Introduction

Public transit is one part of the urban transportation system. It is one of the components of social services provided by governmental agency (Tsamboulas, 2006). Public transit plays a very important role in American's metropolitans that it serves to reduce traffic congestion, counteract air pollution, and, more importantly, transport transit dependants to their destination (Grengs, 2002). However, increasing attention and resources for public transit development have been put to emerging suburbs, while low-income, poor urban residents who really need transit assistance are facing decreasing transit service. Responding to this is the emergences of the spatial mismatch theory (Blumenberg and Manville, 2004) and the transit equity movement (Garrett and Taylor, 1999) that argue that public transit planners should pay much more attention to social disadvantaged people to provide sufficient transit service to meet their need and improve social equity. In other word, they suggest that public transit should not be operational, management oriented. It should also be people oriented that pay attention to local demographic characteristic in planning process. However, due to increasing cost, public transit system operated by agencies are undergoing changes as to achieve a higher level of operational efficiency and efficacy (Tasmboulas, 2006). Pierce Transit, a transportation agency in Washington State, is not exception. Yet, its plan of service changes is operational oriented which aims to overcome budget shortfall by reducing service, and the impact of these changes on local transit dependants is unknown.

The goal of this project is to analyse the service reduction plan of Pierce Transit. In respect of the concept of transit equity, Geography Information System (GIS) in this project is used to mapping the impact of the service reduction, visualizing the demographic characteristic, and revisioning the plan. It is hope that the outcome of this project would provide a fact-based analysis to guild the service reduction plan to a desirable level with

minimized negative impact on local citizens who really need transit service. Brief literature review on public transit and transit equity is provided. Next is the study of Pierce Transit's reduction plan. Analysis of the plan and regional demographic characteristic is followed. And two suggestions on revisioning the plan are offered.

Public transit and planning

Public transit is an important component in local transportation systems (Lao and Liu, 2009). There are many factors that contribute to the implementation of public transit program. Increasing gas prices is a major incentive to choose public transit. Also, driving automobile is becoming more and more costly "to not only the individual drivers but also to the society in general" (Yao, 2007, p.535), making public transit a competitive alternative to private cars. Even more, improving public transit facilities is considered one of the most effective options to moderate traffic congestion problems in American's many metropolitans and reduces air pollutant emission, making significant contribution to social, economic, and environmental sustainability (Sinha, 2003).

Public transit program is operational. That is, to determine whether the system is succeed or not is to investigate whether the transit is operated in a technically efficient way, whether it "researches economic targets such as cost minimization or output maximization conditional on output or input constraints" (Brons et al., 2005, p.1-2). The efficiency-maximization nature of transit system urges transit planners and managers to reach efficiency goal primarily through modifying running schedule and frequency, calculating operating cost, improving facilities, and other means to make the transit as desirable as possible.

As a service provided by government, public transit is political. In order to moderate the pressure from working, middle classes who have greater political representation in decision-making process, transit planners and decision makers are currently shifting transit resources

to areas where services are being asking for, the suburbs. As mentioned by Grengs (2002), over the last couple decades there is an increasing demand for designing and building new metropolitan transit system by constructing rail rapid transit system which aims to transport working and middle classes in suburbs to inner cities. In core cities such as Los Angeles, councillors are actively vote for the plan, which is very costly and which financial demand would be met by raising sale tax and bus fare across the whole region (Grengs, 2002; Adler, 1986).

Growing tension, spatial mismatch hypothesis, and transit equity

As argued by Garrett and Taylor (1999, p.7), there is a "growing tension transit planners face between meeting the strong demand for transit services by predominately low-income and minority inner-city residents on the on hand, and accommodating the political interests and desires of a more mobile, dispersed, and largely white, suburban-based electorate on the other." Such tension is majorly responded by two groups of people. Researchers challenge those who support rail system by the arguing that rail system is very costly which would burden city's taxpayers. Also, they raise the fact that due to the overwhelming domination of automobile in metropolitans, even substantial increases in transit use would be unlikely to significantly reduce suburban traffic congestion. Further attentions from social scholars have been paid to social disadvantaged people. They launch the hypothesis of spatial mismatch, arguing that "the poor living in the inner city do not often live near available employment opportunities and that the distance between their residences and places of employment is frequently amplified by a lack of adequate transportation" (Blumenberg and Manville, 2004, p.183).

