Urban-Rural Classification:
Identifying a System Suitable for Transit

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Disclaimer

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EXECUTIVE SUMMARY

In this paper existing urban-rural classifications are evaluated to determine their ability to appropriately delineate differences among geographic areas as they relate to personal mobility need and transportation service availability with emphasis placed on the definitional boundary between urban, small urban, and rural areas. In the absence of a suitable existing classification system, a new system is constructed, applied, and evaluated.

The new Urban Population-Rural Density Code system is two-part, describing county urban and rural areas independently. Urban portions of a county receive a numeric code, rural portions an alphabetic one. The new system's boundaries are precise with no overlap and rely upon criteria relevant to the mobility needs and service availability. With 25 classes, the system is arguably inefficient – but, given the level of precision desired, a tradeoff was necessary.

Table ES1 describes the urban population-numeric portion of the new classification system. Five classes, identified by the Arabic numbers 1 through 5, roughly correspond to existing definitions used by the Census and other government agencies. Large urban areas, counties with urban populations greater than 200,000, are classified with the number 1. Small urban areas, those with urban populations between 50,000 and 199,999, receive the number 2. Micropolitan areas with populations between 10,000 and 49,999 inclusive are classified with the number 3. Urban clusters with populations less than 10,000 are classified with the number 4. Counties with no urban areas are assigned the number 5.

Table ES1. Urban Population-Numeric Classification

	Urban Population Breaks	
Class	Lower Bound	Upper Bound
1	200,000	+
2	50,000	199,999
3	10,000	49,999
4	2,500	9,999
5	No urban areas	

The rural density-alphabetic portion of the classification system is presented in Table ES2. Breaks between classes are based on population density in rural areas. Counties with no rural areas are denoted with the letter a. Those with densities between 50 and 1,000 persons per square mile are classified by the letter b. Counties with densities between 25 and 49, and 10 and 24 are classified by the letters c and d. All other areas are placed in class e. In order for counties with urban areas to be classified in classes b through e, they must have a rural area greater than 100 square miles. This is done to account for small, undeveloped areas in large urban counties.

Table ES2. Rural Density-Alphabetic Classification

	Rural Density Breaks	
Class	Lower Bound	Upper Bound
a	No rural areas	
b	50	1,000
c	25	49
d	10	24
e	0	10

Table ES3 presents the classification of seven counties and one city to demonstrate the practicality of the system. As expected, New York, New York, is classified as 1a, the same as the city of Baltimore in Maryland. Neither county has rural areas. Anne Arundel and Montgomery Counties are both classified 1b, with relatively densely populated rural areas. They have roughly the same density as rural portions of Frederick County, which is classified 2b due to its less populated urban areas. Cass, Slope, and Stark County in North Dakota all have a rural density of less than 10 individuals per square mile and are assigned the letter e. Urban population codes for the three counties differ from 3 for Cass to 5 for Slope.

Table ES3. Classification Example Table

County	State	Urban Population	Rural Population	Rural Area	Rural Density	SURTC Classification Code
New York	NY	3,141,856	--	--	--	1a
Anne Arundel	MD	462,092	27,564	210	131	1b
Baltimore City	MD	651,154	--	--	--	1a
Frederick	MD	139,462	55,815	537	97	2b
Montgomery	MD	848,752	24,589	247	99	1b
Cass (Fargo)	ND	106,577	16,561	1,734	10	2e
Slope	ND	--	767	1,218	1	5e
Stark	ND	15,920	6,716	1,331	5	3e

To evaluate the new system, two measures of association, Pearson's chi-square test and Kendall's tau-b correlation coefficient, are applied to tables of transit service and classification for counties in eight Upper Great Plains states. Three types of transportation services are considered: fixed-route, demand-response, and intercity bus. For both measures, high levels of association are found for the existing Metropolitan Area Statistical definition and the newly introduction Urban Population-Rural Density Code system.

During the study, the absence of a uniform, up-to-date database of transportation services was noted. Resources do exist, including the National Transit Database, the new Rural National Transit Database, and state publications. However, many are hard documents with dated service information. There is also no guarantee of uniform definitions which makes analysis. Data are almost always presented from the agency perspective, while policy also needs to look at the industry from the client's perspective.

The new Urban Population-Rural Density Code system addresses the shortcomings of existing urban-rural classifications in capturing relevant, local geographic attributes that relate to mobility need and transportation service provision. There are high levels of association between the new system and the presence of fixed-route, demand-response, and intercity bus service. The system's true value will only be proven by its application in future research and public policy formulation.

1. INTRODUCTION

Effective geographic classification of an area is often necessary in public policy, especially during initial program design and periodic decisions on resource allocation. When a community is correctly classified, its residents may be appropriately and efficiently served. Considerable effort has been made by many organizations, especially federal agencies, to establish and maintain classifications to assist in such purposes. The practicality of the resulting myriad classifications depends upon the skill of the practitioner and the subject matter to which it is applied.

1.1 The Research Problem

A geographic classification system to guide transit policy in small urban and rural areas does not exist, nor does a classification system of rural transit services (FTA Strategic Plan Objective 2.4). As the need and resources available for small urban and rural transit services are increasing, these deficiencies are becoming ever more significant. The general case, where program development and resource allocation depends on appropriate classification, appears to apply to small urban and rural transit policy.

1.2 Study Objective

The objective of the study is to evaluate the ability of existing classifications systems to appropriately delineate differences among geographic areas as they relate to personal mobility need and transportation service availability with emphasis placed on the definitional boundary between urban, small urban, and rural areas. In the absence of a suitable classification system, an alternative was to be developed, applied, and evaluated.

1.3 Report Organization

The report begins with a review of existing urban-rural classification systems and explores their strengths and shortcomings when applied to transportation needs and services. An alternative classification system, Urban Population-Rural Density Code, is introduced in Section 3. Section 4 presents population, area, and transit service data for counties in eight states. The results from two statistical tests employed to measure the degree of association between the new and an existing classification system are presented in Section 5. Finally, Section 6 summarizes the study's findings.

2. URBAN-RURAL CLASSIFICATION SYSTEMS

Delineating urban and rural areas is a common task for demographers. A number of organizations including the U.S. Office of Management and Budget; U.S. Census; and the Economic Research Service, an agency within the U.S. Department of Agriculture; maintain urban-rural classification systems. Each system uses different geographic attributes to codify an area. In some instances, urban-rural classification systems are designed to provide investigators a structure with which to address specific, related issues.

While urban-rural classification systems have been successfully used for many public policy purposes, there are exceptions. It would be an error to assume that commonly used classifications will provide an appropriate tool for one's specific purpose. In our case, formal investigation is required to determine if an existing urban-rural classification system can accommodate the unique spatial attributes of mobility need and transportation service availability. In this section, existing urban-rural classification systems are presented and evaluated for their ability to assist in transit policy formation. First, however, characteristics and caveats pertaining to classification systems are presented.

2.1 Classification System Characteristics and Cautions on Use

The necessary characteristics of a geographic classification system have been concisely presented by Atchley (1967):

> Any system of classification should provide a vehicle for efficient communication, a set of definitions, and a system of relationships among these definitions. Each label in the classification system should convey the greatest possible meaning in the fewest possible symbols: the categories should be precisely defined, and overlapping should be eliminated wherever possible.

In addition to efficiency, precision, and mutual exclusivity, Atchley notes that classification criteria must meaningful be based on relevant, significant geographic attributes.

Application of a specific classification system requires a thorough understanding of its mechanics as well as the subject matter to which it is applied. The Office of Management and Budget (OMB) and U.S. Census Bureau specifically caution against haphazard use of their classification systems and data. OMB specifically cautions against considering all parts of a metropolitan area as if they are densely settled (Office of the Federal Register 2000). The U.S. Census Bureau accepts responsibility only for the identification and tabulation of data. Users of their data proceed on their own volition. With these caveats in mind, we proceed to introduce commonly used urban-rural classifications.

