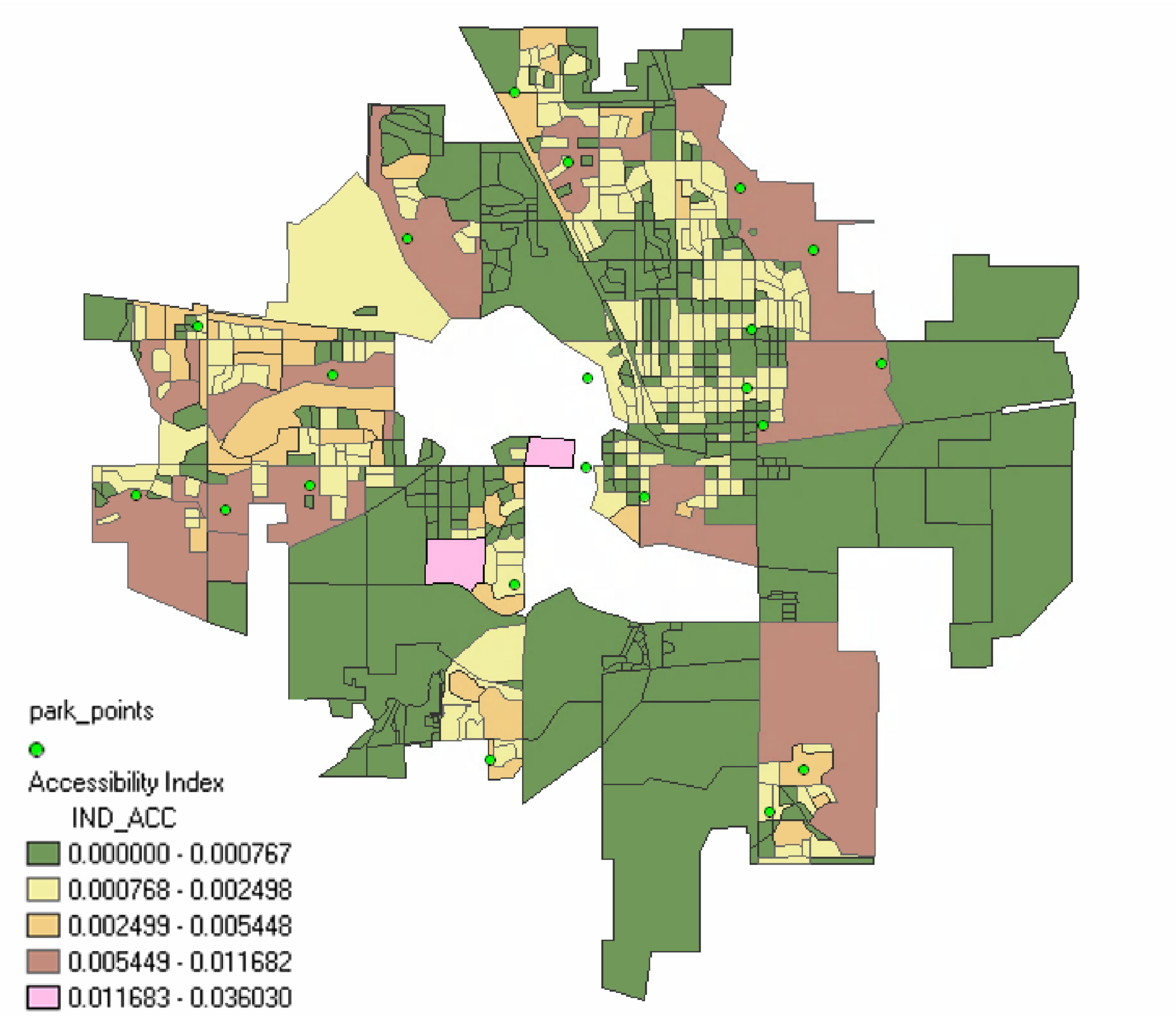

Figure 16: Raw Accessibility Index derived based on Euclidean distance

The figure displays the actual suitable access to public parks afforded to the blocks in City of Ames. The green blocks represent the areas in Ames that have literally no accessibility or very few percentage of population have minimum standard of accessibility to public parks. The areas in yellow are areas where very few percent of population have minimum standard of accessibility. Areas in brown and pink represent blocks where there is significant percent of population that has minimum standard of accessibility. However, even these areas are not defined as areas with very good accessibility, because of the lower percent of population with minimum accessible standard (as we can see that maximum accessibility is 3.6% of population having minimum standard of accessibility).

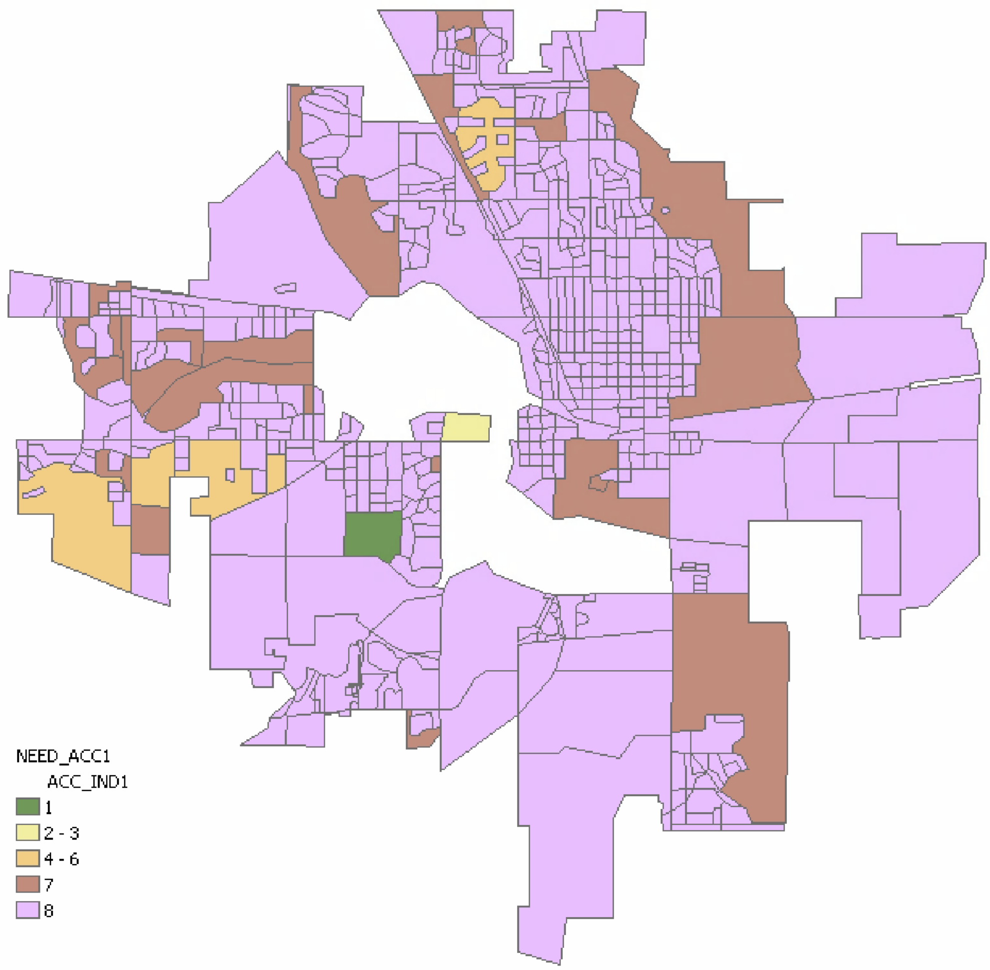

Figure 17: Standardized and scaled Accessibility Index

Fringe areas in the City where the population is the most dispersed clearly have the lowest levels of suitable access to parks. The raw accessibility index ψ_i is standardized using a value of p = 8 and equal intervals. The standardized index value of 8 equates to areas with the greatest proportion of person without suitable access to public parks in relation to the 0.5 mile standard distance. Value of 1 corresponds to the areas where people have some access to parks. The standardized index for access is displayed in Figure 17.

The need index is constructed in this analysis, using three indicators in order to identify blocks that are potentially in need of public parks. The three indicators are; Young population (population below 18 years of age), elderly population (population above 65 years of age) and Nonwhite people (population that is non white). All of the data for these variables are taken from the Census 2000. The number of people associated with each of these variables is then scaled by the total population of the area to create percentages. In this analysis, all the variables are assumed to be of equal importance and are given equal weightings.

The percentages for each variable are then classified into a standard scale. Interval classification of the indicators is based upon a value of p equal to 3. The variables are given a value of 1 when the indicator presents low need, i.e. the total percent of young people below 18, the total percent of elderly people above 65 and the total percent of non white people that is below 5% is termed as group 1 with an indicator value of Need18, Need 65, and NeedNW as 1. Similarly, the variables value above 5% but at or below 20% is considered a medium range and given the indicators value of 2. When the variable value is above 20%, it is considered a significant percent of population and is given a highest range of 3. That is the indicator values of Need 18, Need 65 and NeedNW of 3 represents blocks that has significant number of old, young and non white people and thus demonstrate much higher need in terms of park service than other blocks with low percent of these variables. The maximum and minimum values of need would be then 3 and 9, given that there are three indicator variables, weights equal to 1.0 for each indicator and an interval range of p=3.

The potential need for public parks in the city of Ames using ϕ_i is depicted in Figure 18. The areas with the greatest potential need for the public parks are distributed throughout the city, however, significant clusters with high need can be seen in the North, Southwest and some part of South of Ames.

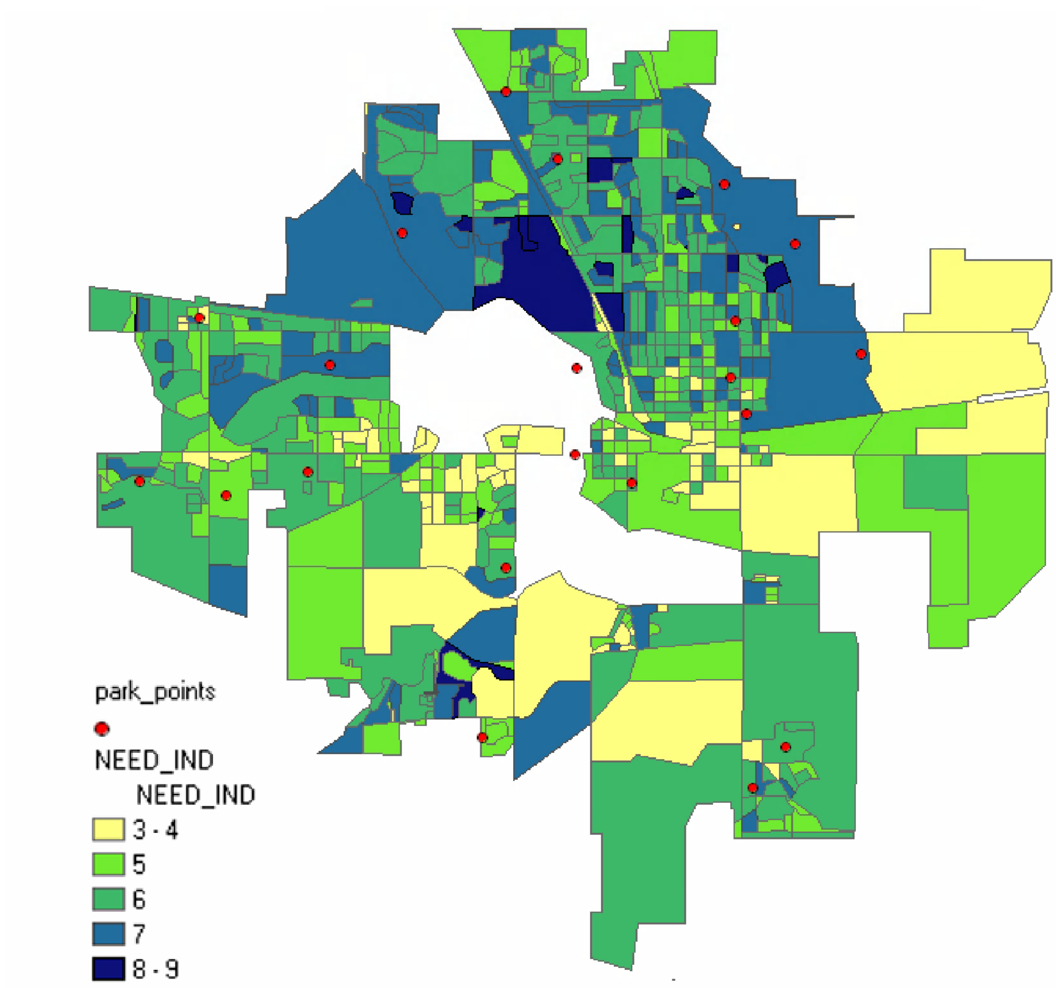

Figure 18: Potential Need for Public Parks in Ames, Iowa

It is interesting to see in the figure, that the fringe areas mostly reflected by the individual bigger blocks in the Southeast and Southwest of Ames contain significant proportions of people with potential need for public parks. These results presented in Figure 16, 17 and 18 can be integrated and compared to see the public park disadvantaged areas. The total population in the census blocks, the accessibility index and the need index are compared in the Figure 19. The accessibility index distribution map shows the areas in darker green shades as the areas with no or very less accessibility. The Need map shows the distribution of need index in the city where the darker shades display a greater need for public parks depending on the type of the population characteristics. The population distribution map displays the distribution of population in the city with the darker shades representing blocks having higher population and lighter shades representing blocks with low population.

When we visually look at these maps, we can see there is some relationship between the need and accessibility and the population distribution in the area. We can similarly create maps for variables used in the derivation of need index to see if they do complement each other. A map with the distribution of population below 18 years of age compared to need map and accessibility map will show if there is a higher need in the areas where there is greater proportion of young people and if such areas currently have any level of accessibility to public parks. Such comparison can be also done for proportion of non white people in the blocks and proportion of old people in the blocks.