This hypothesis has a profound impact on the theory and practice of public transit planning that attention should not only paid to the operational side of transit system, but also

the goal of public transit must be remained that it is to serve people who based on various reasons don't choose to use automobile and it is the characteristics of this group of people that determine the scale, operation and design of a public transit system. Meanwhile, the issue of transit equity rises and argues that public transit should identify who have higher need for public transport instead of where the higher demands are located. If vulnerable and needed people in inner cities, who are poor skilled with low level of personal mobility, receive public transport, they would get meaningful employment opportunity then they can get into the mainstream of American life (Sanchez, 1999).

Methodology

Geography Information System (GIS), a computer software, is used in this project. GIS is a powerful tool in collecting, analysing, visualizing, and sharing geographic information. Increasingly, GIS is being applied in urban transportation planning, which is referred as GIS-T (Sutton, 2005). One of the most important components in GIS-T is to analysis the potential demand population for transit service around a region through identifying, analysing, and mapping the census data, based on which results to plan and design a better transit system to service the transit dependants or to evaluate the efficiency of an existing transit system (Goodchld, 2000). For example, Sanchez (1999) analyses the transit system in Portland and Atlanta with demographic data of employment to see whether working people are provided with transit service connected to their working places. Rogalsky (2009) focuses on the working-poor women and investigate whether welfare recipients are facing spatial segregation due to the lack of transit service. Yao (2007) examining the potential demand for public transit for a commuting trips once transit facility becomes available and accessible.

Spatial data is another core component in this project. Downloaded from U.S. Census Bureau, census data demonstrates demographic characteristic of each block group in Pierce

County, WA. Analysing and visualizing these data in GIS are very important for this project because the results help analysing the impact of Pierce Transit's Reduction Plan on local transit-needed citizens and provide revisioning suggestions. GIS layers of the bus routes and bus stops of each routes of Pierce Transit are acquired to examine how service will be changed which will be mapped in GIS.

Analysing the impact of the service reduction plan

Due to budget shortfall caused by economic recession, Pierce Transit is implementing a service reduction plan, which will reduce existing transit service by 35% by October 2, 2011. Transit service will be changed significantly. Except 3 routes, all routes will be impacted. In the plan, there are three types of change. First, 7 routes will be completely eliminated. Large areas of the Pierce County will be impact massively since transit dependants will not be able to receive service provided by these routes. Second, 22 routes will have service hour reduction, which means trips will be less and buses will come less often. Third, 21 routes will have both service hour reduction and route modifications, which means less areas will be served since trips will be shortened (*Pierce Transit Reductions Notification*, 2011).

This section focuses on analysing the impact of route modifications in the reduction plan. Routes facing modifications will continue to operate, but some areas will not be served as services will be cut off. For example, Route 1 will continue to operate along Pacific Avenue from Wal-Mart to Downtown Tacoma, and the TCC transit Center. But it will no longer serve the Tacoma Dome Station. Bus stop, as point feature in GIS, is used to represent those areas where service being cut off. The reason of using bus stop is, simply, if there is bus stop, there is transit service. In the reduction plan, 21 routes will be modified and totally there are 485 bus stops are found in modified areas where services being cut-off. Thus, citizens who usually access to these bus stops to take buses will have no transit service. In order to

estimate how large the areas will be impact, the Network Analysis tool in GIS is practiced. Basically, the Network Analysis instead of Buffer (Biba et al., 2010), based on the Pierce street layer, creates polygons which cover areas that within 10 minutes walking distance to each 485 bus stops in areas of service being cut off. That is, in estimate, citizens who live in these areas usually walk 10 minutes to these bus stops to take buses when they need. One point needs to be cleared in this step that there might be more than one route serving the areas that being impacted. However, even though one can continue having transit service by taking buses of other route(s), their usual routines going to be impacted and changed to certain extent.