2.2 Commonly Used Urban-Rural Classification Systems

Five urban-rural classification systems are presented for consideration as potential tools to assist in delineating geographic differences relevant to transit policy formulation: Metropolitan Statistical Areas; Urbanized Area, Urban Cluster, and Rural Area; Rural-Urban Continuum; Urban Influence; and Rural-Urban Commuting Codes. Each has found favor among policy makers for different purposes. We begin with Metropolitan Statistical Areas.

2.2.1. Metropolitan Statistical Areas

The U.S. Office of Management and Budget (OMB) is responsible for maintaining the definition of Metropolitan Statistical Areas. Metropolitan Statistical Areas are defined as statistical entities consisting of the county or counties associated with at least one urbanized area of 50,000 or more population, plus adjacent territory that has a high degree of social and economic integration with the core as measure by commuting ties. Non-metropolitan areas are those counties not located in a metropolitan area. A map of U.S. Metropolitan Areas is presented in Figure 2.1.

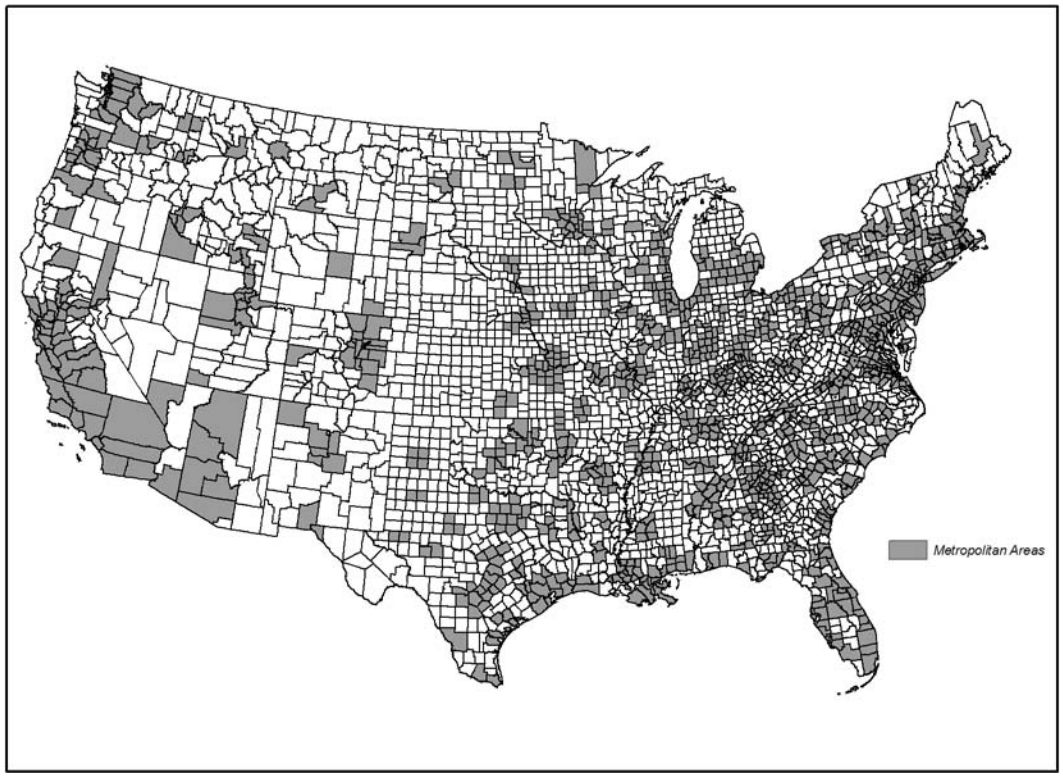

Figure 2.1 Metropolitan Counties

2.2.2. Urbanized Area, Urban Cluster and Rural Area

The U.S. Census Bureau maintains the criteria for urbanized areas, urban clusters, and rural areas as well as tabulates data for public use. The definitions for the three classifications from the most recent census are presented in Table 2.1. Figure 2.2 presents U.S. urbanized areas and urban clusters graphically.

Table 2.1 Census 2000 Area Definitions

Urbanized Areas - An Urbanized Area (UA) consists of a central place(s) and adjacent densely settled territory that together contain a population of at least 50,000 people, generally with a population of at least 1,000 people per square mile.

Urban Cluster - An Urban Cluster (UC) consists of a central place(s) and adjacent densely settled territory that together contain a population of at least 2,500 people, but fewer than 50,000 people, generally with a population of at least 1,000 people per square mile.

Rural - Rural areas are all territories outside of urbanized areas and urban clusters.

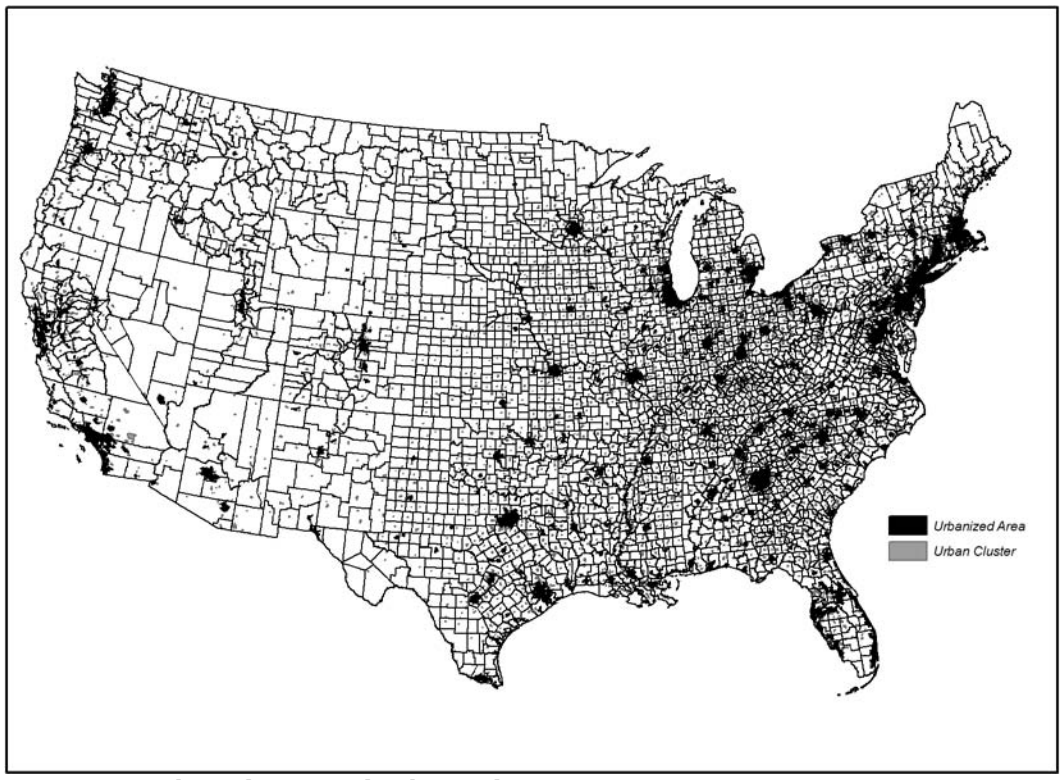

Figure 2.2 Urban Clusters and Urbanized Areas

2.2.3. Rural-Urban Continuum Code

The Economic Research Service, an agency of the U.S. Department of Agriculture, uses population and adjacency to classify counties using its Rural-Urban Continuum Code system. Population thresholds are set at 2,500, 20,000, 250,000, and one million residents. The system is intended to allow for the investigation of the impacts of relative rural nature and proximity to metropolitan areas of counties. The 2003 Rural-Urban Continuum Code definitions are presented in Table 2.2. U.S. counties shaded by their Rural-Urban Continuum Code are presented in Figure 2.3.