Though it is possible to do lot of analysis within ArcGIS and see the effect of one variable on the need and accessibility, this study limits the use of ArcGIS analysis in further analysis, and presents Exploratory Spatial Data Analysis and Raster Analysis as easy techniques for understanding the spatial locations of the variables within the study area as they relate to the derived value of need and accessibility indexes and their significance.

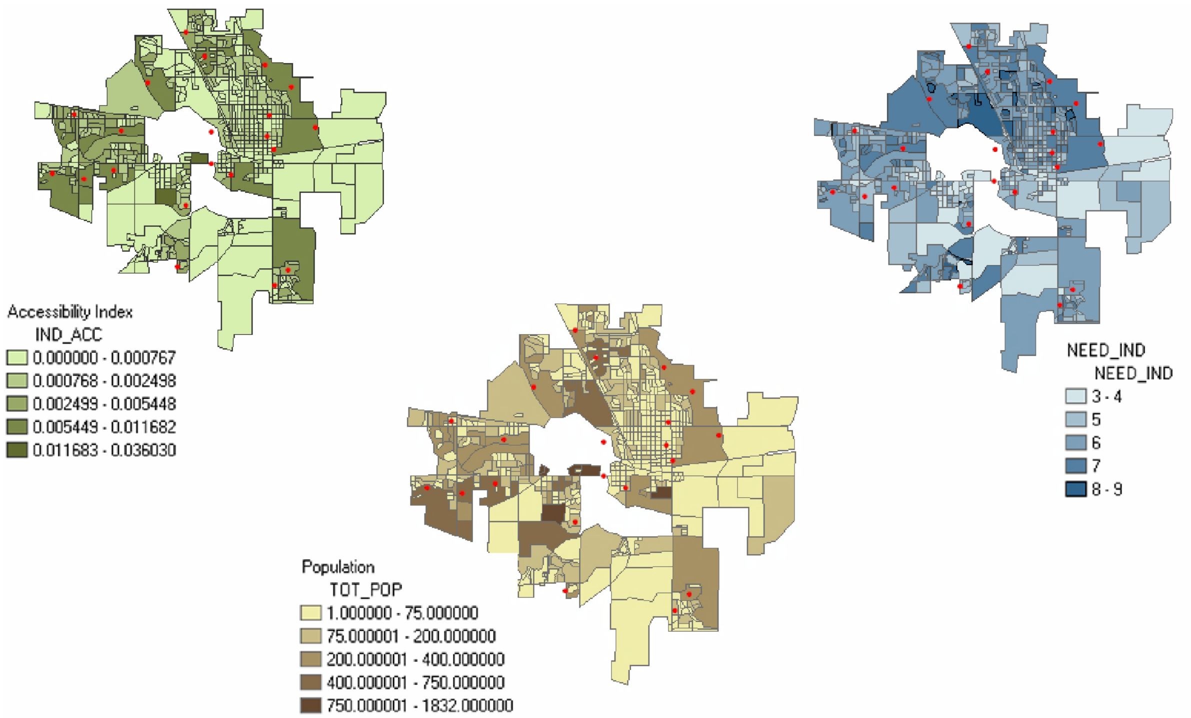

Figure 19: Distribution of population, potential need and current level of accessibility

5.4 DISCUSSIONS

The need and accessibility index calculated and presented in maps are easier and accurate methods for determining the current level of accessibility as well as the potential need for public services in the blocks or in the neighborhood. It is useful to see how many blocks within the city have current minimum level of accessibility as based on NRPA's recommendation of 0.5 mile as acceptable distance for walking between parks and residences. The accessibility measured could be made more accurate by applying some other distance measuring techniques which measures the actual distance between the public parks and the blocks based on the street networks and the access points to parks (Nicholls, 2001).

Distance could be measured by using Geometric Networks function in ArcGIS, but because of time and data constraints, this method could not be applied in the current study.

The need index created and displayed in the maps, present a need based approach in providing services to residents. Depending on the characteristics of the population, the need of the population varies and it is important for planners to see that these varying needs for different groups of population are considered in the study and not excluded. However, it is always not possible to get the detailed data on the population characteristics, because of the level of the spatial unit of analysis. The Census data for the income and poverty and vehicle occupancy is not available at the block level, and thus this study could not consider the need for those population defined by characteristics such as low income and no vehicle. However, using the block groups as unit of analysis was not feasible in this case, because of the low number of spatial units and also because of the extension of the units outside the city and the 2 mile planning area in the fringe.

Thus, by measuring the shortest distance between the parks and the blocks, accessibility index can be measured. ArcGIS functions help in performing this action easily. Similarly, using some demographic variables that define those in need of park services, need index can be calculated and mapped in ArcGIS. The accessibility and need index maps help identify the sectors in the city that have higher needs, lower needs, higher accessibility and lower accessibility.

The need and accessibility indexes are used to perform Spatial Analysis (Raster Analysis) and Exploratory Spatial Data Analysis (ESDA) in the next chapter.

CHAPTER VI: SPATIAL ANALYSIS

In this chapter, the accessibility index and the need index are used to perform Spatial Analysis to see their relationship in space. Spatial Analysts (Raster Analysis) and Exploratory Spatial Data Analysis are used to determine the areas in Ames that have high need and high accessibility to public parks. Exploratory Spatial Data Analysis (ESDA) helps to identify the spatial relationship between the need and the accessibility and tests their significance. Raster Analysis helps in identifying areas with high need and high accessibility and high need and low accessibility.

6.1. EXPLORATORY SPATIAL DATA ANALYSIS

As stated by Talen (1998) evaluating access is significant for considering spatial equity issues and addressing questions of whether access to services is discriminatory or not. Such enquiries might entail an examination of the extent to which there is a spatial pattern to varying levels of access and whether that spatial pattern varies according to spatially defined socioeconomic patterns (Talen, 2003). Exploratory Spatial Data Analysis can be used to identify the variation in level of access and need of the census blocks and identify any type of spatial autocorrelation between these indexes. Exploratory spatial analysis very much compliments the purposes and functionality of GIS (Murray *et al,* 2001).

ESDA is a set of techniques aimed at describing and visualizing spatial distributions, at identifying atypical locations or spatial outliers, at detecting patterns of spatial association, clusters or hot spots and at suggesting spatial regime or other forms of spatial heterogeneity (Gallo, 2003). In this study, spatial data analysis techniques are used to compare (i.e. map) the spatial relationships. ESDA is used to study the spatial distribution of the indexes and relate them to the degree of accessibility and levels of spatial equity. Local tests are performed for determining the spatial autocorrelation between the need and accessibility indexes.

Spatial Weight Matrix

It is necessary to define a spatial weight matrix W to conduct ESDA (Haddad, 2006). Spatial weight matrices are first created where each unit is connected to a set of neighboring sites, therefore the way the characteristics of each unit are compared to those of its neighbors is directly taken into account. Various spatial weight matrices have been considered in the literature like simple binary contiguity matrices, distance based, nearest neighbors and so on (Guillain *et al*, 2004). The simple binary queen contiguity matrix is composed of 0 and 1: if district i have a common boundary and/or vertex with district j, then they are neighbors and w_{ij} is1; and if unit i does not have a common boundary and/or vertex with unit j, they are not neighbors and w_{ij} is 0.

Nearest neighbor matrices are computed from the distance between the units' centroids and imply that each spatial unit is connected to the same number k of neighbors, wherever it is localized (Guillain *et al*, 2004). The general form of a k-nearest neighbor's weight matrix W (k) is defined as;

$$w_{ij}^{*}(k) = 0 \quad \text{if} \quad i = j$$

$$w_{ij}^{*}(k) = 1 \quad \text{if} \quad d_{ij} \le d_{i}(k) \quad \text{and} \quad w_{ij}(k) = w_{ij}^{*}(k) / \sum_{j} w_{ij}^{*}(k) \ldots\ldots\ldots\ldots(1)$$

$$w_{ij}^{*}(k) = 0 \quad \text{if} \quad d_{ij} > d_{i}(k)$$

where, $w_{ij}(k)$ is an element of the unstandardized weight matrix; $w_{ij}(k)$ is an element of standardized weight matrix and $d_i(k)$ is a critical cut-off distance defined for each unit i. More precisely, $d_i(k)$ is the k^{th} order smallest distance between unit i and all the other units such that each unit i has exactly k neighbors. Since the average number of neighbors in this case is four, the results are presented with $k = 4$. The spatial data analysis is carried out with the simple contiguity (queen) and 4 nearest-neighbors matrices to check for the robustness of the results.

Spatial Autocorrelation

ESDA provides statistical tests aimed at indicating if the global and local spatial autocorrelation are significant. Measurement of global spatial autocorrelation is usually based on Moran's I statistics. Positive autocorrelation indicates that areas with similar values tend to be spatially clustered in space. According to Anselin (2001), spatial autocorrelation can be defined as the coincidence of value similarity and locational similarity. Therefore there is positive spatial autocorrelation when high or low values of a random variable tend to cluster in space. For example, blocks with high (or low) need are surrounded by blocks with high (or low) need, and patterns of clustering in the study area can be observed. There is negative spatial autocorrelation when geographical areas tend to be surrounded by neighbors with very dissimilar values, i.e. when high values correlate with low neighboring values and low values correlate with high neighboring values and no clustering pattern can be observed. Spatial heterogeneity implies unstable relationships between values of observations, and detectable spatial regimes.

Spatial autocorrelation can be detected using ESDA. According to Guillain (2004), "ESDA can be used to describe spatial distributions in terms of spatial association patterns such as global spatial autocorrelation, local spatial autocorrelation and spatial heterogeneity" (p.11). Result of global spatial autocorrelation needs to be refined and spatial clustering of high values and spatial clustering of low values need to be distinguished. ESDA help assess local spatial autocorrelation in the sample. In this study, Local Indicators of Spatial Autocorrelation (LISA) are used. LISA statistics explicitly allow comparing the value in one location to the value of neighboring locations.

Local Spatial Autocorrelation

Moran Scatter plots and Local Indicators of Spatial Autocorrelation (LISA) statistics can be used to assess local spatial autocorrelation. These reveal the structure of spatial autocorrelation within the city, by identifying local clusters of high or low values.

Moran scatterplot allows detecting the local spatial instability in the sample; however, they do not allow assessing the statistical significance of such spatial association. According to Anselin (1995), LISA satisfies two criteria: first, the LISA for each observation gives an indication of significant spatial clustering of similar values around that observation; second, the sum of the LISA for all observations is proportional to a global indicator of spatial association. Therefore, LISA maps are created for the need and accessibility indexes to determine High Need and High Accessibility, Low need and Low Accessibility, High Need and Low Accessibility and Low Need and High Accessibility.

Anselin (1995) defines a Local Indicator of Spatial Association as any statistics satisfying two criteria; first the LISA for each observation gives an indication of significant spatial clustering of similar values around that observation; second the sum of the LISA for all observations is proportional to a global indicator of spatial association.

The LISA is defined as:

$$I_i = \frac{(x_i - \mu)}{m_o} \sum_j w_{ij}(x_j - \mu) \qquad \text{with} \qquad m_o = \sum_i (x_i - \mu)^2 / n$$

where, x_i is the observation in unit i, μ is the mean of the observations across units and where the summation over j is such that only neighboring values of j are included. Anselin (1995) describes that, positive values of I_i indicate spatial clustering of similar values (either high or low), and negative values of I_i indicate spatial clustering of dissimilar values (for example, blocks with high values of indexes surrounded by neighbors with low values).

6.2 APPLICATION OF ESDA

Exploratory Spatial Data Analysis is performed using the software Geoda 9.5. Geoda 9.5 is available for downloading and is useful in analyzing spatial relationships between variables. The Local Indicators of Spatial Association (LISA) concept is applied. LISA-based patterns are derived for Need Index and Accessibility Index, using the pseudo-significance level of one percent. The results are presented in the LISA Cluster Maps using matrices; the rook matrix, the queen matrix and the four nearest neighbors' matrix. The appropriate choice of a spatial weight matrix is still one of the most difficult and controversial methodological issues in spatial statistics and econometrics. Choice can be based on the geographical characteristics of the spatial area. In this study, several weight matrices are tried. Simple contiguity matrices such as queen and rook and nearest neighbor matrices are used and the robustness of the results tested.

LISA statistics are computed and their significance evaluated according to the approach. The p-values obtained for the local Moran's statistics are actually the pseudo significance levels. LISA maps for need and accessibility are shown in figures below. LISA results are very sensitive and thus should be checked for their significance. Their significance is tested for the pseudo significance of 0.01 to imply the robustness of the results. The LISA maps for the accessibility index using the rook, queen and the 4 nearest neighbors are displayed in Figure 20. These maps are tested for pseudo significance of 0.01.

When we look at the LISA map for accessibility index, there is no clustering of high values of accessibility surrounded by neighboring high values of accessibility. There are no significant high-high or low-low clusters. We can see clustering of low accessibility surrounded by low accessibility in the LISA Cluster Map using rook matrix. This cluster is significant in North part of Ames.