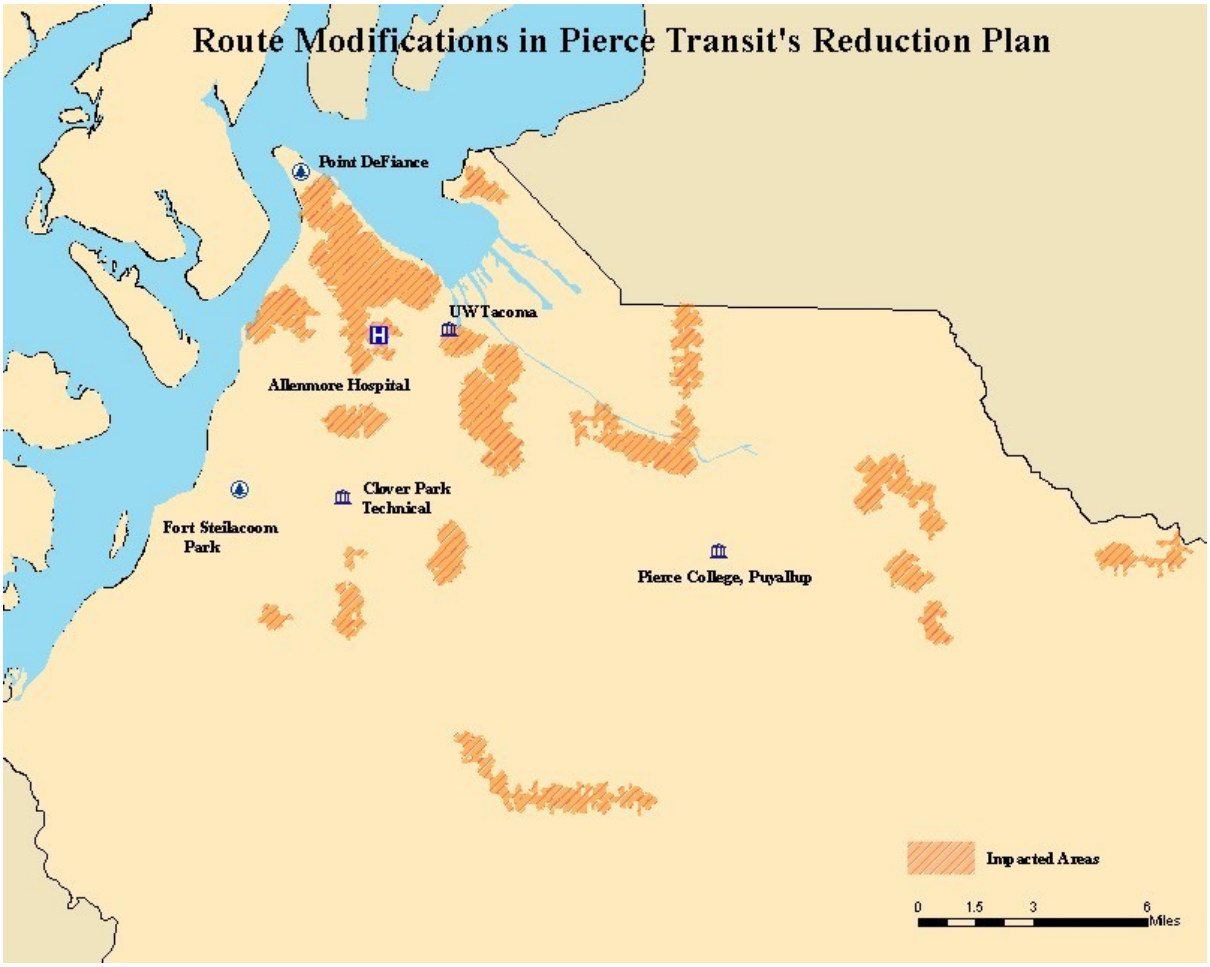

Figure 1: Areas Impacted by Route Modifications: areas of service being cut off

Revisioning the reduction plan in respect to transit equity

The reduction plan is operational oriented which tends to help Pierce Transit to achieve financial sustainable in economic recession. Yet, in respect to the concept of transit equity, the reduction plan should be people oriented. Thus this project aimed to revision the reduction plan by suggesting that transit service that being cut off should be preserved for those citizens who really need public transportation service.