Table 2.2 2003 Rural-Urban Continuum Codes

Code	Description
1	Counties in metro areas of 1 million population or more
2	Counties in metro areas of 250,000 to 1 million population
3	Counties in metro areas of fewer than 250,000 population
4	Urban population of 20,000 or more, adjacent to a metro area
5	Urban population of 20,000 or more, not adjacent to a metro area
6	Urban population of 2,500 to 19,999, adjacent to a metro area
7	Urban population of 2,500 to 19,999 not adjacent to a metro area
8	Completely rural or less than 2,500 urban population, adjacent to a metro area
9	Completely rural or less than 2,500 urban population, not adjacent to a metro area

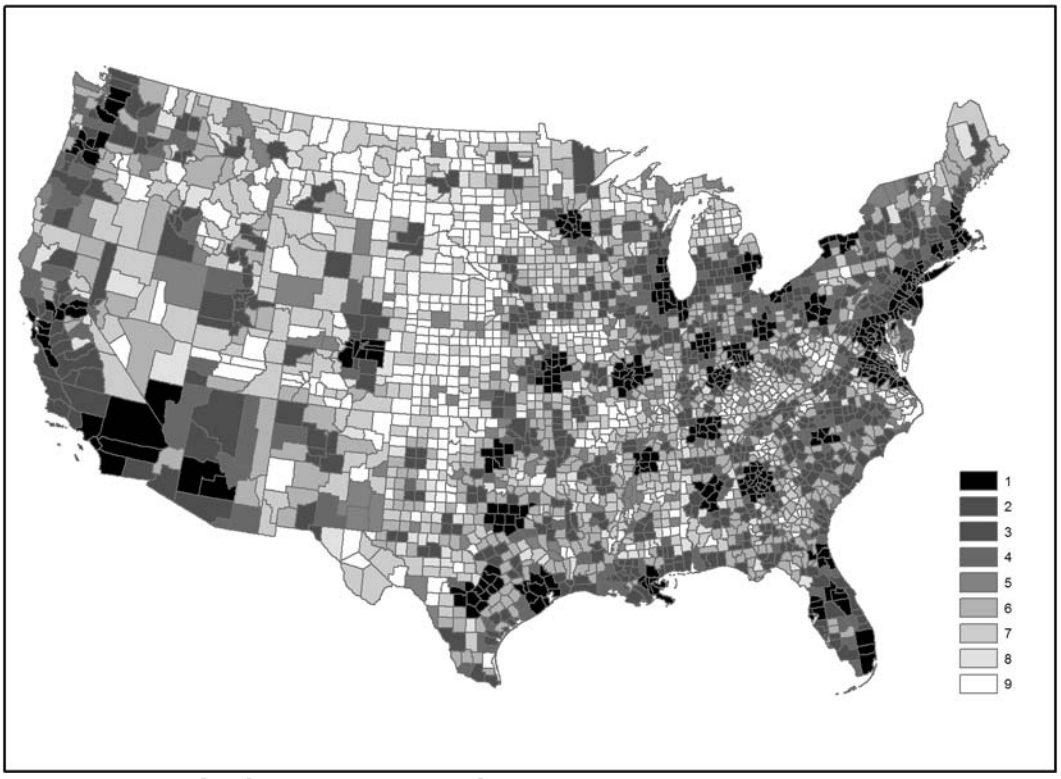

Figure 2.3 Rural Urban Continuum Codes

2.2.4. Urban Influence Code

The Economic Research Service uses metropolitan, micropolitan, and non-core designations; population; and proximity to large urban areas to classify counties using its Urban Influence Code system. Micropolitan Statistical Areas are similar to Metropolitan Areas with the exception that the core urban area must have at least 10,000 residents. Metropolitan and Micropolitan Statistical Areas are jointly referred to as Core Based Statistical Areas. The Urban Influence system is intended to capture the role of urban areas and access on economic opportunity. Table 2.3 presents the definitions for the 2003 Urban Influence Code system. Figure 2.4 presents a map of U.S. counties shaded by Urban Influence Code.

Table 2.3 2003 Urban Influence Continuum Codes

Code	Description
1	Counties in metropolitan areas of 1 million population or more
2	Counties in metropolitan areas of fewer than 1 million population
3	Counties in micropolitan areas next to metropolitan areas of 1 million population or more
4	Counties in noncore areas adjacent to metropolitan areas of 1 million population or more
5	Counties in micropolitan areas adjacent to metropolitan areas of fewer than 1 million population
6	Counties in noncore areas adjacent to metropolitan areas of fewer than 1 million population and contain a town of at least 2,500 residents
7	Counties in noncore areas adjacent to metropolitan areas of fewer than 1 million population and do not contain a town of at least 2,500 residents
8	Counties in micropolitan areas not adjacent to a metropolitan area
9	Noncore counties adjacent to a micropolitan area and contains a town of at least 2,500 residents
10	Noncore counties adjacent to a micorpolitan area and does not contain a town of at least 2,500 residents
11	Noncore counties not adjacent to metropolitan or micropolitan area and contains a town of at least 2,500 residents
12	Noncore counties not adjacent to metropolitan or micropolitan area and does not contain a town of at least 2,500 residents

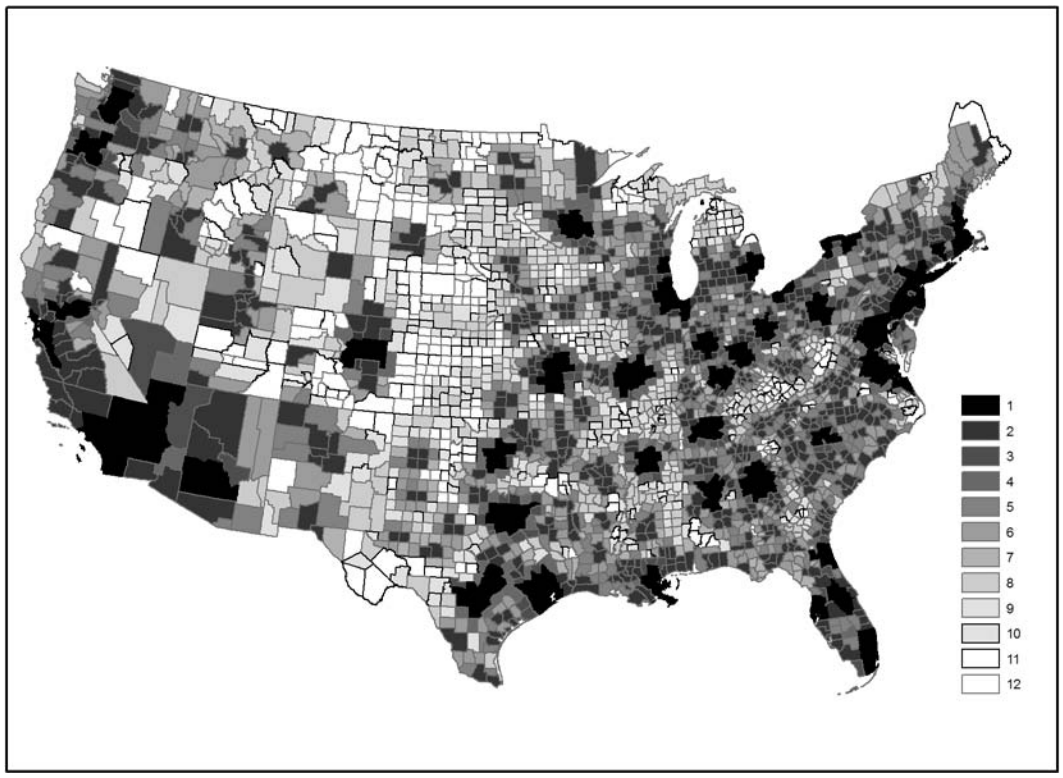

Figure 2.4 Urban Influence Codes

2.2.5. Rural-Urban Commuting Code

The Economic Research Service uses population and commuting relationships for its Rural-Urban Commuting Area Code system. The intent of the system is to identify areas with significant economic integration. As noted, the use of commuting behavior is used in determining Metropolitan Statistical Areas. The Rural-Urban Commuting Code explicitly includes this phenomenon in its coding. The system is applied at the census tract as opposed to county level, allowing for more detailed analysis. Table 2.4 presents the criteria for Rural-Urban Commuting Area codes.