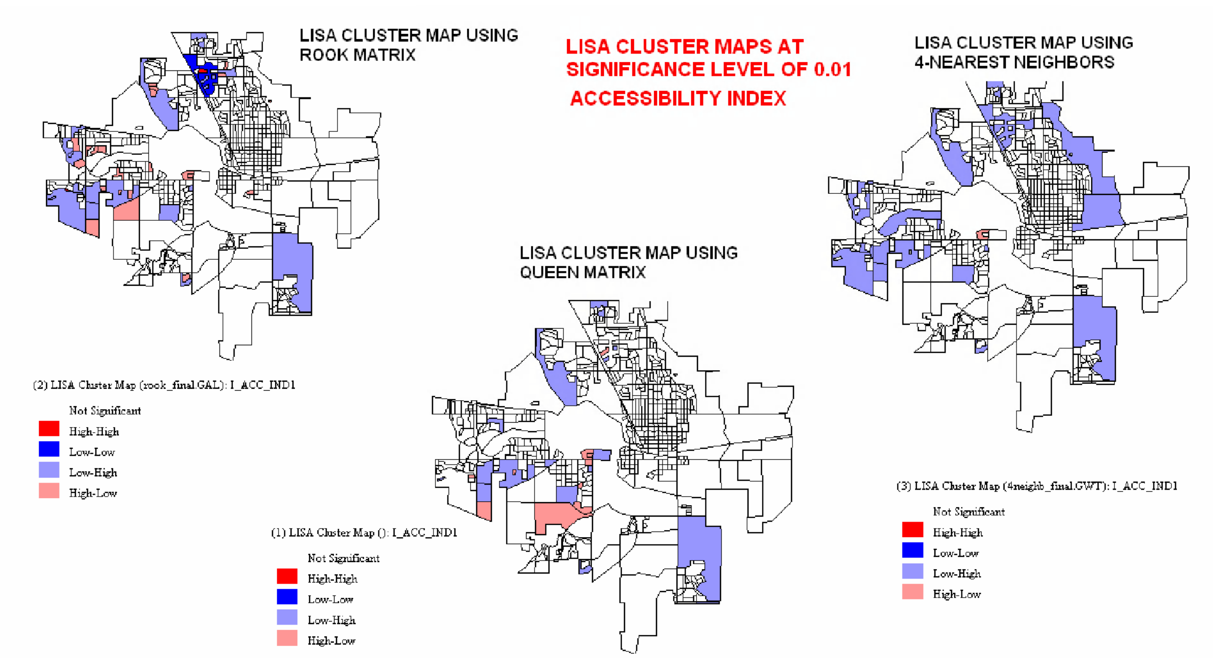

Figure 20: LISA maps for Accessibility Index using rook, queen and 4 neighbor matrices

If we look at Figure 20, we can see the areas in purple that are low values of accessibility surrounded by high values of accessibility for neighbors. The areas in pink are the blocks with high accessibility surrounded by neighbors with low accessibility.

The LISA maps for the need index using the rook, queen and the 4 nearest neighbors are displayed in Figure 21. These maps are tested for significance at the significance scale of 0.01. The LISA maps depict the presence of some clustering of high need surrounded by the neighboring values of high need. Also, some clusters of low need are visible in the figure. We can observe the high need blocks surrounded by neighboring blocks of high need on the northern part of Ames which are shown in red. The red clusters are the areas which have high need index surrounded by neighbors with high index. The clusters in blue depict the areas whose need index is low and are also surrounded by the neighbors with low need for parks. The pink clusters display areas of high need surrounded by areas of low need and the purple cluster displays area of low need surrounded by the areas of high need.

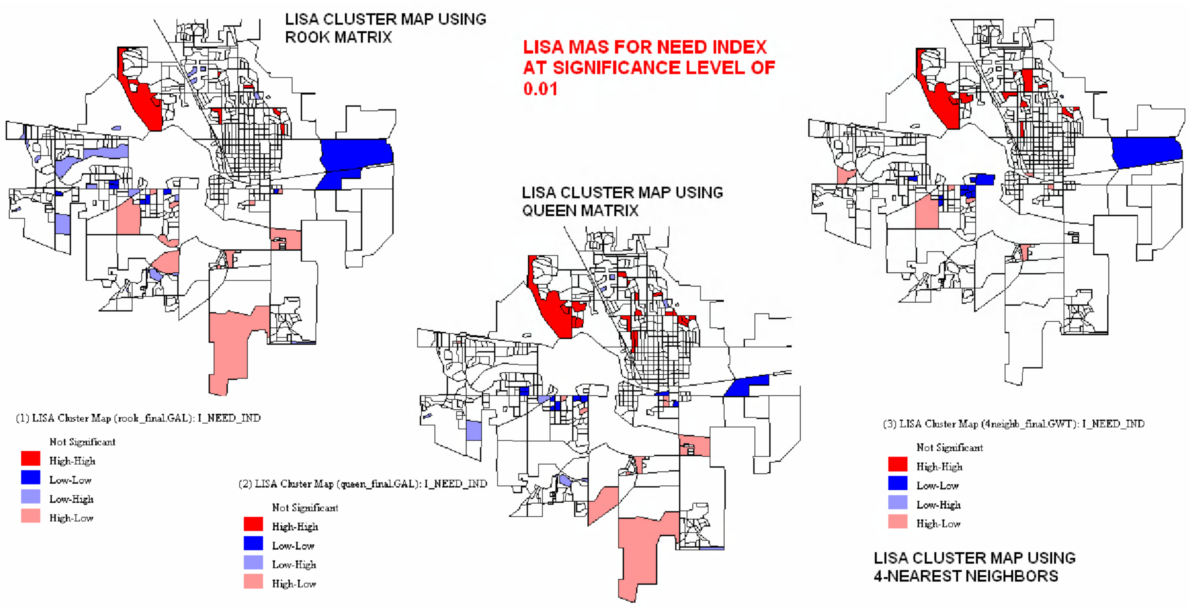

Figure 21: LISA maps for Need Index using rook, queen and 4 neighbor matrices

Finally, a bi-variate LISA is performed to analyze need and accessibility and to identify clusters of high need surrounded by high accessibility, low need surrounded by low accessibility, high need surrounded by low accessibility and vice versa.

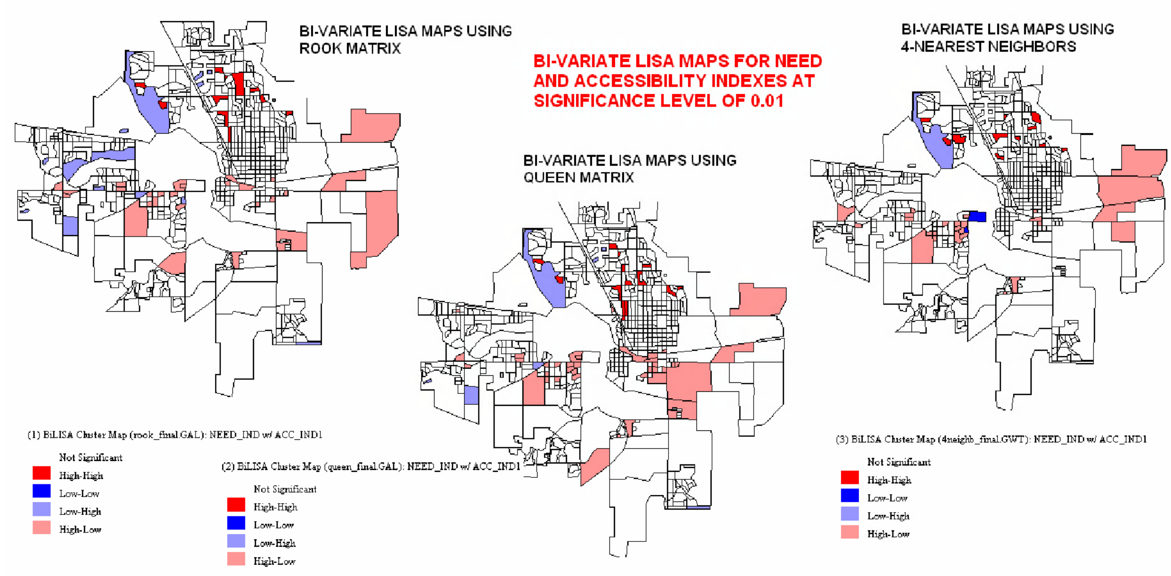

Figure 22: Bivariate LISA maps for Need and Accessibility Indexes

Figure 22, displays the results from the bi-variate LISA for Need and Accessibility Index. The clusters in red are the areas with high need for parks surrounded by neighbors with high accessibility to parks. The areas in blue are the ones with low need for parks surrounded by neighbors with low accessibility to parks. The figure displays only those clusters that are significant at 0.01 significance level only. High-High clusters are obvious in North of Ames. The pink clusters depict the areas of high need surrounded by neighbors with low accessibility. These are significant in Northeast and Southwest Ames.

5.3 RASTER ANALYSIS

After testing for local spatial autocorrelation, the need index and accessibility index are converted to raster layers and reclassified into a common scale. By using spatial analyst extension of the ArcGIS, the need index feature is converted to a raster. The raster is then reclassified in a common scale. Higher need is determined by block groups with higher need index values. Need index is then reclassified into 1, 2 and 3 where 1 represents the census blocks where there is a low need for parks, 2 represents medium need and 3 represents high need. From the reclassified raster, only the block groups that have high need or reclassified value of 3 are extracted to get high need areas. Similarly, the census block groups that have low accessibility and high accessibility are extracted separately. Since both the need raster and accessibility raster are reclassified into a standard scale now, these two rasters are then combined to get the areas that have high need with high accessibility and high need with low accessibility.

By using Map algebra function from the Spatial Analyst, the two raster are combined producing the areas in the city that have high need and low accessibility for parks. The final raster is then overlaid over the existing parks features, street networks and census block features to identify areas within the city that have low accessibility to parks, but because of the demographic characteristics within the blocks, the need for parks is high. Similarly, areas with high need and high accessibility are identified.

The combined layer which demonstrates areas within the city that have high need and high accessibility and high need and low accessibility to parks when overlaid over the land use and the parks and recreation master plan of Ames, helps to answer the research questions. This analysis helps to determine how the current parks are doing in terms of service provision. Also important is that the analysis helps to see whether the future sites of parks are in the localities that we have identified as having low access to parks currently. It also helps to see whether the future locations will help address the needs determined by the demographic characteristics of the blocks.

6.4. APPLICATION OF RASTER ANALYSIS

Spatial Analysts is an extension within ArcGIS which can be used to perform raster analysis. The need index and the accessibility indexes are converted to raster and the spatial analysis procedures are performed to extract and identify those area within the study boundary that has currently high accessibility and high need and low accessibility and high need. It is possible to perform this analysis and get the results using the Geoprocessing tools within the ArcToolbox; however, it is a long process. Raster analysis can ease this process, by use of some simple functions within Spatial Analyst toolbar. The converted accessibility index and need index raster are shown in Figure 23 and 24.