It is needed to analyse the demographic characteristic of Pierce County to see where service-needed people are. Four kinds of people are identified as service-need population, who are elderly, disable, and students of middle school, high school and college, and people has no automobile. Data of these people are downloaded from U.S. Census Bureau in geographic scale of block groups. Each group of data is individually analysed and mapped with same procedures. Firstly, for example, dividing the number of disable person in each block group by each block group's total population number, disability density of each block group is resulted. Then, convert the block group feature layer to point layer. Based on the number of disability density, the point-layer map is rasterized using Interpolation to estimate the overall disability density of Pierce County. Using the same tools and procedures, eventually four rasterized maps are made representing the density of each kind of service-needed people in Pierce County. Finally, each map is reclassified, and then they are combined together using Raster Calculator. The final map, as a need index, visualizes the demographic data and shows where transit service is need in Pierce County.

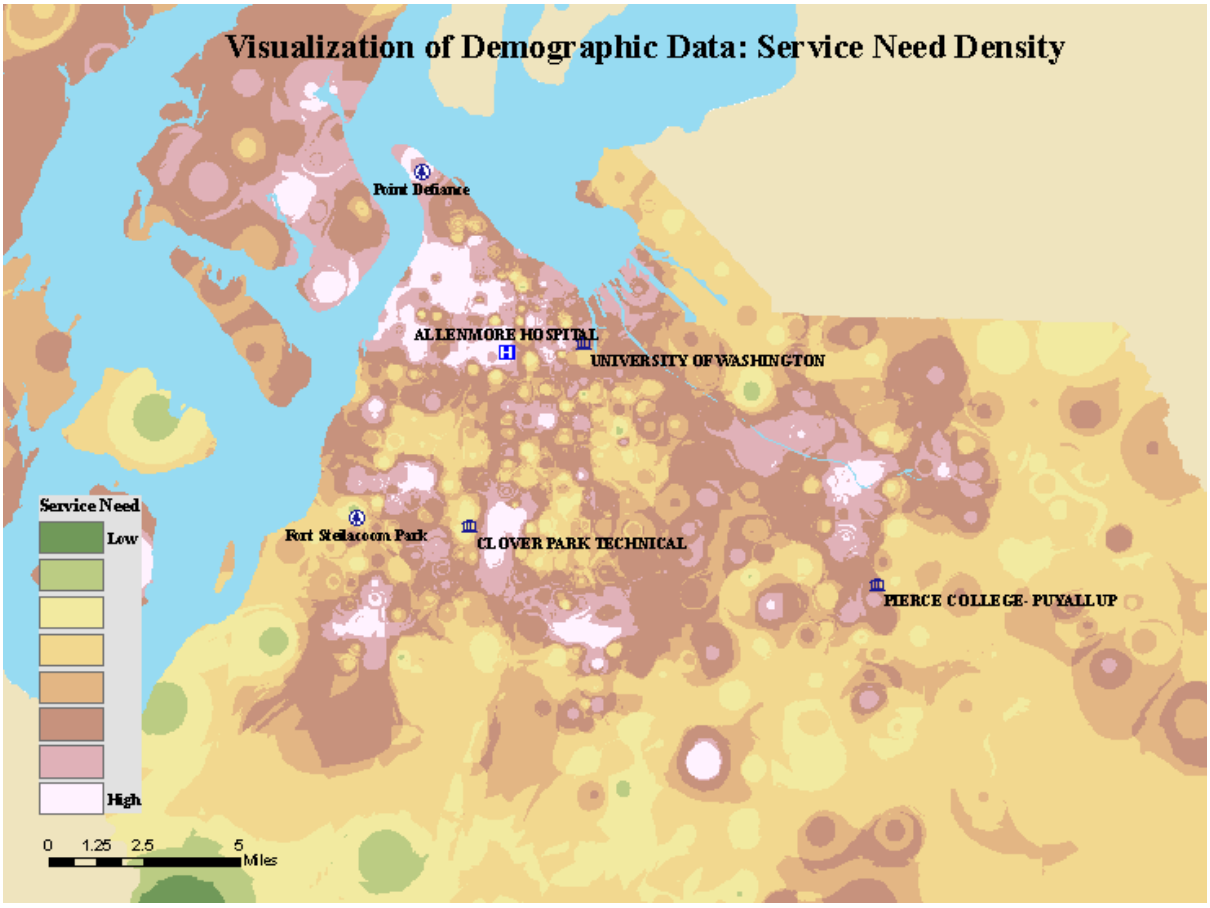

Figure 4:Transit Service Need Density of Pierce County

In order to preserve transit service in areas of high service need, it is needed to find out which bus stops are located in high service need areas. Using the Select by Location tool, 101 bus stops are selected from 485 bus stops that being eliminated. These 101 bus stops are located within or just nearby 33 block groups that have percentage of service need higher than the mean of that of Pierce County by 1.5 standard deviations or more. These areas include, for example, Allenmore Hospital in Hilltop Tacoma and Chief Leshchi High School in Puyallup. Thus, it is suggested here that in order to promote social equity in public transit system for citizens who really need, transit service in areas where 101 bus stops are selected should be preserved without elimination.