Table 2.4 Rural-Urban Commuting Area Codes

Code	Description
1	Metropolitan area core: primary flow within an urbanized area
1.0	No additional code
1.1	Secondary flow 30% to 50% to a larger UA
2	Metropolitan area high commuting: primary flow 30% or more to a UA
2.0	No additional code
2.1	Secondary flow 30% to 50% to a larger UA
3.0	No additional code
4	Micropolitan area core: primary flow within an Urban Cluster of 10,000 to 49,999 (large UC)
4.0	No additional code
4.1	Secondary flow 30% to 50% to a UA
4.2	Secondary flow 10% to 30% to a UA
5	Micropolitan high commuting: primary flow 30% or more to a large UC
5	No additional code
5.1	Secondary flow 30% to 50% to a UA
5.2	Secondary flow 10% to 30% to a UA
6	Micropolitan low commuting: primary flow 10% to 30% to a large UC
6	No additional code
6.1	Secondary flow 10% to 30% to a UA
7	Small town core: primary flow within an Urban Cluster of 2,500 to 9,999 (small UC)
7	No additional code
7.1	Secondary flow 30% to 50% to a UA
7.2	Secondary flow 30% to 50% to a large UC
7.3	Secondary flow 10% to 30% to a UA
7.4	Secondary flow 10% to 30% to a large UC
8	Small town high commuting: primary flow 30% or more to a small UC
8	No additional code
8.1	Secondary flow 30% to 50% to a UA
8.2	Secondary flow 30% to 50% to a large UC
8.3	Secondary flow 10% to 30% to a UA
8.4	Secondary flow 10% to 30% to a large UC
9	Small town low commuting: primary flow 10% to 30% to a small UC
9	No additional code
9.1	Secondary flow 10% to 30% to a UA
9.2	Secondary flow 10% to 30% to a large UC
10	Rural areas: primary flow to a tract outside a UA or UC
10	No additional code
10.1	Secondary flow 30% to 50% to a UA
10.2	Secondary flow 30% to 50% to a large UC
10.3	Secondary flow 30% to 50% to a small UC
10.4	Secondary flow 10% to 30% to a UA
10.5	Secondary flow 10% to 30% to a large UC
10.6	Secondary flow 10% to 30% to a small UC

2.3 Urban-Rural Classifications to Mobility Needs and Services

Having presented five urban-rural classification systems, we next consider their use as tools to guide transit policy. This is done by comparing each against Atchley's general criteria as well as the unique needs of our particular application: delineating differences among geographic areas as they relate to personal mobility need and transportation service availability.

The classification systems readily meet Atchley's four measures: efficiency, precision, exclusivity, and relevant criteria when considered subjectively. A possible exception is the Rural Urban Commuting Code that when fully expanded includes more than two dozen codes, which could be considered less than efficient. Boundaries between classes are precise for all systems, and there is no overlap between classes. Criteria for classification vary but primarily rely on total population, population density, and commuting ties.

In addition to meeting general standards, to be of value as a framework to guide transit policy, the ideal geographic classification system needs to accommodate unique spatial attributes of mobility and transportation services. Most important is the concept of neighborhood, that is, the geography unit of consideration. Classification at the county level is likely too large as population density varies greatly within such a large area.

Metropolitan Statistical Areas are insufficient for our purpose for three reasons. First, the system fails to recognize significant differences among urban and rural areas in the same county. Second, counties with rural attributes can be classified as metropolitan because of commuting ties. Finally, there are only two classes metropolitan and non-metropolitan, not enough to capture the variability in mobility needs and transportation services.

The U.S. Census Bureau's urbanized area, urban cluster, and rural area classes benefit from smaller geographic areas, census tracts, as opposed to counties. However, with only three classes, they are unable to adequately model variability in mobility need and available services. A deficiency of classifying at the census tract level is that the boundaries of these areas are not well known.

The Rural-Urban Continuum and Urban Influence Code Systems utilize Core Based Statistical Area and adjacency. Adjacency is not a relevant attribute for our purpose. Commuting behavior, a creative proxy for identifying social and economic ties, which is used by the Rural-Urban Commuting Code system, also is not germane to our cause.

The existing urban-rural classification systems suffer from significant deficiencies for our particular use. These include too few classes, uncertainty in geographic boundaries within county variability, and the use of commuting behavior. As a result, a new classification system that specifically addresses these shortcomings is in order.

3. URBAN POPULATION-RURAL DENSITY CODE CLASSIFICATION SYSTEM

In Section 2, the study presents five existing urban-rural classification systems and evaluates them for their merit to serve as tools to delineate differences among geographic areas as they relate to personal mobility need and transportation service. Each system had at least one significant shortcoming such as: an inadequate number of classes, uncertain geographic boundaries, within county variability, and commuting ties which are not germane to our subject matter. In this section, a new Urban Population-Rural Density Code classification system that addresses these deficiencies is presented.

The new system relies on U.S. Census Bureau urban and rural definitions due to their focus on census tract level geography. The two shortcomings of this data, an inadequate number of classes and uncertain census tract boundaries, are accommodated directly. The former issue is easily remedied by adding additional thresholds within existing definitions of urbanized area, urban cluster, and rural area. The boundary issue is dealt with by grouping all rural areas in a county. Concern about census tract awareness is only pertinent for rural areas, as urban census tracts are part of either urbanized areas or urban clusters whose boundaries are usually understood.

The system is applied to a particular geographic level in the form of a two-part classification. The first part describes its urban nature, the second its rural one. It is expected that the system will be most often applied to counties, although it can be applied to other areas that exhibit an urban-rural dichotomy such as Native American tribal lands. The urban portion can be used separately to codify urban areas and clusters.

Table 3.1 presents the urban portion of the classification system. Five classes, coded 1 through 5, roughly correspond to existing definitions used by the Census and other government agencies. The first two classes are based on the Metropolitan Area core definition and require urban populations of greater than 50,000. The dividing point between the two codes is 200,000 residents. This is the same threshold used by the FTA to determine the flow of 5307 funds, which may be provided either directly to the designated recipient, as is the case for urbanized areas with populations greater than 200,000, or to the governor of the state. The third class is similar to that of Micropolitan Areas where an urban population of at least 10,000 is necessary. The fourth class is assigned to communities with urban populations between 2,500, the minimum threshold for urban clusters, and 9,999. Counties with no urban areas are assigned the number 5.

Table 3.1 Urban Population-Numeric Classification

	Urban Population Breaks	
Class	Lower Bound	Upper Bound
1	200,000	+
2	50,000	199,999
3	10,000	49,999
4	2,500	9,999
5	No urban areas	

The rural density classification coding classifications are presented in Table 3.2. Counties with no rural areas receive the highest classification, the letter a. Those with densities between 50 and 1,000 persons per square mile are classified by the letter b. Those with densities between 25 and 49, and 10 and 24 are classified by the letters c and d. All other areas are placed in class e. In order for counties with urban areas to be classified in classes b through e they must have a rural area greater than 100 square miles. This is done to account for small, undeveloped areas in large urban counties.

Table 3.2 Rural Density-Alphabetic Classification

	Rural Density Breaks	
Class	Lower Bound	Upper Bound
a	No rural areas	
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c	25	49
d	10	24
e	0	10

Table 3.3 presents the classification of seven counties and one city to demonstrate the practicality of the system. As expected, New York, New York, is classified as 1a, the same as the city of Baltimore in Maryland. Neither county has rural areas. Anne Arundel and Montgomery Counties are both classified 1b, with relatively densely populated rural areas. They have roughly the same density as rural portions of Frederick County, which is classified 2b due to its less populated urban areas. Cass, Slope, and Stark County in North Dakota all have a rural density of less than 10 individuals per square mile and are assigned the letter e. Urban Population codes for the three counties differ from 3 for Cass to 5 for Slope.