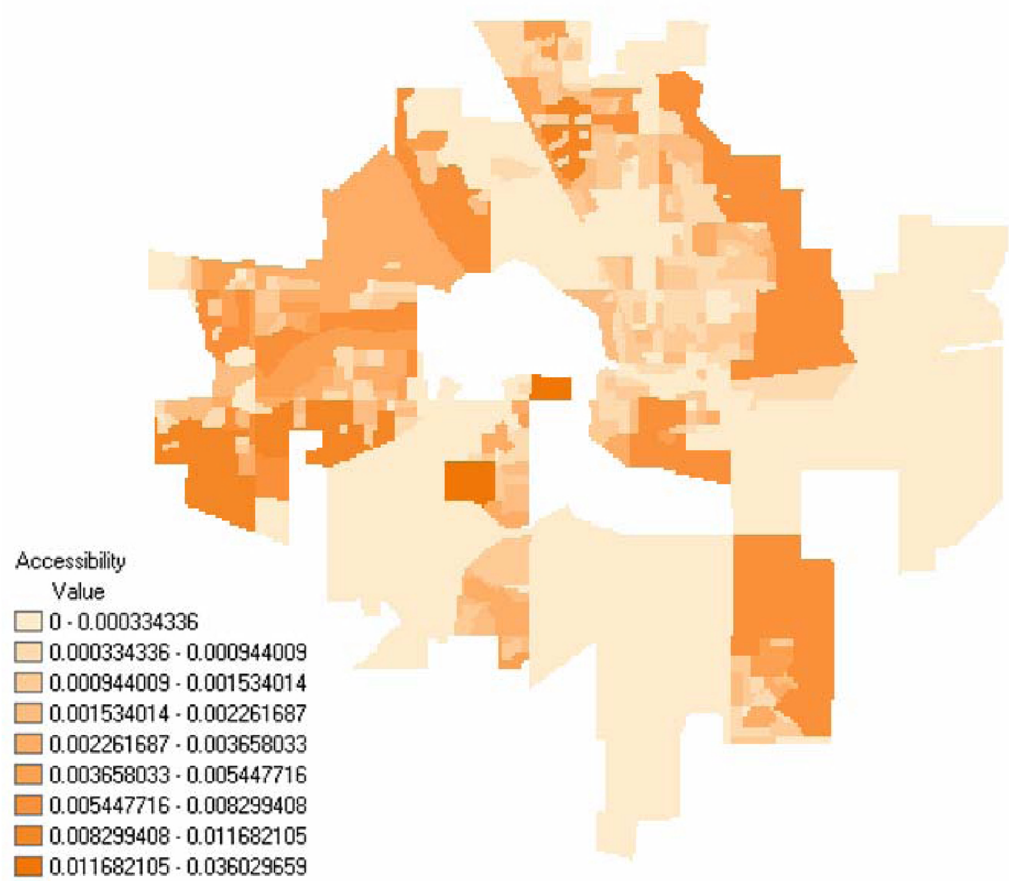

Figure 23: Accessibility raster

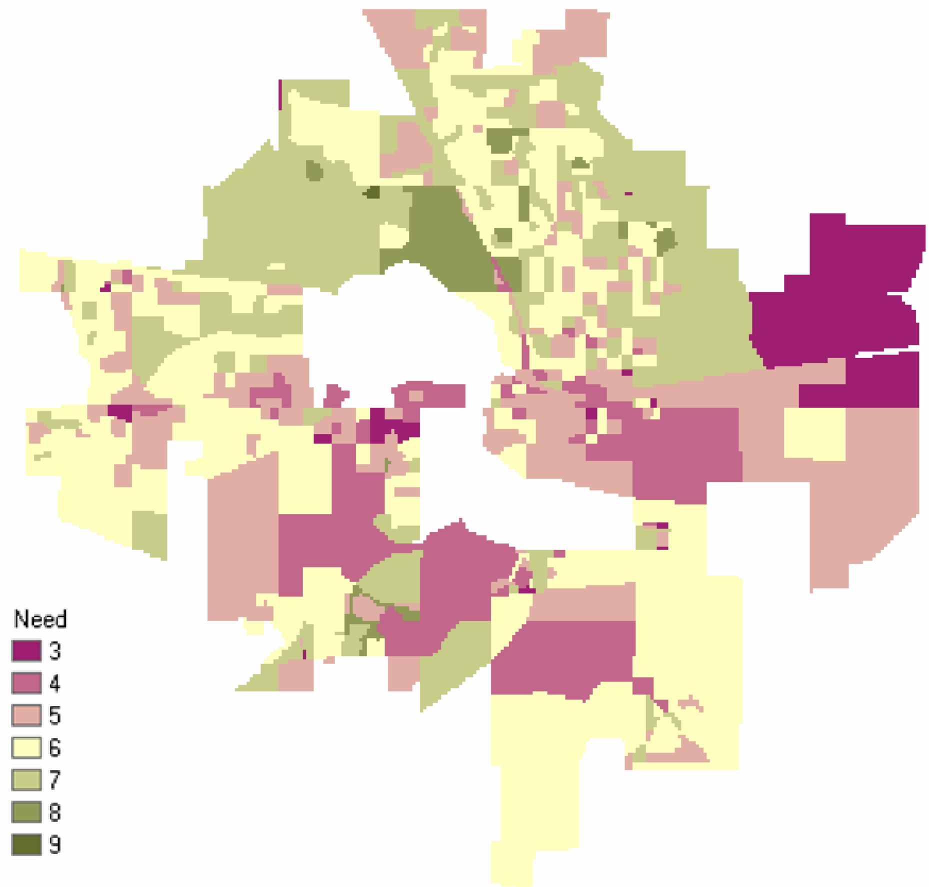

Figure 24: Need Raster

In Figure 23, the darker shades of orange shows areas with higher accessibility and the lighter shades demonstrate areas with low accessibility. In the Figure 24, the purple shades are areas with low need for parks and green shades are areas with high need for parks.

The raster are reclassified using the Spatial Analyst toolbox. Spatial Analyst Extension should be turned on before we can use any of the tools within the Spatial Analysts. The Accessibility index is reclassified as low accessibility with a value of 1, medium accessibility as value of 2 and a high accessibility of 3. The accessibility indexes are reclassified as 3 illustrating that these areas have at least minimum standards of accessibility. The reclassified accessibility indexes with all values are displayed in the Figure 25.

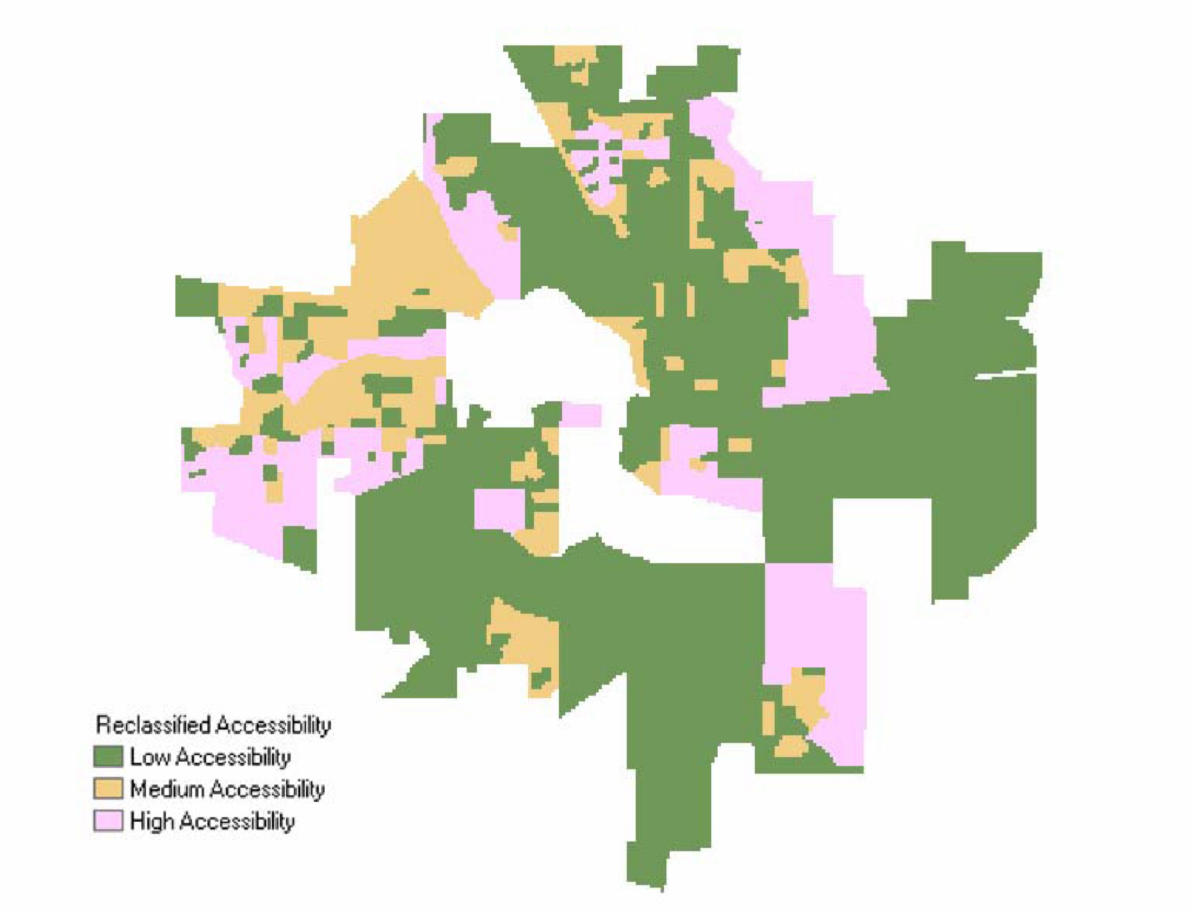

Figure 25: Reclassified Accessibility

The need index is also reclassified using the spatial analyst tool. The need index is reclassified such that the values of 3 and 4 represent the low need for public parks and thus are reclassified as 1 (low need). The need index value of 5 and 6 are reclassified as medium need. The need index values of 7, 8 and 9 are reclassified as a value of 3 demonstrating high need for public parks. The reclassified need index with a value of 1 (low need), 2 (medium need) and 3 (low need-high access) are displayed in Figure 26.

From the reclassified raster areas with high need, low need, high accessibility and low accessibility can each be extracted as separate layers in ArcGIS. This requires using the Extraction by Attribute function in the Spatial Analyst toolbox.

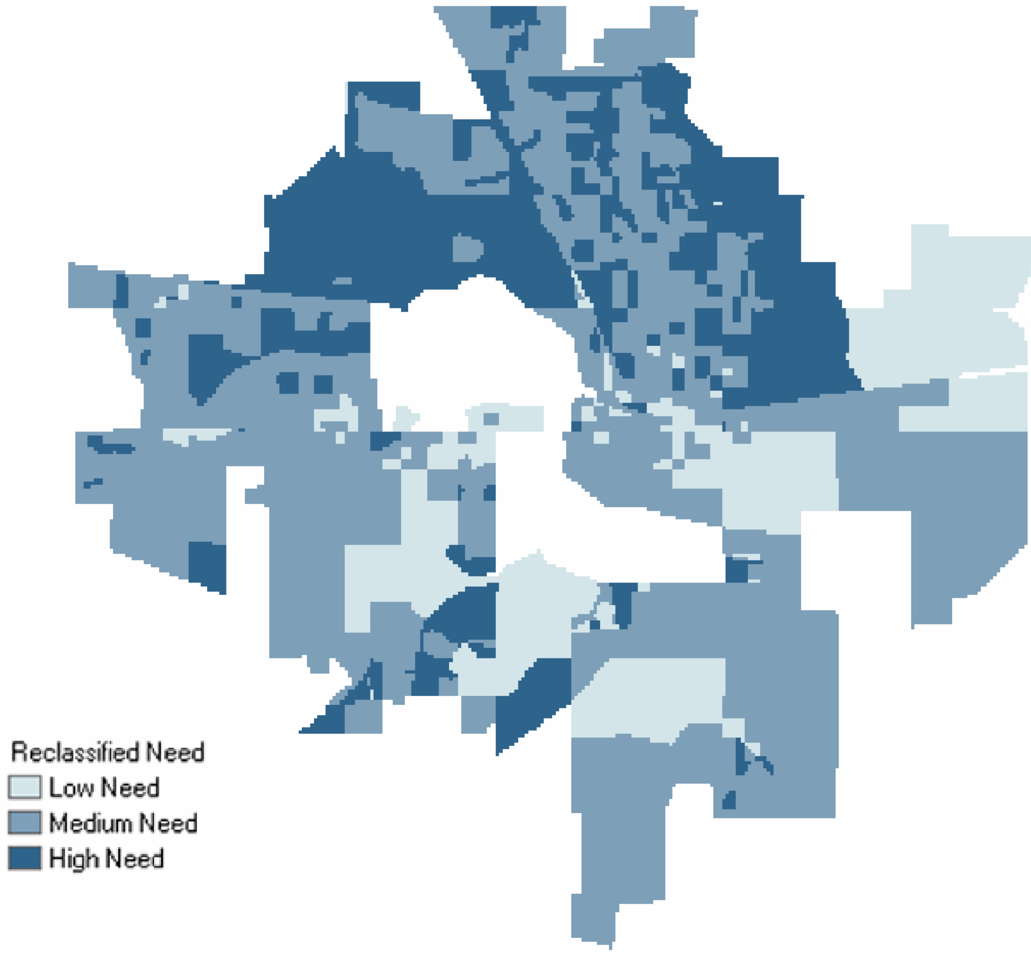

Figure 26: Reclassified Need

From the reclassified accessibility raster, only the cells with the value of 3, i.e. high accessibility are extracted at first and a separate layer is created. Similarly, another extraction is performed for low accessibility using the value of 1. From the reclassified need raster, cells with the value of 3 are extracted to get high need areas. Similarly, cells with value of 1 are extracted to get low need areas in the city. Figure 27, shows the high need areas in the City of Ames. Figure 28, shows the high accessibility areas in the city. Similarly, Figure 29 demonstrates the low accessibility areas and Figure 30 displays low need areas.