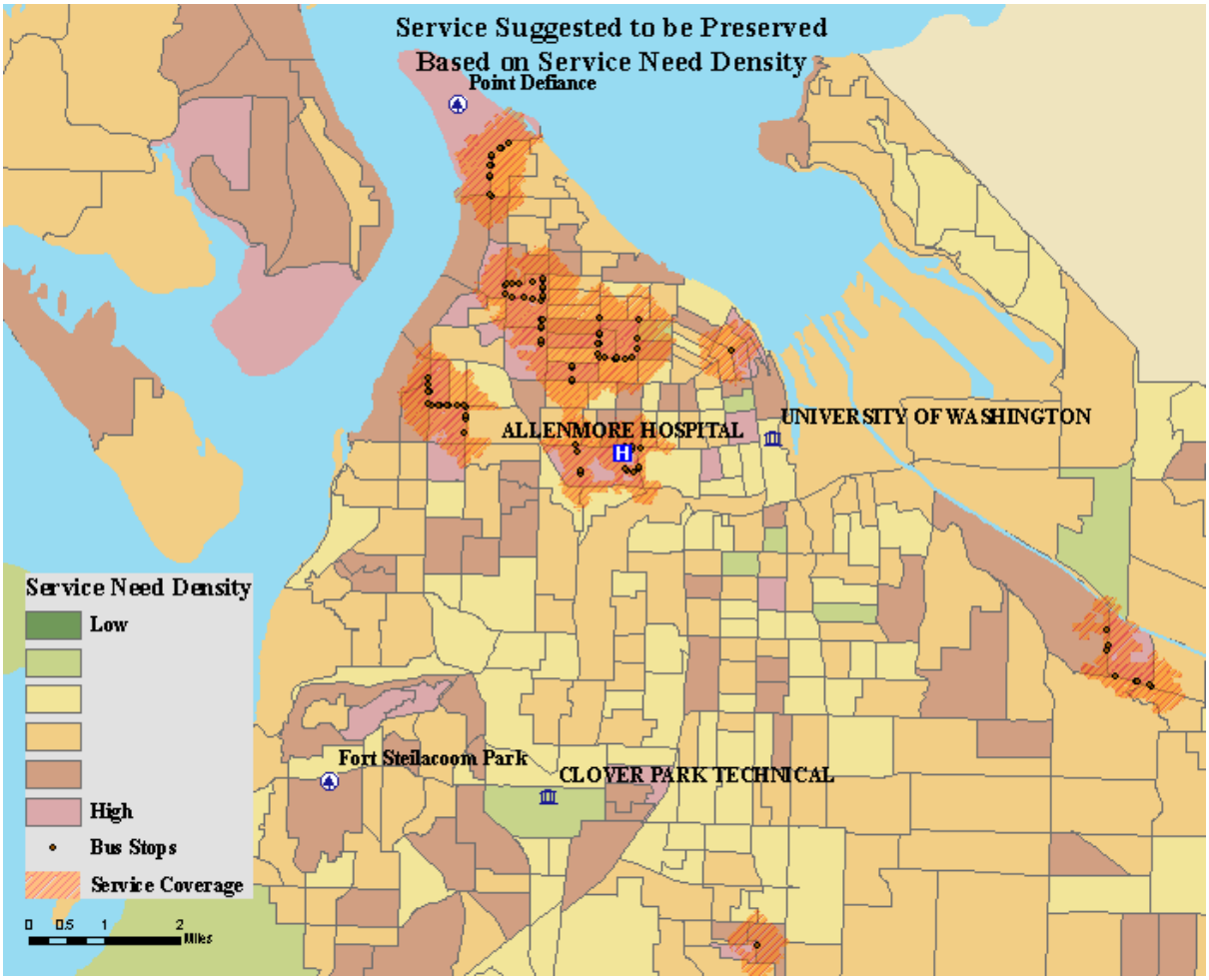

Figure 5: Areas that Should be Preserved with Transit Service Based on Service Need Density

Revisioning the reduction plan based on population density

Another revisioning strategy is offered in this section, which is based on the population density of Pierce County. Considering urban population density in transit planning is one of the criteria in the concept of transit equity since concentrated, highly populated city areas are argued should be the focused area where urban transit service is provided, instead of the dispersal, low population density suburbs. Using the same techniques deployed in creating the map of service need density, a rasterized map of population density of Pierce County is made. Compared with the map with of service need density, it is seen that population density is higher in the 6th Avenue Business District of Tacoma than other places in the county.