Table 3.3 Classification Example Table

		Urban	Rural			SURTC
County	State	Population	Population	Area	Density	Classification Code
New York	NY	3,141,856	--	--	--	1a
Anne Arundel	MD	462,092	27,564	210	131	1b
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Frederick	MD	139,462	55,815	537	97	2b
Montgomery	MD	848,752	24,589	247	99	1b
Cass (Fargo)	ND	106,577	16,561	1,734	10	2e
Slope	ND	--	767	1,218	1	5e
Stark	ND	15,920	6,716	1,331	5	3e

4. UPPER GREAT PLAINS AND TRANSIT SERVICE

In this section population, land area, and transportation service information are provided for eight Upper Great Plains states. The purpose is to illustrate differences among classifications and the type of transportation service available. The information will later be used to conduct the statistical analysis presented in Section 5. The eight-state region of Colorado, Iowa, Minnesota, Montana, Nebraska, North Dakota, South Dakota, and Wyoming was selected as it is geographically diverse and large. Many of the states are located in the Small Urban and Rural Transit Center's area of focus.

4.1 Demographic and Geographic Data

We begin by presenting demographic and geographic data by classification. Three classifications are used: U.S. Census Bureau definitions, Metropolitan Statistical Areas, and the newly introduced Urban Population-Rural Density Codes. The Urban Population-Rural Density Codes are presented separately by urban and rural code given the large number of possible combinations.

4.1.1. Urbanized Areas/Urban Clusters

U.S. Census Bureau definitions for urban area, which are either urbanized areas or urban clusters, and rural area, form the foundation of the new Urban Population-Rural Density Code system. A map of urban clusters and urbanized areas is presented in Figure 4.1. The eight-state region appears predominantly rural with its relatively few large urban centers, Minneapolis-St. Paul, Minnesota; Denver, Colorado; Omaha, Nebraska; and Des Moines, Iowa; clearly noticeable.

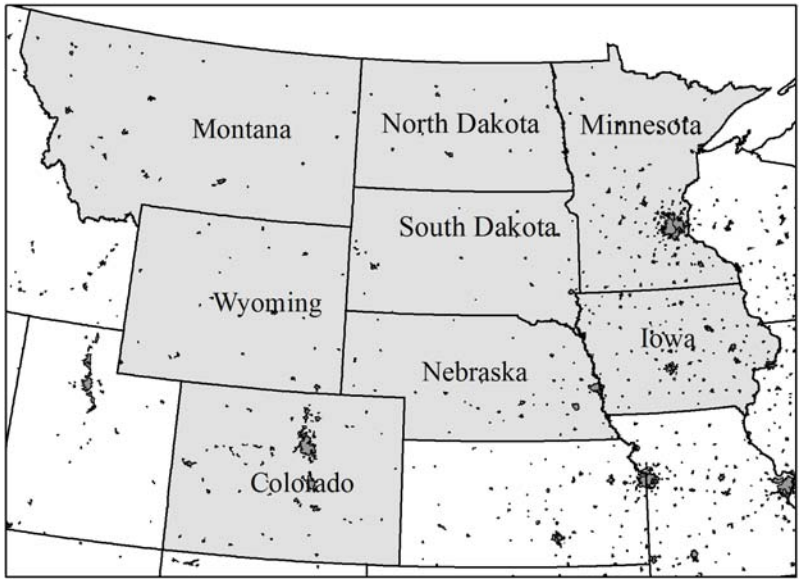

Figure 4.1 Urban Clusters and Urbanized Areas

Urban and rural population, as defined and tabulated by the U.S. Census, for each of the eight states is presented in Table 4.1. Colorado, Iowa, Minnesota, and Nebraska have urban populations greater than one million residents. Surprisingly, at least half of each of the eight-state's residents live in an urban area.

Table 4.1 Urban and Rural Population by State

	Colorado	Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming
Urbanized Areas	3,212,849	1,114,790	2,711,750	234,195	805,111	230,797	194,584	125,921
Urban Clusters	420,336	672,642	778,309	253,683	388,614	128,161	196,843	195,423
Urban	3,633,185	1,787,432	3,490,059	487,878	1,193,725	358,958	391,427	321,344
Rural	668,076	1,138,892	1,429,420	414,317	517,538	283,242	363,417	172,438
Total	4,301,261	2,926,324	4,919,479	902,195	1,711,263	642,200	754,844	493,782

Urban and rural land area measured in square miles by state is presented in Table 4.2. Colorado and Minnesota have urban areas greater than 1,000 miles square. On average, about one percent of the region's land mass is urban.

Table 4.2 Urban and Rural Area by State

	Colorado	Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming
Urban	1,271	806	1,483	254	454	247	170	168
Rural	102,465	55,095	78,128	141,135	76,422	68,500	75,559	96,770
Total	103,736	55,901	79,611	141,389	76,876	68,747	75,729	96,938

4.1.2. Metropolitan Areas

Metropolitan counties are presented in Figure 4.2. A large number of metropolitan counties are located in Colorado, Iowa, and Minnesota. Contrasting this map with that of urban areas demonstrates the error that results from the belief that metropolitan counties are uniformly dense.

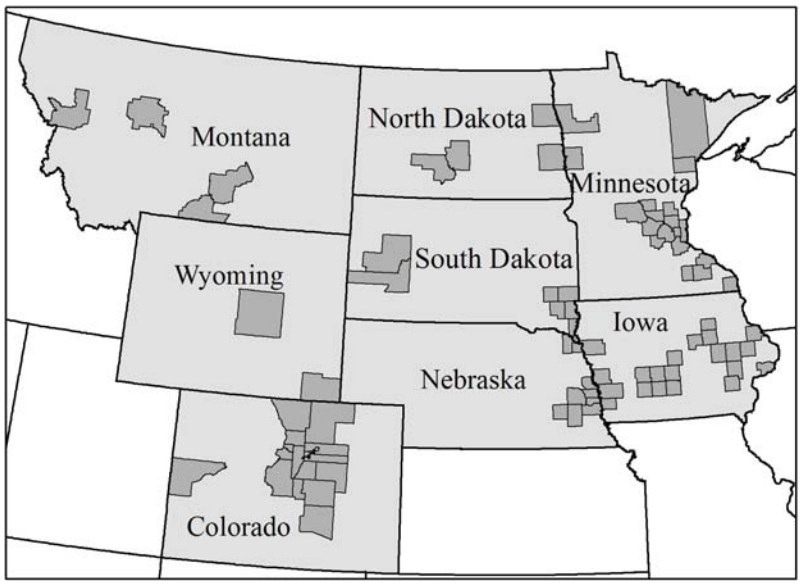

Figure 4.2 Metropolitan Counties

Table 4.3 presents the number of metropolitan and non-metropolitan counties for each of the eight states. Wyoming has the fewest number of metropolitan counties, two. Iowa has the greatest number of metropolitan counties, 21.

Table 4.3 Number of Metropolitan and Non-Metropolitan Counties by State

	Colorado	Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming
Metropolitan	17	21	19	4	9	4	7	2
Non-Metropolitan	47	78	68	52	84	49	59	21
Total	64	99	87	56	93	53	66	23

Table 4.4 presents the population living in metropolitan and non-metropolitan areas by state. Colorado has the largest metropolitan population with 3,690,656. North Dakota has the smallest with 283,966.

Table 4.4 Metropolitan and Non-Metropolitan Population by State

	Colorado	Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming
Metropolitan	3,690,656	1,572,018	3,403,773	315,063	942,503	283,966	312,489	148,140
Non-Metropolian	624,576	1,354,489	1,512,706	587,132	768,760	358,234	442,349	345,642
Total	4,315,232	2,926,507	4,916,479	902,195	1,711,263	642,200	754,838	493,782

Table 4.5 presents the land mass of metropolitan and non-metropolitan counties for each of the eight states. Nebraska has the smallest area of land located in metropolitan counties, 4,136 square miles. Colorado has the largest with 23,006.

Table 4.5 Metropolitan and Non-Metropolitan Area by State

	Colorado	Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming
Metropolitan	23,006	12,248	16,873	9,862	4,136	6,673	9,194	7,966
Non-Metropolian	79,635	43,152	57,070	131,410	72,447	62,231	66,613	89,080
Total	102,641	55,400	73,943	141,272	76,583	68,904	75,807	97,046

4.1.3. Urban Population Code

Figure 4.3 presents a map of counties classified by the Urban Population code. The impacts of five classes versus the dichotomous metropolitan area definitions is apparent by the greater number of shaded counties.