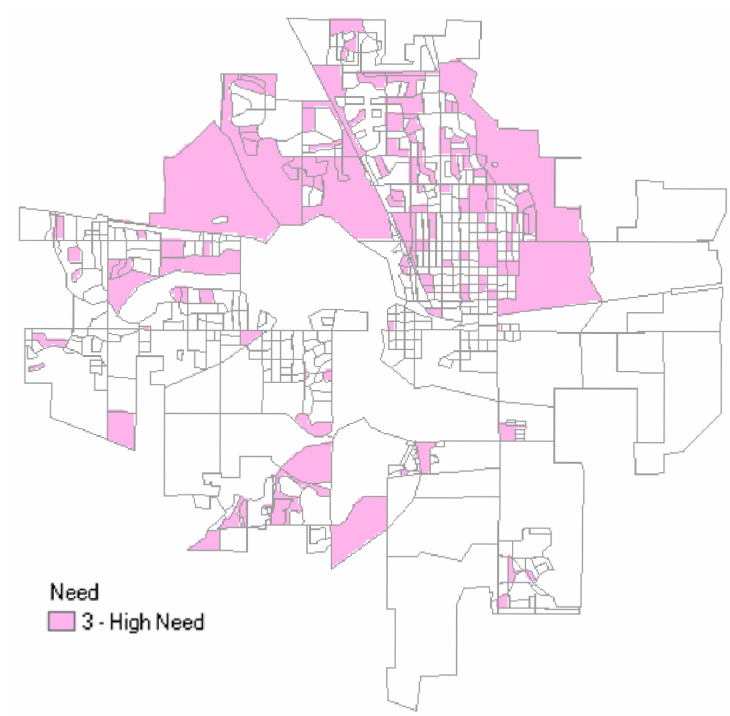

Figure 27: Extracting High Need

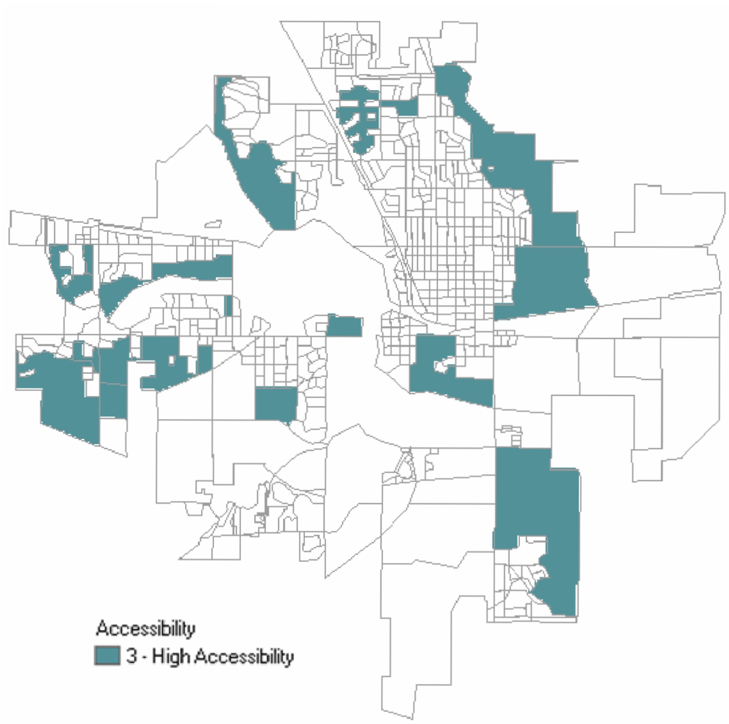

Figure 28: Extracting High Accessibility

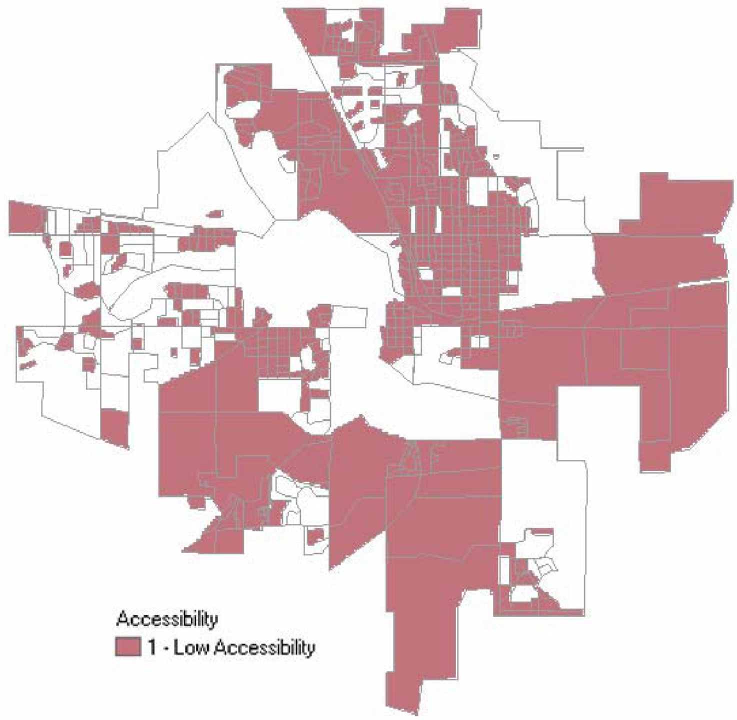

Figure 29: Extracting Low Accessibility

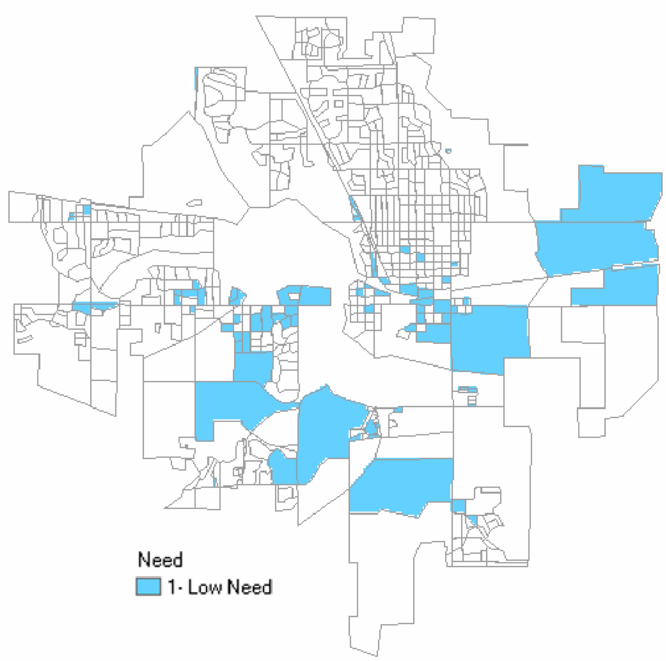

Figure 30: Extracting Low Need

For need, the extraction is done using the attribute value of 1 for low need and 3 for high need. Now that we have high need, low need, high accessibility and low accessibility area defined, we can combine the raster to get areas with high need and high accessibility and high need and low accessibility. By using Map algebra function from the Spatial Analyst, the high need and high accessibility raster are combined producing the map for the areas in the city that have high need and higher accessibility. Figure 31 displays the areas with higher need for public parks and provided with higher accessibility.

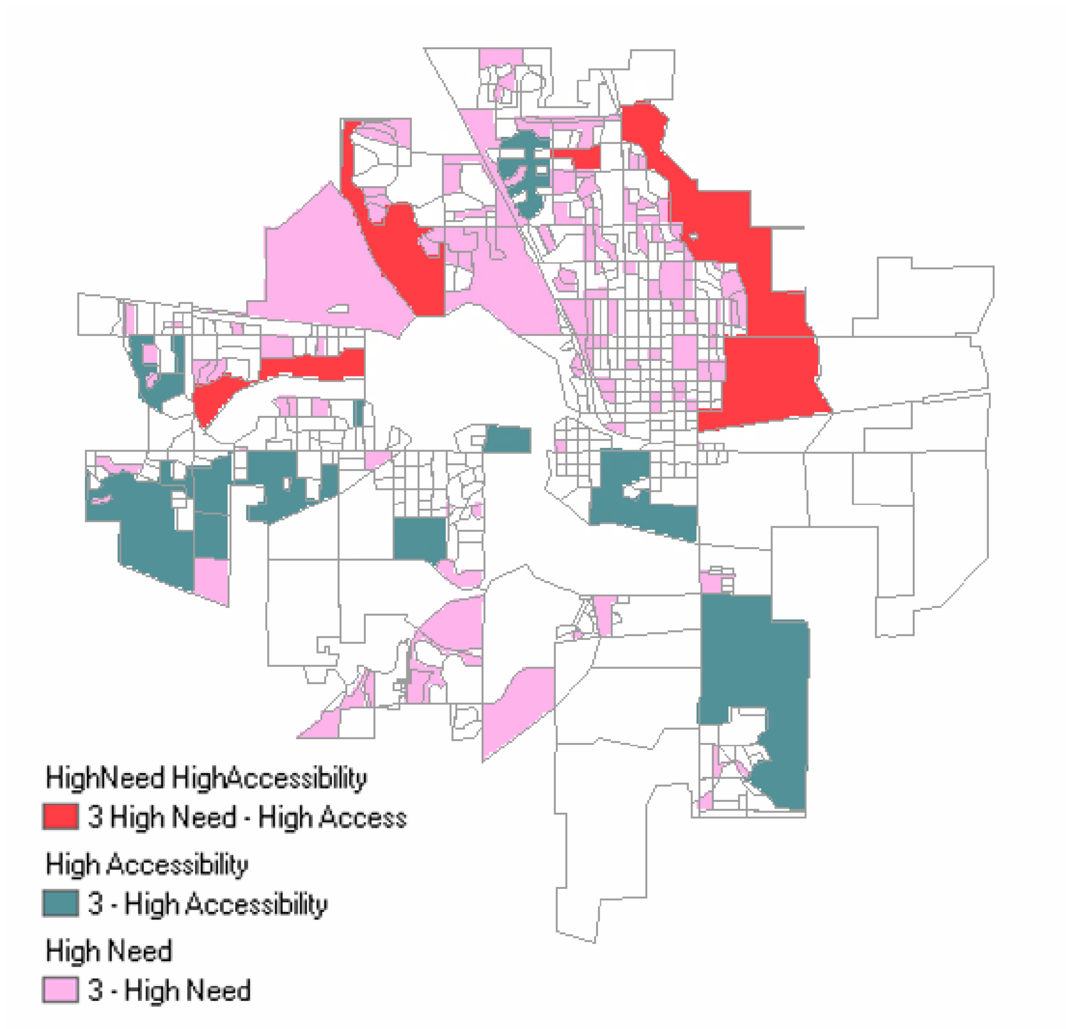

Figure 31: Areas with High Need for Public Parks having Higher Accessibility

Figure 32, displays the areas in Ames that are identified as the areas with high need but correspondingly low accessibility at the current situation.

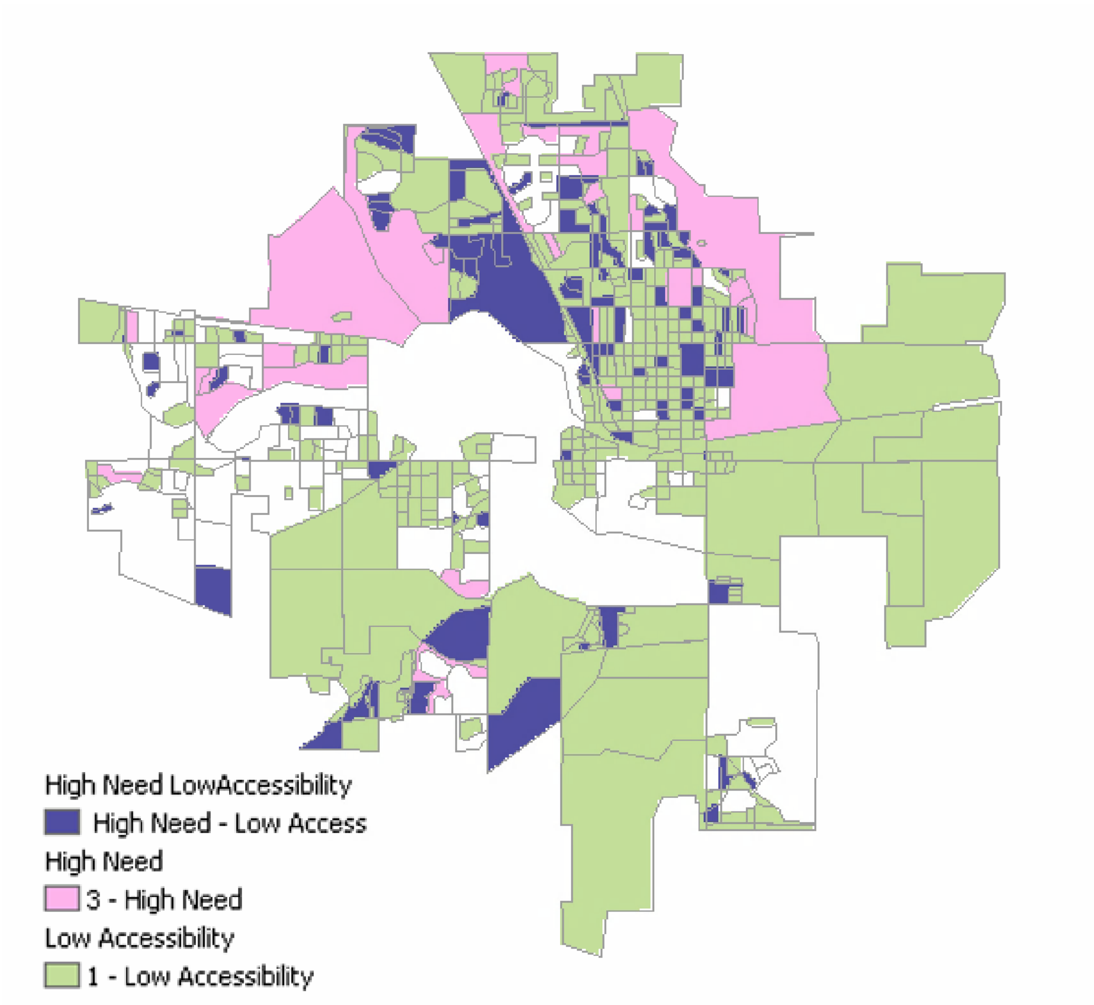

Figure 32: Low accessibility and High Need Areas

When overlaid over the street networks, census blocks and existing parks, the census blocks that falls within the high need – high accessibility and high need - low accessibility zones can be identified. Thus by using spatial analyst, it is much easier to identify these areas. Figure 33, demonstrates the neighborhoods in Ames that have currently high need and high accessibility to parks and also high need and low accessibility to parks.