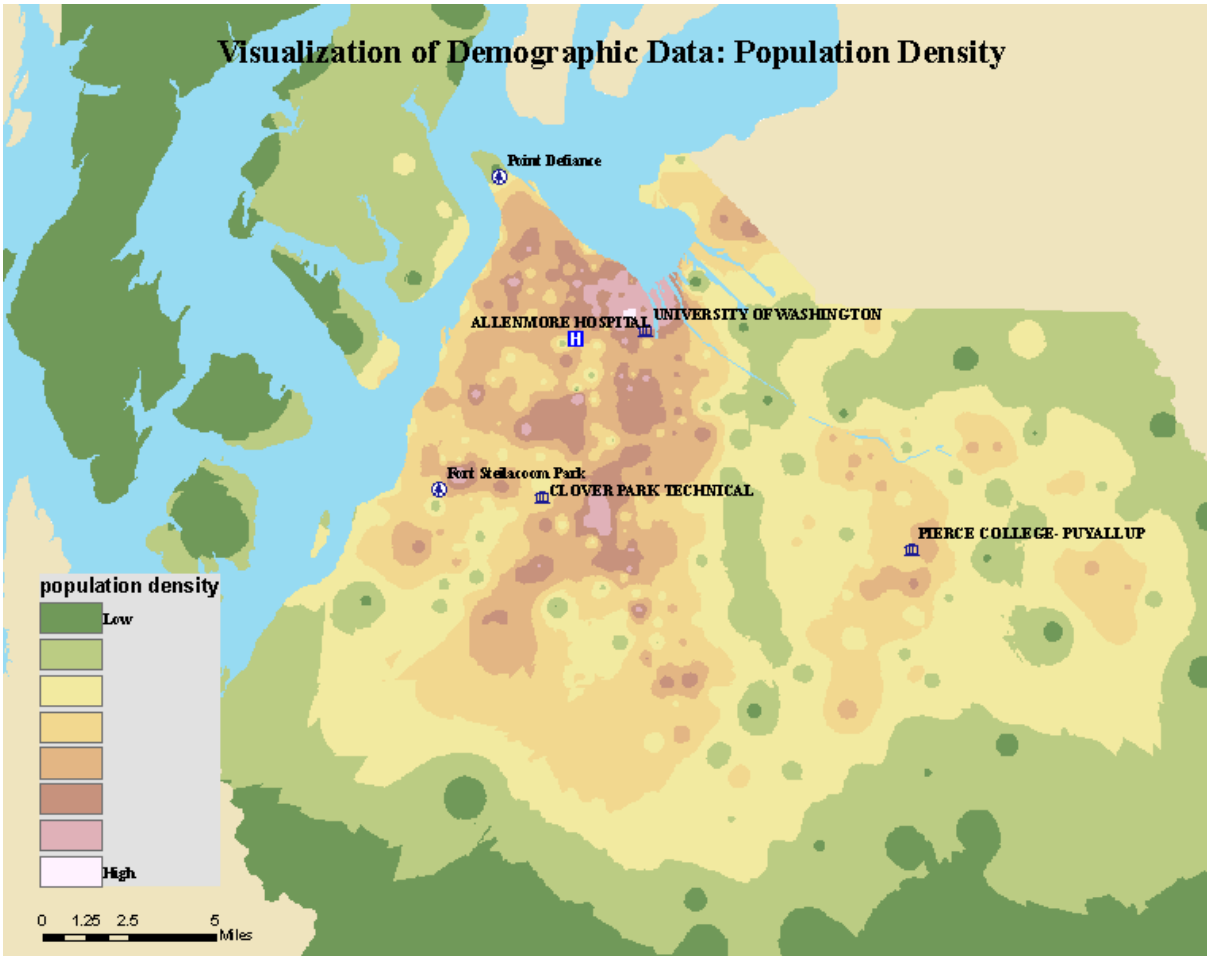

Figure 2: Population Density of Pierce County

Again, block groups of high population density need to be selected. 34 block groups are selected that the population density of each of them is higher than the mean of that of Pierce County by 1.5 standard deviations or more. Then, 61 bus stops are selected which located within of just right by these 34 block groups of high population density. Thus, in order to service more citizens in a higher efficient way, Pierce Transit should consider preserve transit service in these highly populated neigherhoods.