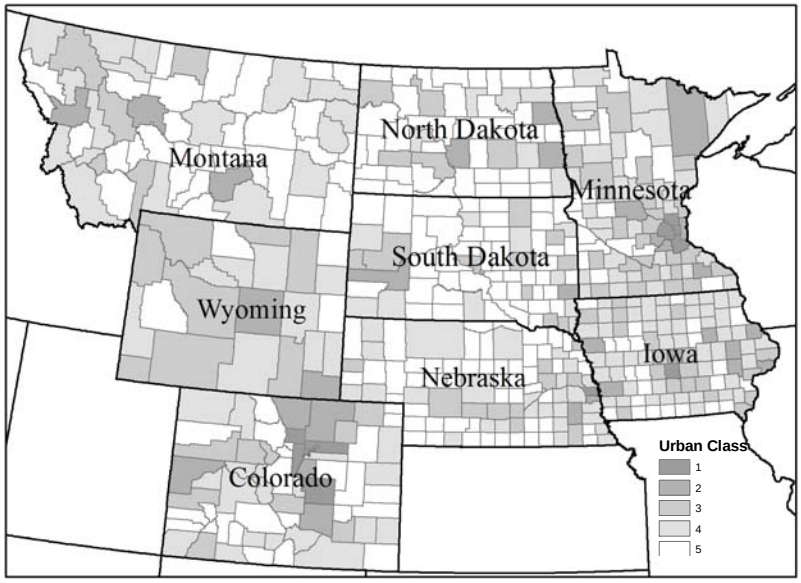

Figure 4.3 Urban Areas

Table 4.6 presents the population by Urban Population code. Colorado and Minnesota each have approximately 2.2 million residents residing in the most urbanized counties. Four states, Montana, North Dakota, South Dakota, and Wyoming, have no urbanized areas with population over 200,000.

Table 4.6 Population by Urban Code by State

	Colorado	Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming
1	2,267,737	374,601	2,281,223	-	463,585	-	-	-
2	865,923	950,092	818,804	305,511	372,886	258,663	236,840	148,140
3	300,502	636,335	1,041,155	249,297	369,186	148,403	223,066	229,468
4	744,621	737,761	566,510	221,126	307,167	67,547	104,709	90,499
5	136,449	227,718	208,787	126,261	198,439	167,587	190,223	25,675

Table 4.7 presents area by Urban Population Code. North Dakota, South Dakota, and Montana have sizeable area of counties with no urban cluster or greater.

Table 4.7 Area by Urban Code by State

	Colorado	Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming
1	4,992	570	1,707	-	331	-	-	-
2	13,151	5,365	9,330	7,931	1,080	4,837	3,585	8,026
3	15,098	10,767	20,884	14,681	9,297	9,570	10,836	44,236
4	34,273	26,970	27,893	46,222	27,026	7,460	12,192	31,340
5	36,222	12,229	19,797	72,555	39,142	47,127	49,286	13,504

4.1.4. Rural Density Code

Counties in the eight-state region shaded by their Rural Density Code are presented in Figure 4.4. None of Iowa's counties have average rural area density fewer than 10 people per square mile, while all of Wyoming's counties have densities in that range. The low population densities in Montana, Wyoming, and the Dakotas is clearly noticeable in the map.

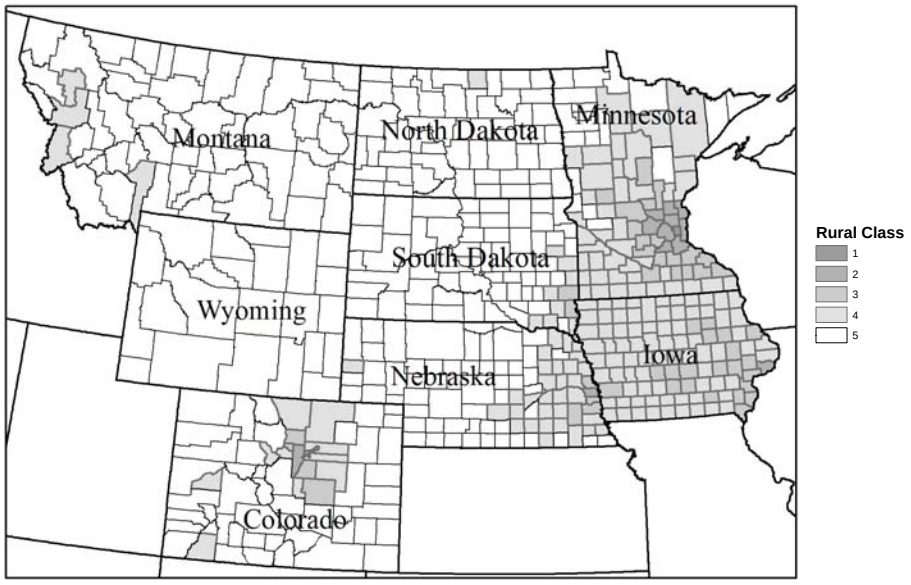

Figure 4.4 Rural Counties

Table 4.8 presents population by Rural Density Code by state. All of Wyoming's residents live in counties with a rural population density of fewer than 10 persons per square mile. Iowa has no counties with a population density of fewer than 10 persons per square mile.

Table 4.8 Population by Rural Code by State

	Colorado	Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming
1	554,636	-	511,035	-	-	-	-	-
2	527,056	158,668	2,287,607	-	463,585	-	-	-
3	988,740	1,497,110	847,187	-	416,000	-	172,403	-
4	1,443,297	1,270,729	1,084,880	226,210	517,193	13,674	96,532	-
5	801,503	-	185,770	675,985	314,485	628,526	485,903	493,782

The area in square miles of rural areas organized by state and rural density code is presented in Table 4.9. Only a small portion of two states, Colorado and Minnesota, have counties with no rural portions. Montana, North Dakota, and Wyoming are sparsely populated, with all rural portions having an average density of fewer than 25 people per square mile.

Table 4.9 Area by Rural Code by State

	Colorado	Iowa	Minnesota	Montana	Nebraska	North Dakota	South Dakota	Wyoming
1	153	-	156	-	-	-	-	-
2	772	458	4,255	-	331	-	-	-
3	3,859	12,471	11,136	-	2,029	-	1,387	-
4	14,841	42,972	41,686	8,993	17,495	902	4,562	-
5	84,111	-	22,378	132,396	57,021	68,092	69,950	97,106

4.2 Transportation Service

Next, this study presents transportation service availability by county classification. Three service types are considered: fixed-route, demand-response, and intercity bus service. A number of data sources are used to construct the following tables, including the American Public Transportation Association and various state resources. These sources, accurate at the time of publication, may be dated due to recent changes in service. Given the variety of data sources, there is little assurance that the definitions for the three service types are uniform.

The Rural Density Code may be of little value with this data set as service was seldom well-described by urban and rural location. However, a spurious relationship between rural density code and transportation service may be found due to a correlation between urban population and rural density. Also, data was typically found to be organized by agency, not geography, making it difficult to know precisely where service is available.

4.2.1. Fixed-Route

Fixed-Route Service can be defined as transit service operating on fixed routes and schedules, regardless of passenger activity. A map of counties with fixed-route service is presented in Figure 4.5. Fixed-route service is commonly found in metropolitan counties and those with urbanized areas.