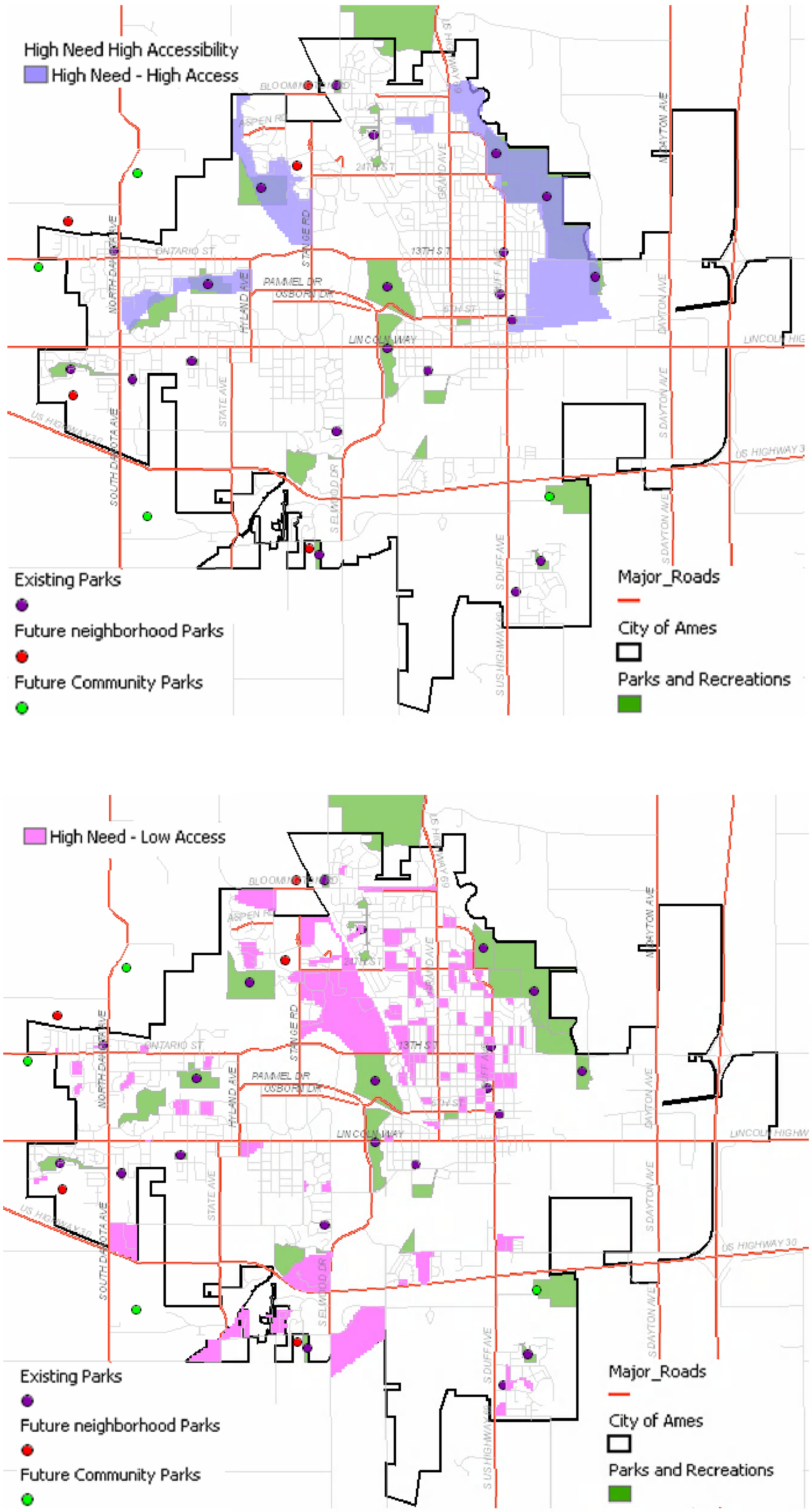

Figure 33: Neighborhoods according to Need and Accessibility

Finally, the future parks are overlaid over the neighborhoods identified as low accessibility and high need and high accessibility and high need for parks. Figure 34 displays the future locations of the parks and the neighborhoods.

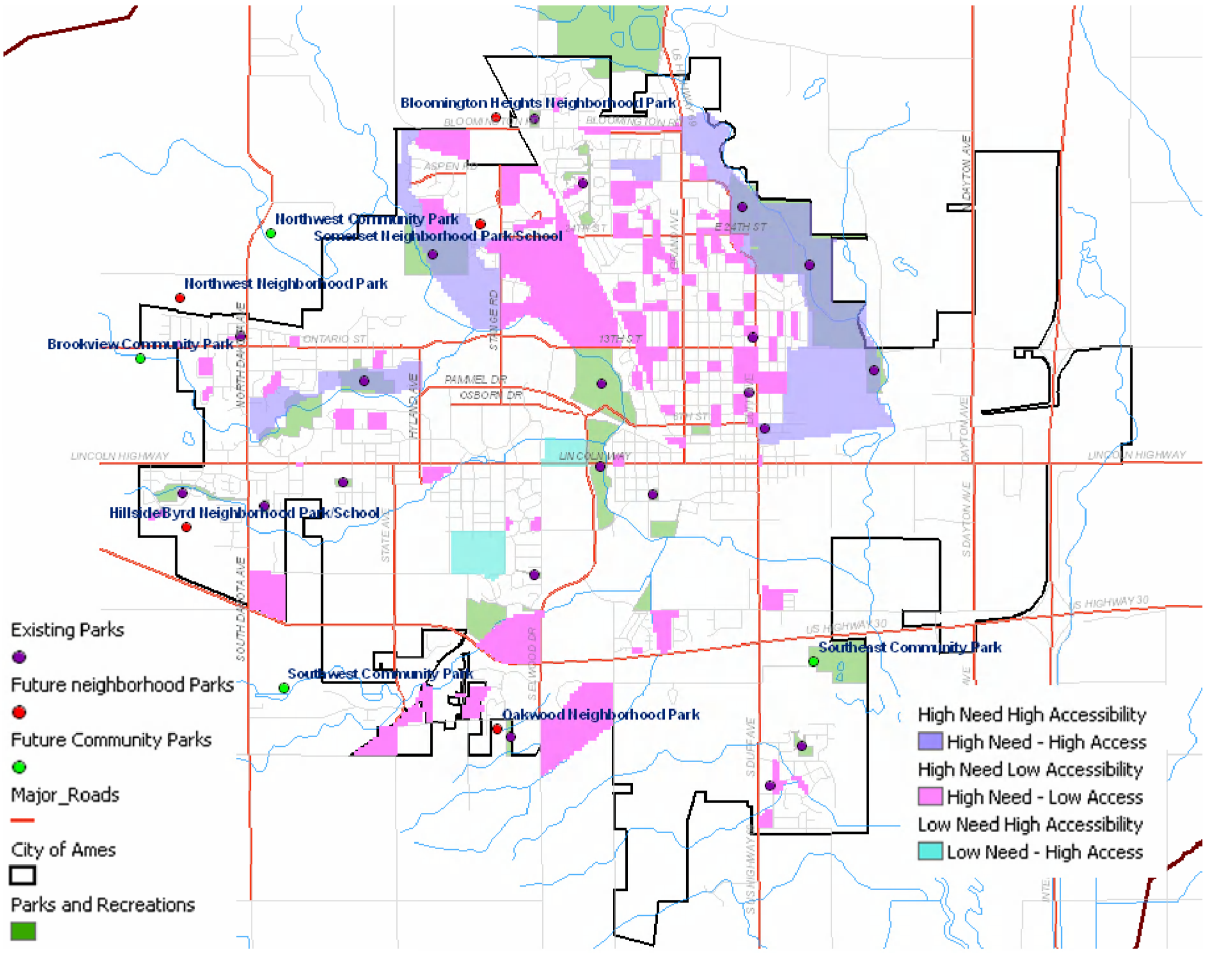

Figure 34: Future Parks and Need and Accessibility

The future locations of the parks are illustrated in the Parks Master Plan. These locations are based on the land availability and future assumption of need in these areas for public parks. The parks located in the Parks Master Plan for future development are; Future Northridge Heights Neighborhood Park, Future Northwest Community Park, Future Northwest Neighborhood Park, Future West Community Park, Future Hillside Byrd

Neighborhood Park/School, Future Southwest Community Park and Future Southeast community park. Most of these parks will be developed on the Northwest and South of Ames. The location of future parks and the Masterplan of the Ames parks are further discussed in the last chapter which is conclusion and recommendations interpreting the results obtained from park service analysis, need and accessibility indexes and raster analysis.

6.5 DISCUSSIONS

LISA is performed using all the three weight matrices (rook, queen and four neighbors) and the results show that similar numbers of blocks are statistically significant. For the accessibility index, there are no significant clusters of high accessibility surrounded by high accessibility. It may be because of the low accessibility index in the blocks, i.e. very few blocks have minimum standard of accessibility. Thus, the LISA result for accessibility does not confirm the presence of local spatial autocorrelation in the blocks.

For the need index, there are some significant clusters of high need surrounded by high need. The LISA result for need index confirm the presence of local spatial autocorrelation in some blocks which depicts presence of spatial regimes. Some clusters of high-high are seen in the Northern part of the City of Ames.

The Bi-Variate LISA for need and accessibility depicts some clusters of high need surrounded by high accessibility. Some blocks in the Northern Ames are statistically significant as high need surrounded by high accessibility. There are no significant blocks with low need surrounded by low accessibility, except for one block that is depicted as low-low when 4-neighbors matrix is used.

The Exploratory Spatial Data Analysis is important in the sense that it helps to understand the distribution of the indexes of need and accessibility. The power of maps and the visualization of quantitative data allow conclusions to be made about how access and need varies across the urban landscape. Using LISA statistics, their significance and clustering in space is checked. The high needs surrounded by high accessibility are the areas where the public authority is doing well in terms of public parks provision. The other blocks that are not significant are the areas that lack proper accessibility. The high low areas with high need and low accessibility are critical areas that need consideration and attention from the public service providers.

The raster analysis performed helps to identify and extract only those areas that have low levels of current accessibility but high levels of need and high level of accessibility with high levels of need. The high need surrounded by high accessibility are the sectors in the city, where there is good provision of park service, as well as because of the demographic composition of those blocks, there is a high need for parks. The high need high accessibility sectors are the areas where public authority is doing well in terms of public parks provision. The high needs surrounded by the low accessibility are the sectors in the city, where there is very low accessibility to parks, but the need is high. These areas need greater attention from public authorities as these areas are critical.

CHAPTER VII: FINAL REMARKS

7.1. DISCUSSIONS

The concepts of equity, justice and fairness have been central elements in the planning field since few decades. It is important that such issues be carefully considered while planning public facilities. This study takes public parks as a basic service need for residents within a city and evaluates the current situation of accessibility of parks while also looking at the need defined by various variables of population.

The Ames Park system is tested for accessibility and need using different service area methods and the need and accessibility indexes are calculated. These indexes are then used to perform spatial analysis to find out areas within Ames that are doing good in terms of public parks provision, i.e. they have high need and have good accessibility. Also, the critical areas that need more attention are identified, that is the areas within Ames, where there is higher need for parks, but lack the minimum accessibility standards. These findings can now be discussed along with the land uses and future locations of parks.

The analysis helps to compare the current and future locations of parks as per the Parks Master Plan and see if the future locations will focus on improving the accessibility and need of the residents. The future location of parks at the Northwest and Southwest of Ames does make a lot of sense as these areas are highlighted in the analysis as having high need but currently low accessibility to parks. In Figure 35, we can see the locations for the future parks which are based on the Parks Master Plan. Five neighborhood parks and four community parks will be developed in future.

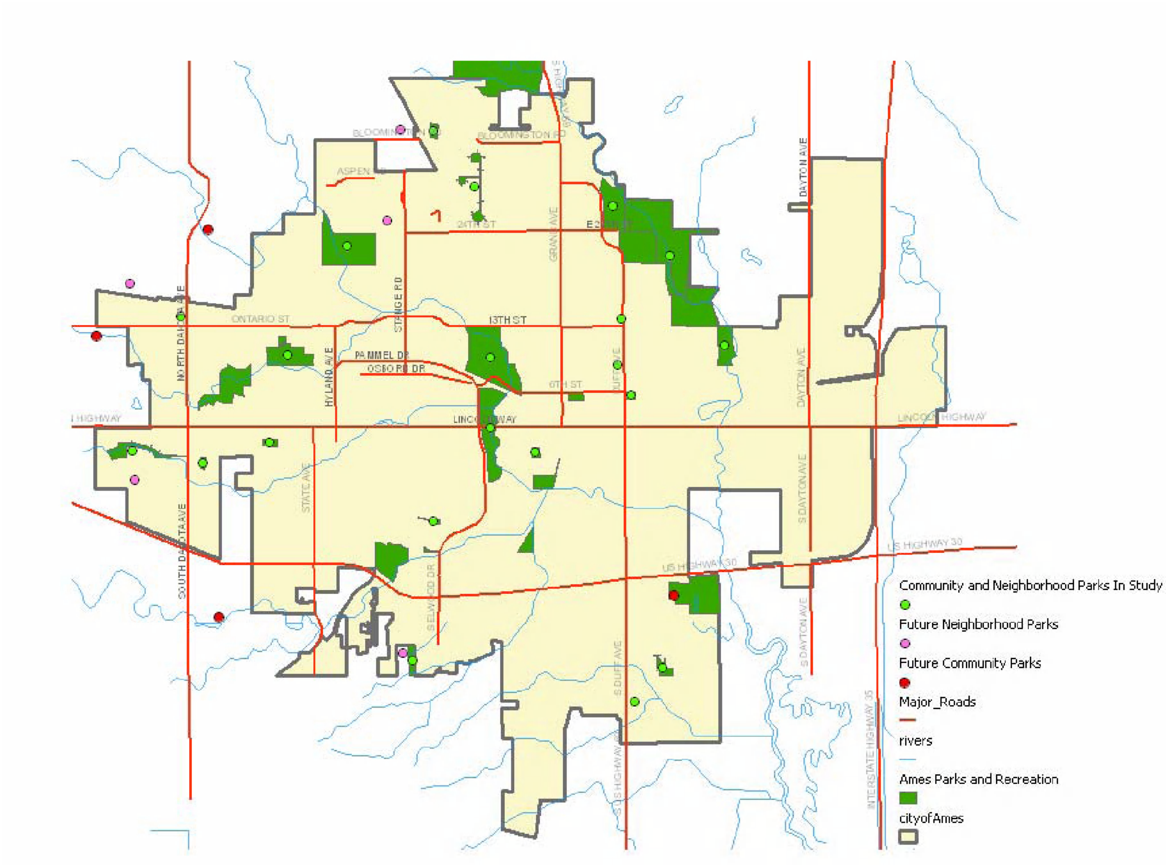

Figure 35: Locations for Future Parks (Source: Ames Parks Master Plan)

The Land Use policy plan of Ames, Iowa (1997) also emphasizes the need of development of community parks on the South of Lincoln way. As per the Parks Master plan there are two future locations for developing parks in the South, which also support the results from the analysis. Figure 36 presents the high need low accessibility areas, high need high accessibility areas and the future locations of the parks as determined by the Parks Master Plan. The future locations for parks fall on the Northwest, Southwest and South of Ames. If we look at the figure we can see that these are the areas in Ames that currently have high needs but low accessibility to public parks. Similarly, there are areas with high need and currently has high accessibility to parks. These are the areas where the parks authority has been able to provide good access to public parks for local residents.