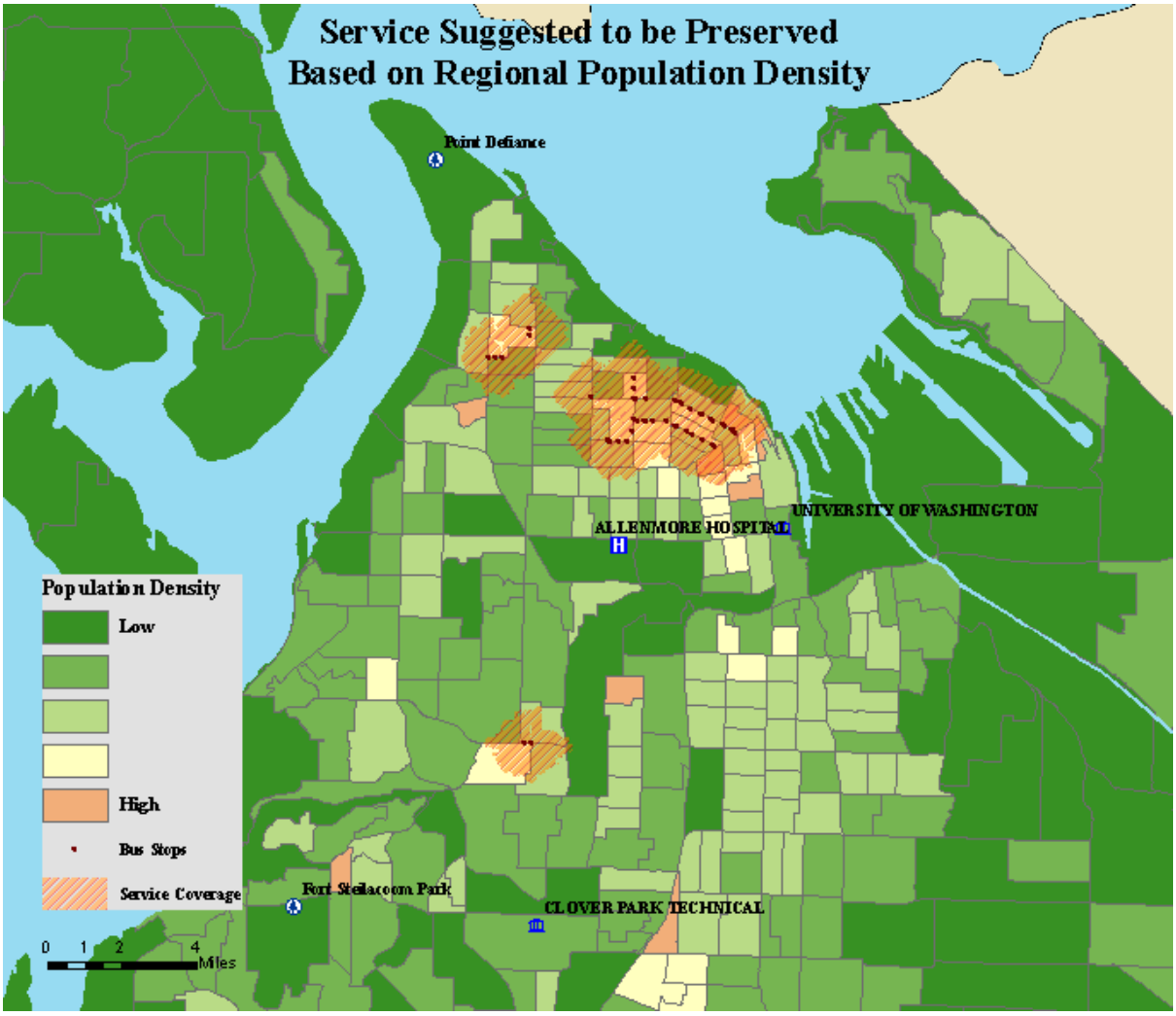

Figure 3: Areas that Should be Preserved with Transit Service Based on Population Density

Conclusion

Public transit increasingly is a social service provided by public agency. Increasingly, transit planning is considered as a social equity issue. Scholars argue that transit planning should not be management or operational oriented. Instead, it should people oriented that planning process should take consideration of demographic characteristic of the region where transit service is provided and transit service should be provided to social disadvantaged people who really need public assistance in transportation to overcome spatial segregation. Also, cities where population is highly concentrated should be the priority where transit service should be provided over dispersal, low population density suburbs.

Pierce Transit, a public transportation agency in Washington state, is undergoing a service reduction plan in order to overcome the budget shortfall caused by economic recession. However, its reduction plan is operational oriented, eliminating 35% of service that being provided now by October, 2011. Almost all routes are impacted. In order to shift the orientation of this reduction plan from operation and management to people, this project analyse the both route modifications as a part of the reduction plan and demographic characteristic of Pierce County. Two revisioning plans are offered based on the outcomes of analyses. The first one is that in Pierce County, areas of high service-needed people, which are disable persons, elderly aged over 65, students and people own no automobile, should be preserved with continuous transit service. The second one is that areas of high population density should also be preserved with continuous transit service. In a word, Pierce Transit should consider the demographic characteristic more in planning service reduction in order to promote transit equity in Pierce County.

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