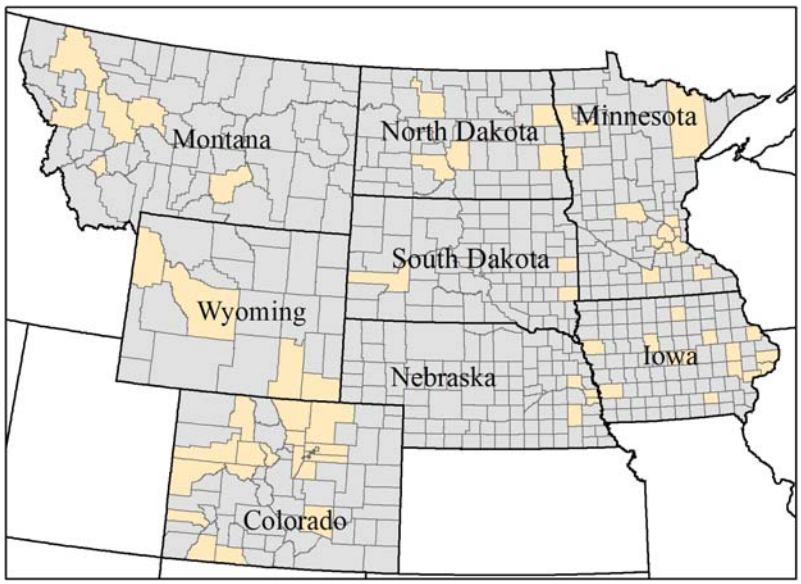

Figure 4.5 Counties with Fixed-Route Service

Table 4.10 presents the number of counties with fixed-route service by metropolitan area classification. Surprisingly, nearly half of the metropolitan counties do not have fixed-route service. This is likely explained by relatively rural counties being classified as metropolitan areas due to their social and economic ties to the core county.

Table 4.10 Fixed-Route Service by Metropolitan County

	Fixed-Route Service	No Fixed-Route Service
Metropolitan	44	39
Non-Metropolitan	25	432

Table 4.11 presents the number of counties with fixed-route service classified by their urban code. All counties with urban populations greater than 50,000 have fixed-route service.

Table 4.11 Fixed-Route Service by Urban County Code

	Fixed-Route Service	No Fixed-Route Service
1	11	0
2	31	0
3	23	69
4	4	163
5	1	238

Table 4.12 presents the number of counties with fixed-route service classified by their rural code. There appears to be some association between less rural counties and fixed-route service.

Table 4.12 Fixed-Route Service v. Rural County Code

	Fixed-Route Service	No Fixed-Route Service
1	2	0
2	8	4
3	20	30
4	16	155
5	25	280

4.2.2. Demand Response

Demand-response transportation can be defined as transit operated in response to requests by passengers or their agents. Identifying demand-response transportation is difficult due to variations in service. A map of counties with demand-response service is presented in Figure 4.6. There is some type of demand-response service in nearly every county in the eight-state region.

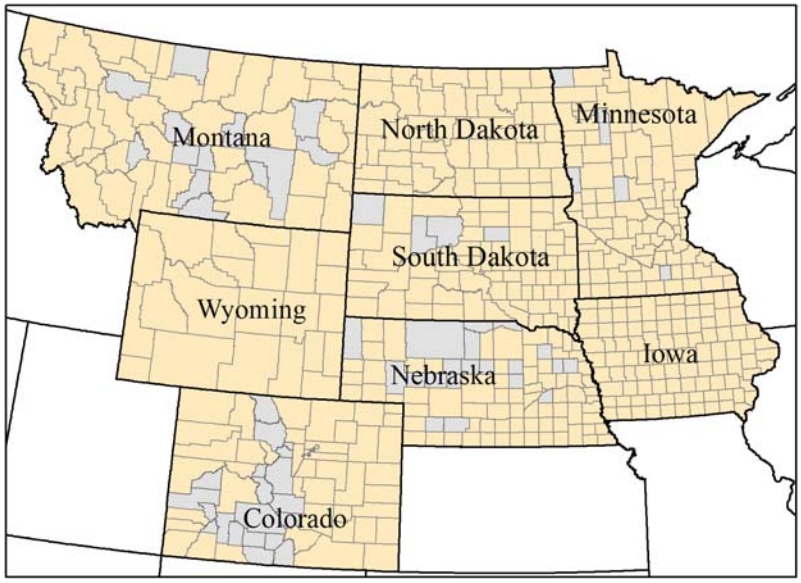

Figure 4.6 Counties with Demand-Response Service

Table 4.13 presents the number of counties with demand response service by metropolitan classification. All but one metropolitan has demand-response service.

Table 4.13 Demand Response v. Metropolitan County

	Demand-Response Service	No Demand-Response Service
Metropolitan	82	1
Non-Metropolitan	400	57

Table 4.14 presents the number of counties with demand-response transportation service by Urban Population Code. All counties with an urban population greater than 50,000 have demand-response service. Approximately 80% of counties without an urban area have demand-response service.

Table 4.14 Demand Response v. Urban County Code

Urban Code	Demand-Response Service	No Demand-Response Service
1	11	0
2	31	0
3	89	3
4	157	10
5	190	49

Table 4.15 presents the number of counties with demand-response service classified by their Rural Density Code. All but one of the 64 least rural counties had demand-response service. Approximately five-sixths of the most rural counties had demand-response transportation service.

Table 4.15 Demand Response v. Rural County Code

	Demand-Response Service	No Demand-Response Service
1	2	0
2	12	0
3	49	1
4	163	8
5	250	55

4.2.3. Intercity Bus

Intercity bus service can be defined as fixed-route transportation with limited stops between two areas not in close proximity to one another. A map of counties with intercity bus service is presented in Figure 4.7.

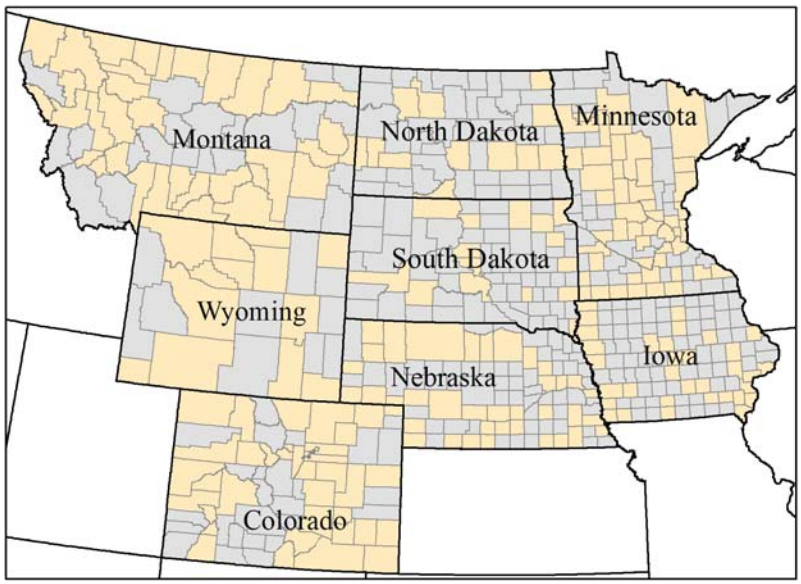

Figure 4.7 Counties with Intercity Bus Service

Table 4.16 presents the number of counties with intercity bus service by metropolitan classification. About two-thirds of metropolitan counties and one-third of non-metropolitan counties have intercity bus service.

Table 4.16 Intercity Bus v. Metropolitan County

	Fixed-Route Service	No Fixed-Route Service
Metropolitan	50	33
Non-Metropolitan	179	278

Table 4.17 presents the number of counties with intercity bus classified by Urban Population Code. All but one of the counties with large urban populations has intercity bus service.

Table 4.17 Intercity Bus v. Urban County Code

	Intercity Bus Service	No Intercity Bus Service
1	10	1
2	28	3
3	69	23
4	68	99
5	54	185

The number of counties with intercity bus service classified by Rural Censity code are presented in Table 4.18. With one exception, all counties in the two least rural classes have intercity bus service. A majority of counties with rural population densities between 25 and 49 people per square mile has intercity bus service.

Table 4.18 Intercity Bus v. Rural County Code

	Intercity Bus Service	No Intercity Bus Service
1	2	0
2	11	1
3	30	20
4	72	99
5	115	190

5. MEASURES OF ASSOCIATION

In this section, two measures of association, Pearson's chi-square test statistic and Kendall's tau-b correlation coefficient, are employed to quantify the relationship, if any, between geographic classes and available transportation service. Two-way tables presented in Section 4 are used as input. Two systems, Metropolitan Statistical Area definitions and the new two-part classification system introduced in this paper and each of the three service types presented are considered: fixed-route, demand-response, and intercity bus.