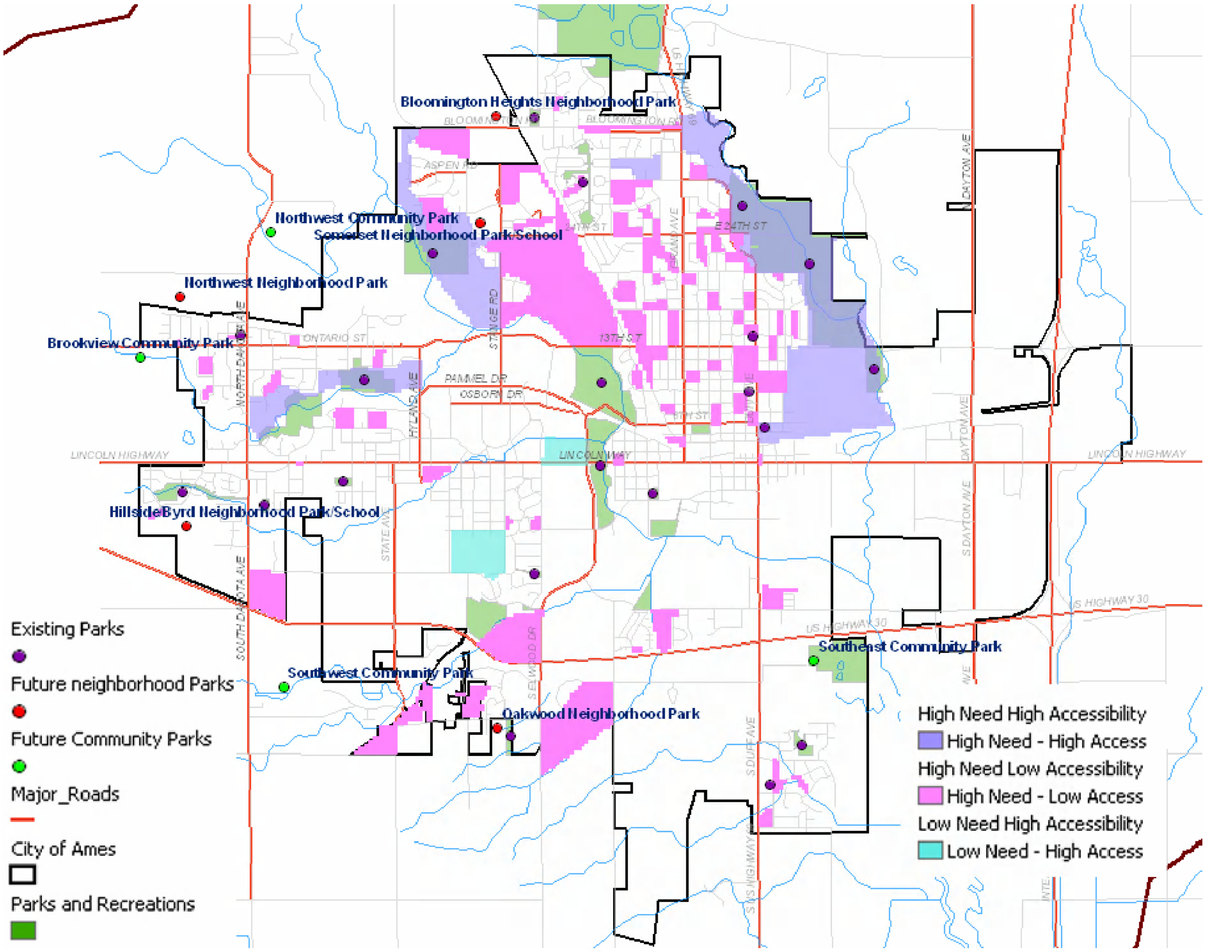

Figure 36: Future Parks and areas with high need and low accessibility

In Figure 36, there are some future locations for parks that fall in the area identified as having high need and high accessibility to public parks currently. For example, if we look at the Somerset Neighborhood Park School, the location falls on the blue shaded area which represents the high need and high accessibility neighborhood. This maybe because this particular park is to be developed as School Park and their function is different than the community and neighborhood parks. However, they will certainly respond to the growing need for public parks in Northwest Ames. We can see that there are neighborhoods in the

South and Southwest of Ames (pink clusters) that are currently high need but having low accessibility. The location of Southwest Community Park and Oakwood neighborhood parks south of Lincoln Highway and Highway 30 falls within the surrounding of these neighborhoods. Development of these parks in future will certainly help to match the growing need for parks in the South of Ames.

Existing land uses (i.e. residential, commercial, industrial, business etc) give the city a certain development structure that has a major influence on the development of park system. Likewise, the city's Land Use Guide Plan, which defines the type of development guided (i.e. proposed) for all areas of the city, will also have a major influence on the development of park system. Since the extent of park system is essentially tied to the extent and density of residential development within the city, the areas guided for residential development will be one of the primary factors in shaping and defining the extent of the park system plan. It should be recognized that if (or perhaps when) the area guided for residential development changes in the future, the park system plan will have to respond accordingly because the need will change.

Figure 37 displays the Ames Land Use Plan and also the overlaying of the neighborhoods with high need and low accessibility and high need and high accessibility. The areas in pink depict areas that have high need and low accessibility to parks. These mostly cover the residential uses, i.e. these areas are the areas which are classified as Residential uses in the Land Use Map.

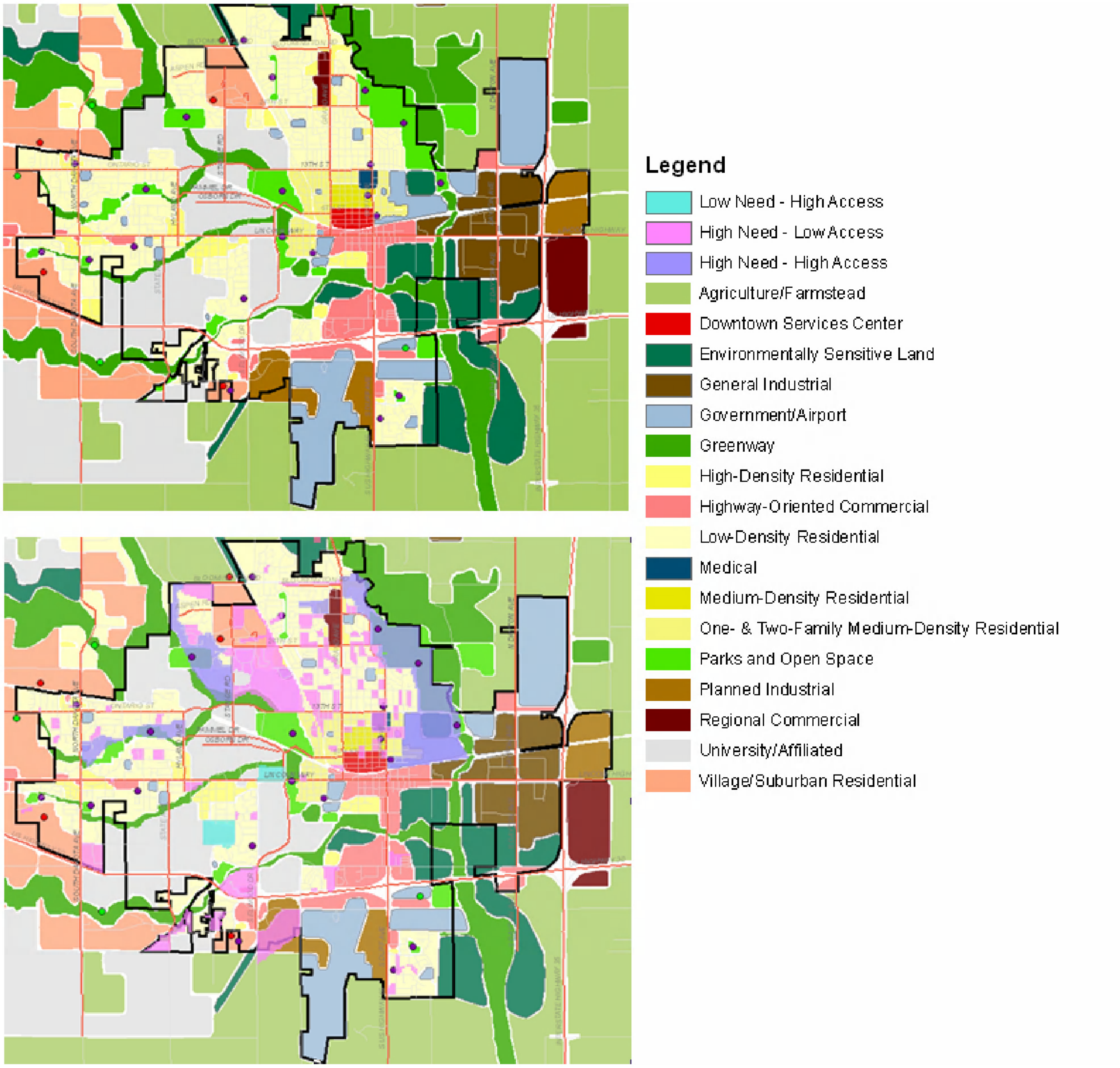

Figure 37: Land Use and Neighborhood Needs and Accessibility for Parks

In the figure, areas with high need and high accessibility are also displayed. These areas classified as high need and high accessibility cover mostly the residential uses and the parks itself. That is residential areas adjoining to parks currently have very good access for public parks. The future locations of the park overlapped over the Land use displays their location in areas classified as residential and village/suburban residential development within the Ames Planning Area. This way, their location will best serve the growing residential development in the Northwest, Southwest and South of Ames. Some future locations are within the Agricultural land use classified areas.

The future locations if tested for their service provision, appears to cover some part of the currently identified high need low accessibility areas as shown in Figure 38.

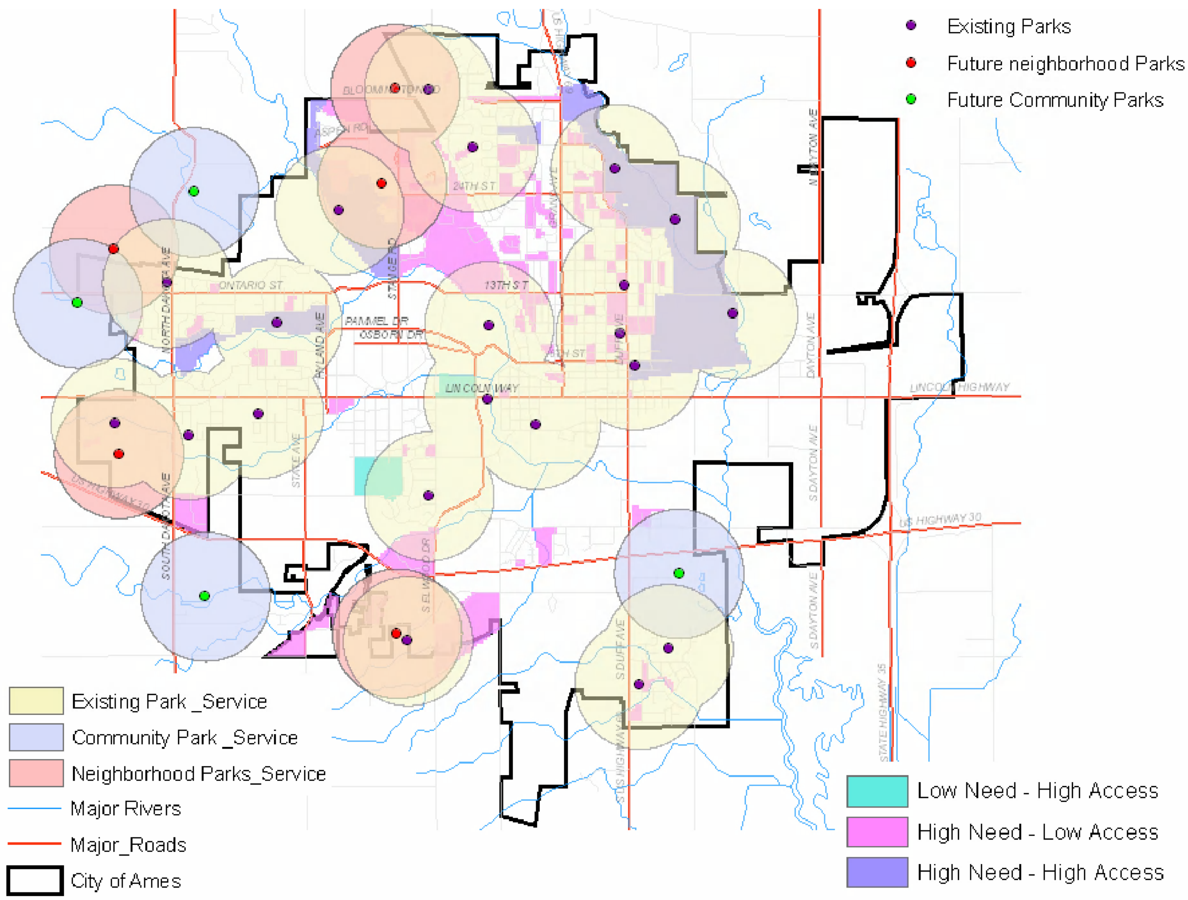

Figure 38: Service Areas for Existing and Future Parks

After the analysis and looking at the results, it is seen that even though Ames Park system is described as an efficient park system, there are some areas in Ames, where the residents do not have good access to the park services provided by the public authority. The analysis helps to answer the research questions stated earlier in the study. There are some prominent clusters of neighborhoods with high need served by higher accessibility. Some neighborhoods have higher need but lower levels of accessibility. It is seen from the results that neighborhoods in the Northwest and some part of Southwest Ames have higher needs for park services. Currently some blocks in close proximity to the existing parks have the minimum standard of accessibility. The blocks identified as high-high clusters in the exploratory analysis are the areas where residents have good access to parks. Very few blocks have significantly high need provided with high accessibility. This means, there are areas in Ames that lack proper public park provision. Need is derived in this study by indicators such as percentage of older people, percentage of younger people and non whites. The areas identified as high need and low accessibility through raster analysis are the critical areas where there is greater percentage of disadvantaged people (young, elderly, and minority) but they have not been properly serviced by parks. These are the areas where the public authority has been unsuccessful in providing equity of services.