5.1 Pearson's Chi-Square Test

Pearson's chi-square test is a commonly used statistic employed to investigate association among variables. It tests the hypothesis that an observed distribution of events in a sample is consistent with a theoretical one. The formula for the chi-square statistic is

$$Q_P = \sum_i \sum_j \frac{(n_{ij} - e_{ij})^2}{e_{ij}}$$

where

$$e_{ij} = \frac{n_i \cdot n_j}{n}$$

When row and column variables are independent, Q_P has an asymptotic chi-square distribution with (R-1)(C-1) degrees of freedom.

High levels of association for each of the three classifications and each of the three service types is found. Table 5.1 presents the results of the chi-square test results. The first value is the calculated chi-square statistic, the second the related p-value. It is not possible to compare urban, rural, and metropolitan classification systems directly as the tables have different degrees of freedom. Also, there are not enough observations in the eight state dataset to calculate the chi-square values for the 25 possible urban-rural combinations.

Table 5.1 Chi-Square Test Results

	Urban	Rural	Metropolitan
Fixed	300.84 (<.0001)	83.58 (<.0001)	142.8484 (<.0001)
DR	35.65 (<.0001)	26.1 (<.0001)	9.3024 (.0023)
ICB	118.35 (<.0001)	23.7076 (<.0001)	12.7710 (.0004)

5.2 Kendall's Tau-b

Kendall's tau correlation coefficient is used to measure association among ordered variables. In this case, urban and rural classifications can be thought of being ordered as classes arranged in descending order. Kendall's tau-b, one of three variations of the method, is used as it is readily calculated by SAS.

Kendall's tau-b test statistic is a function of the number of concordances and discordances in paired observations. Concordance occurs when paired observations vary together, and discordance occurs when paired observations vary differently. The formula for the statistic is

$$\tau = \frac{\sum_{i<j}(\text{sgn}(x_i - x_j)\,\text{sgn}(y_i - y_j))}{\sqrt{(T_0 - T_1)(T_0 - T_2)}}$$

where

$$T_0 = n(n-1)/2$$
$$T_1 = \sum_k t_k(t_k - 1)/2$$
$$T_2 = \sum_1 u_1(u_1 - 1)/2$$

With t_k the number of tied x values in the k^{th} group of tied x values, u_l is the number of tied y values in the l^{th} group of tied y values, n is the number of observations.

Values of Kendall's tau-b coefficient range from -1 to 1. Extreme values occur when there is strict monotonicity in the data. The coefficient has the benefit of being relatively easily interpreted with the odds ratio of concordant to discordant sets being equal to $(1+\tau)/(1-\tau)$. For example, if τ=.5 then it is three times as likely that a pair of observations is concordant rather than discordant.

Table 5.2 presents the Kendall's tau-b coefficient followed by the asymptotic standard error in parentheses. As expected, there is a positive association between higher classes and service availability. The urban classification shows the strongest degree of correspondence between class and service availability.

Table 5.2 Kendall's Tau-B Results

	Urban	Rural	Metropolitan
Fixed	.4931 (.0280)	.2371 (.0464)	.5065 (.053)
DR	.2333(.0305)	.2091 (.0298)	.1313 (.0196)
ICB	.4170 (.0342)	.143 (.0411)	.1538 (.0431)

Pearson's chi-square and Kendall's tau-b show high levels of association between the new Urban Population-Rural Density classification system and transportation service. These findings support, but do not guarantee, the value of the system. Its true practicality will be only be noted by its successful employment by practitioners.

6. CONCLUSIONS

In this paper, existing urban-rural classification systems are presented and evaluated as tools to guide transit policy. Due to various deficiencies, no system reviewed proved suitable for that purpose. Given the potential benefit of classification on the development and delivery of transit policy, a new system was devised.

The Urban Population-Rural Density Code system addresses the shortcomings of existing urban-rural classification systems. It individually classifies urban areas by total population and rural areas by their population density. The new system exhibits high levels of association with transportation services provided for counties in an eight-state region.

During the course of the study the need for a uniform, up-to-date source of transportation service provider data was identified. Resources do exist, including the National Transit Database, the new Rural National Transit Database, and state publications. However, many are hard documents with dated service information. There is also no guarantee of uniform definitions among data sources, which makes analysis difficult and results questionable.

Transportation service data are primarily classified by agency, not services provided or area. In some cases, it is difficult or impossible to positively determine what services were provided to what area. As information presented in this way would be beneficial to other researchers and, more importantly, system users, a significant concerted effort to reorganize transportation service may be worthy of effort.

The value of the Urban Population-Rural Density Coding system will only be proven by practical benefits resulting from its appropriate application in the future. The system may prove valuable outside of transit, especially in other fields of transportation and logistics. The Urban Population-Rural Density Code is easily amenable to alteration, such as making adjustments to class thresholds.

7. REFERENCES

American Public Transportation Association. Colorado Transit Links. http://www.apta.com/links/state_local/co.cfm (accessed June 5, 2007).

American Public Transportation Association. Iowa Transit Links. http://www.apta.com/links/state_local/ia.cfm (accessed June 5, 2007).

American Public Transportation Association. Minnesota Transit Links. http://www.apta.com/links/state_local/mn.cfm (accessed June 5, 2007).

American Public Transportation Association. Montana Transit Links. http://www.apta.com/links/state_local/mt.cfm (accessed June 5, 2007).

American Public Transportation Association. Nebraska Transit Links. http://www.apta.com/links/state_local/ne.cfm (accessed June 5, 2007).

American Public Transportation Association. North Dakota Transit Links. http://www.apta.com/links/state_local/nd.cfm (accessed June 5, 2007).

American Public Transportation Association. South Dakota Transit Links. http://www.apta.com/links/state_local/sd.cfm (accessed June 5, 2007).

American Public Transportation Association. Wyoming Transit Links. http://www.apta.com/links/state_local/wy.cfm (accessed June 5, 2007).

Atchley, R.C. A size-function typology of cities. *Demography* 4:721-733 (1967).

Colorado Association of Transit Agencies. Transit Directory. http://www.coloradotransit.com/transitdirectory.php (accessed June 5, 2007).

Hegland, G., Miller, J., Mielke, J. and J. Hough. Enhancing Passenger Mobility Services in North Dakota through increased coordination. Upper Great Plains Transportation Institute, North Dakota State University DP-160. 2004.

Iowa Department of Transportation. Office of Public Transit. Iowa Transit Services http://www.iatransit.com/services/index.asp (accessed June 5, 2007).

Public and Specialized Tranpsortation Fiscal Year 2006. South Dakota Department of Transportation. http://www.sddot.com/fpa/transit/docs/FY2006StatisticalReport.pdf (accessed June 5, 2007).

2006 Minnesota Transit Report: A guidebook to Minnesota's Public Transportation Network. Minnesota Department of Transportation http://www.dot.state.mn.us/transit/transitreports/06/index.html (accessed June 5, 2007).

Nebraska Transit Directory. Nebraska Department of Roads http://www.dor.state.ne.us/rpt/transit-dir/transitdir-rural.pdf (accessed May 2, 2008).

Standards for Defining Metropolitan and Micropolitan Statistical Areas; Notice. Federal Register 65 (December 27, 2000): 62228-62238.

United States Department of Agriculture. Economic Research Service. 2004. Measuring Rurality: Rural-Urban Continuum Codes. http://www.ers.usda.gov/briefing/Rurality/RuralUrbCon/ (accessed October 17, 2007).

United States Department of Agriculture. Economic Research Service. 2007. Measuring Rurality: Urban Influence Codes. http://www.ers.usda.gov/Briefing/Rurality/UrbanInf/ (accessed October 17, 2007).

United States Department of Agriculture. Economic Research Service 2005. Rural-Urban Commuting Area Codes. http://www.ers.usda.gov/Data/RuralUrbanCommutingAreaCodes/ (accessed January 25, 2007).

Urban Area Criteria for Census 2000. Federal Register 67 (March 15, 2002): 11663-11670.