The Ames Parks Master plan does not include any kind of analysis of the degree to which block residents are able to walk to neighborhood level parks, other than accounting of the total number of park acres that exist in the different sections of the city. That is why, study as such carried out in this research help the city authorities and planning officials to imply methods available and easy to adapt in determining accessibility and need and implementing such need in the public decisions.

7.2 CONCLUSIONS & RECOMMENDATIONS

Local governments tend to focus on issues of economic efficiency and decide project priorities on the basis of cost benefit analysis. Thus they fail to consider service need and equity as suggested by the use of terms such as social justice and fairness. Planning in today's world is very much inclined towards serving the public because it is the public that is going to either benefit or not from what is planned for that specific community. Given this, there is a greater need to evaluate people's access to public services and distributional equity of such services.

This study has presented an approach for evaluation of accessibility and need in public parks provision. Drawing upon a variety of datasets and methods from many academic researches and disciplines, this study presented a case study of Ames public park system. The step by step approach presented in this study can be easily adapted to other issues where the location of public services is compared to a multivariate demographic profile. The advantage of this approach is that it is flexible, needs less calculation and easily generates information for the purpose of decision making. Any public authority would be able to conduct an accessibility and need based analysis similar to the one presented here for City of Ames, Iowa in order to evaluate the effectiveness of public services provided by the City, County or any corporate area.

This method can also be a basis for comparison between alternative proposals, future proposals based on the achievement of accessibility and equity outcomes and assessment of need. Similarly, two different park locations could be evaluated in terms of their relative success in serving the disadvantaged population. This type of analysis is also advantageous over other methods because of the less financial demands than methods that are more financially demanding. The analysis can be performed by the public authorities if they have access to ArcGIS and the working knowledge of GIS. The methods and tools used are simple and applicable to the context of other public services as well, such as hospitals, bus stops, public libraries, and transportation facilities.

Traditional methods for accessibility measurements have been criticized by academic professionals and researchers in the past. However, it is not necessary to discard the traditional accessibility measures such as coverage method and container methods completely because for certain categories of public services such as parks, they are applicable for gaining general ideas on where the disadvantaged could be located and looking at the service areas of parks. Then public authorities can concentrate their studies in these areas and detail the accessibility and need. For detailed study, creating accessibility and need indexes and locating areas of high need - low access, low need – low access and high need - high access can be carried out to see the actual condition of park services in the community or city.

Any public authority should understand that access to essential public services is a basic right for every human being. A planner should always try to promote growth and settlement patterns that give priority to increasing access between humans, their places of work, and the services they require. The Ames Parks Master Plan is designed to fulfill the need for parks and open space for the residents in Ames. The current locations for parks are serving the local people to some extent with their level of service. There are future locations designated for the parks in the Parks Master Plan. These locations are designed towards serving the growing population and the need of the city. As the city is projected to grow with an increase in population, providing enough parks and maintaining an accessible system is a great challenge to the city. The Ames Parks and Recreation Department needs to consider the current locations, as well as predict what the future need could be. The current parks provided by the city served different sections of the city. There are few locations within the city that have low accessibility and these areas are mostly the residential uses. This might be because of the high densities in those neighborhoods, and a higher percent of disadvantaged population. The park accessibility also depends on the location of the current parks which are mostly the functions of land suitability in the communities. While the natural landscape of the area also dominates the suitability and location of parks, park locations should not only be a result of suitability but also of need assessments. The Ames parks authority is providing service to all the sections within the city, however because of the existing locations of parks; there are areas that are not serviced properly. By using methods demonstrated in this study, parks department should be able to generate information about high need areas and provide park services to such neighborhoods. The future locations of parks should each be considered based on the perspective of accessibility and need. Supplementing the land use plan for the city, most of the future designations for parks are located in the areas that will develop as village/suburban residential and other types of residential communities. This means that the locations will serve the growing population in these areas.

Recent debates in planning and geography seem to be working against the idea of accessibility and equity in distribution of goods and services. With the development growing on the suburbs of the cities and access to private and public automobiles, the importance of physical distance is decreasing in value. Even when the idea of pedestrian oriented access for the population who lack mobility (such as the elderly, children, poor, minorities and so on) is important in planning, the concept of equal access is being downplayed by private developers and public authorities as well. However, it is essential to understand that access is the key component for promoting activities and integration of various spaces within the city, basically the public uses.

The physical design of cities and neighborhoods and the way the activities are located and linked affects quality of life of residents in significant ways. Access to public facilities profoundly affects the poor, minorities, children and elderly. However, planning authorities seldom spend time evaluating neighborhood level access. Given the importance of neighborhood level access, it is necessary that planning officials have a working idea of evaluating, planning and promoting pedestrian access, determining needs for neighborhoods, yet such practice has not received much attention in planning field. Lack of practical application of accessibility measures may be result of conceptual complexities and extensive data requirements. This study demonstrates how park need and accessibility for a geographic area can be easily carried with use of GIS if we have the information for origins, destinations, distances, geographic limit, and corresponding attribute information of population.

A series of maps and results as produced in this analysis is very effective planning tool. If planners and residents are concerned about access to services, planners should be able to make a comparative assessment about which part of city have relatively long distances to travel to reach needed services, and which parts of city do not. Then, it becomes easier to make recommendations about which neighborhoods/sectors are in need of better access to facilities relative to population needs. Planners and residents should be able to actively seek development where it is most needed. Developing parks in areas where there is no need for new parks does not make any sense and implies wastage of land, and money. Future locations should be tested for their significance in providing services to those most needy and the disadvantaged population.

The achievement of equity in the distribution of public resources is a goal of vital importance to planners. The Ames Parks and Recreation Department in evaluating its Parks Master Plan should reconsider this idea of equal provision of services, and provision of services based on need rather than just depending on land availability and suitability for parks construction. In planning, equitable distribution requires locating facilities such that many spatially defined social groups can benefit the service. Usually resources are distributed according to some predefined standards such as per capita allocation (e.g., 1 acre of park land per 1,000 residents) without conscious attention to distributional fairness. While such an approach minimizes the costs of decision making, it ignores the social geography of such areas. Thus it is essential that spatial equity of public services distribution be analyzed and incorporated into public decision making.

The use of GIS for mapping distributions of access and need based on the population characteristics of the area and using it to analyze the areas in cities, counties that are disadvantaged is very useful. This study presents methods that planners can use to readily generate and evaluate accessibility and need for public services. For planners it is useful to evaluate proposed (i.e. planned) as well as achieved distributional patterns. Comparing the planned accessibility patterns, based on planned distribution of facilities with actual, achieved, accessibility patterns demonstrated whether the plan is successful or not. Any locality that has the basic components such as location information of public facilities, census data, a standard GIS package and ESDA can explore accessibility and need for such facilities and impact decisions.

Each community may have a current park, recreation, open space and pathways system plan. Building flexibility into a system plan is essential in order to accommodate the unique circumstances and situations that can arise in every community. Park and open space planning, like any other type of planning, must be able to respond to changes that can occur at any time. A city cannot rigidly adhere to a plan based upon a theoretical principle when the situation at hand suggests that following the master plan will result in missed opportunities. In such case, authorities should be able to incorporate changes such that it suits the appropriate local context. If the city is projected to grow South and Southwest and lots of developments are going there, it is essential that such areas should be given much importance and relocating facilities in such areas should be considered.

From an acquisition perspective, park system planning is limited by the opportunity to acquire the land before it is used for other purposes. Once the community is developed, acquiring land for park, recreation, and open space and pathway purposes is difficult and expensive. Given this, setting aside adequate land for comprehensive system is a difficult part of the planning job. But it is also an important element in building flexibility into the system. Having adequate land is the key to long term flexibility as response to future needs are greater. Without it, a park agency’s ability to respond to changing needs becomes limited.

The way the parks and open space are used is directly related to the type of users that live in the community and/or the recreational trends of the time. The success or failure of these will be based on whether the planning authority meets the needs of the current user groups. That is why the focus of the comprehensive plan lies in identifying specific parcels of land to meet current and anticipated future community needs. Meeting current need is a matter of understanding your current user. Anticipating future needs requires and approach to planning that allows reacting to opportunities as they arise. The system plan must be continually updated to ensure that a public park and recreation agency is in the best position to respond to the opportunities at hand. Constant reassessment of needs and modification of the systems plan based on those reassessments is important for achieving desirable results.

The rate of demographic change in the community directly affects how extensive certain aspects of the park system will need to be to keep pace with the change. In addition, changes in recreational trends also affect the demand for certain type of facilities. A basic goal of the system is to provide and maintain a high level of quality throughout park and open space in order to meet user expectations. If the parks and open space is expected by the citizens to be a primary determinant in the quality of life in a jurisdiction, then the public park agency will only be successful by providing quality parks to the residents.

Research in leisure studies provide planners with better tools to measure participation rates, patterns, needs and preferences, quality of recreation experience, economic benefits of recreation, and desire or demand for certain types of facilities within a certain distance from home. Over the past few decades, a uniform national land standard such as 10 acres per 1000 population was an accepted standard for park provision. This was held as a goal that every community strived for to have an excellent park and recreation system. For many communities, achieving such a standard was impossible. Too often such a published standard was adopted as a policy upon which funding decisions. A standard for parks and recreation cannot be universal, nor can one city be compared with another even though they are similar in many respects.

Planning for growth opportunities, connecting and integrating people, places and activities, and involving people with their neighborhood and community is very important in creating a sense of place for any locality. There is a need for change in earlier planning policies in cities, which placed importance on suitability and cost. Now, accessibility is of more importance. Accessibility is also related to the success of communities in providing services to its residents. Citizens and users judge the public services by its output, like how the parks look, and how easy it is to reach there, whereas, any authority or agency judges the service allocation through inputs and amount of expenditure. Thus there seems to be conflicts among the ones receiving the service and ones delivering the service. Thus, it is important that the public be involved in the decision making process as well. One way of involving them indirectly is to measure the need. Also, citizen groups can be included in planning and policy making process.

7.3 LIMITATIONS AND FUTURE IMPLICATIONS OF THE STUDY

The research and findings reported here in the study are just a beginning. Future research must continue along several fronts. More case studies must be undertaken, and the methods for analyzing spatial patterns must be improved. Accessibility has been used in previous facilities distribution analysis to summarize the ease of interaction between an individual facility and its users, and the benefits to the users have been derived as a function of distance. This study presented here also used the distance based measure in defining accessibility. However, distance as such has been measured as the shortest straight line distance, which in reality is unrealistic. That is why, methods that derive the actual distance (along the existing roads) between the services and the users would be more appropriate and the results will be error free.

Parks and Open Space are classified according to their characteristics and service provision. Therefore there exists a hierarchy of open spaces. This hierarchy of open space could be incorporated in further studies. Looking at how different types of parks and open space are serving people, which ones are the most widely used by the users, can help determine the need for the different types of parks and open spaces. For example, for a community with lots of children, small mini parks are more efficient than neighborhood parks, as the children would not have to cross streets and it's easier for parents to monitor them. Assessing people's accessibility to only playgrounds or community parks or any other type of park and open space also can be performed to look at how these spaces are serving people. In this study, a general standard of half mile is established and used throughout regardless of types of park. However, this standard differs for types of parks and thus studying each types of open space and parks separately would create another dimension in accessibility analysis.

Adding a survey and analysis of the people who visit parks into the methods of accessibility evaluation is another future implication for such kind of study. Such details help in accurately determining what percent of population are using the parks in reality than assuming the whole population inside the spatial unit to be served by that park or service. In this study and past studies too, it is assumed that people go to the nearest parks available to them. Assuming that, the spatial units (census blocks, tracts etc) are assigned to a park. However, a survey of users could show the users inclination towards a particular park which may not be the nearest. Thus, a survey of users could probably be more helpful in such case.

A number of limitations are faced in this type of analysis and thus questions can be raised regarding the sensitivity of the results. Spatial unit of analysis, spatial scale, standardized data, interval range, classification and indicator variables can make a difference on the results. Theoretically some of these issues can be addressed, whereas practically some are more difficult to analyze than others. Though it is helpful and more accurate to have the spatial information at households' level, but such data is not available from the census or other sources. Even in this study, because of the spatial unit of analysis taken (census blocks) information regarding vehicles and poverty could not be implemented in the study. The classification method chosen will have an effect on which areas are identified as disadvantaged, so attention and justification has to be given for the use of a particular method (quantile, percentile, equal interval and so on).

The sensitivity of indicator variables incorporated in the need index, the choice and combination of the variables used, and the weightage given to each variable, can also have an effect on the identification of disadvantaged areas. The variables included in this study reflects to the greatest extent possible, the groups with potential need for public park services in Ames, however as stated earlier, at this scale of analysis, the use of variables has been limited. However, the analysis is more accurate and easier to implement as it considers population at block level.

This study is conducted as a Master's Thesis for the fulfillment of the Master's Degree in Community and Regional Planning. Because of the time constraints, the secondary data used, data constraints and other limitations, the study could not be carried out as efficiently as has been thought in the beginning. However, the methods and applications used in the study reveal the study that is carried out to the greatest extent possible encircling the idea of access and need for public facilities in a city to serve the population to the maximum. Parks are a public resource particularly relevant to planning applications because of their important role in comprehensive planning efforts as well as their capacity to improve neighborhood quality. Thus, public parks has been chosen particularly for this study, however, this application can be used for any other public service.

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