GIS Modeling for Transportation Planning in Oklahoma

Final Report
ODOT Item Number 2202

by

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15. Abstract

Transportation planning is an important process in the development of Oklahoma and the United States. Gaps traveling from one place to another are addressed in this research. The purpose of the research is to analyze the patterns and changes of activities related to transportation. Some of the major factors that affect transportation are population, education, employment, income, and transportation behaviors. Depending on the needs of the people, their travel patterns vary.

This project produces maps providing the visual pattern of the data related to transportation variables. These maps would form the basis of any transportation analysis. The maps generated in this research pertain to variables in population, education, employment, and income for transportation planning.

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SI (METRIC) CONVERSION FACTORS

Approximate Conversions to SI Units					*Approximate Conversions from SI Units*				
Symbol	**When you know**	**Multiply by**	**To Find**	**Symbol**	**Symbol**	**When you know**	**Multiply by**	**To Find**	**Symbol**
		LENGTH					**LENGTH**		
in	inches	25.40	millimeters	mm	mm	millimeters	0.0394	inches	in
ft	feet	0.3048	meters	m	m	meters	3.281	feet	ft
yd	yards	0.9144	meters	m	m	meters	1.094	yards	yds
mi	miles	1.609	kilometers	km	km	kilometers	0.6214	miles	mi
		AREA					**AREA**		
in^2	square inches	645.2	square millimeters	mm^2	mm^2	square millimeters	0.00155	square inches	in^2
ft^2	square feet	0.0929	square meters	m^2	m^2	square meters	10.764	square feet	ft^2
yd^2	square yards	0.8361	square meters	m^2	m^2	square meters	1.196	square yards	yd^2
ac	acres	0.4047	hectacres	ha	ha	hectacres	2.471	acres	ac
mi^2	square miles	2.590	square kilometers	km^2	km^2	square kilometers	0.3861	square miles	mi^2
		VOLUME					**VOLUME**		
fl oz	fluid ounces	29.57	milliliters	mL	mL	milliliters	0.0338	fluid ounces	fl oz
gal	gallon	3.785	liters	L	L	liters	0.2642	gallon	gal
ft^3	cubic feet	0.0283	cubic meters	m^3	m^3	cubic meters	35.315	cubic feet	ft^3
yd^3	cubic yards	0.7645	cubic meters	m^3	m^3	cubic meters	1.308	cubic yards	yd^3
		MASS					**MASS**		
oz	ounces	28.35	grams	g	g	grams	0.0353	ounces	oz
lb	pounds	0.4536	kilograms	kg	kg	kilograms	2.205	pounds	lb
T	short tons (2000 lb)	0.907	megagrams	Mg	Mg	megagrams	1.1023	short tons (2000 lb)	T
		TEMPERATURE (exact)					**TEMPERATURE (exact)**		
°F	degrees Fahrenheit	(°F-32)/1.8	degrees Celsius	°C	°C	degrees Fahrenheit	9/5(°C)+32	degrees Celsius	°F
		FORCE and PRESSURE or STRESS					**FORCE and PRESSURE or STRESS**		
lbf	poundforce	4.448	Newtons	N	N	Newtons	0.2248	poundforce	lbf
lbf/in^2	poundforce per square inch	6.895	kilopascals	kPa	kPa	kilopascals	0.1450	poundforce per square inch	lbf/in^2

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I. Introduction

Information systems have been modifying the world of business in Oklahoma and the United States. Transportation planning is no exception for the need to be integrated with an information system. Geographical Information System (GIS) is an interconnected unit consisting of hardware, software, data, people and organizations for collecting, storing and analyzing the different spatial information. The GIS can be used for different applications with respect to transportation, such as infrastructure planning, design and management, public transit planning and operations, traffic and accident safety management, logistics, and intelligent transport systems. Most cities and communities have been involved in developing GIS data and applications related to transportation due to better spatial visualization, data management, decision modeling and planning.

In general, a Geographical Information System for transportation can serve three different functions: (1) serve as an information database for spatial and nonspatial identities, (2) serve as an analytical tool, and (3) serve as a decision support system as shown in Shaw and Miller (2001). The GIS can aid the “front-end” (user interface) and the “back-end” (database) of the transportation decision process.

II. Study Area

The study area is the State of Oklahoma taking into consideration all the seventy-seven counties. Spatial extent of the study area is shown in the Figure 1. This project is aimed at developing maps using projected data on population, income, education and employment for the state of Oklahoma. The maps in this report display distribution of population, income, education and employment in all the counties of Oklahoma for the time period 2010 to 2035. The required data for this project is in MS Excel format and later used in ArcGIS 9.2 software to create the maps.

Coordinate system used in the GIS is the following system.

Projection system: Albers Projection

Central Meridian: -96

1st Parallel: 20

2nd Std Parallel: 60

Latitude of Origin: 40

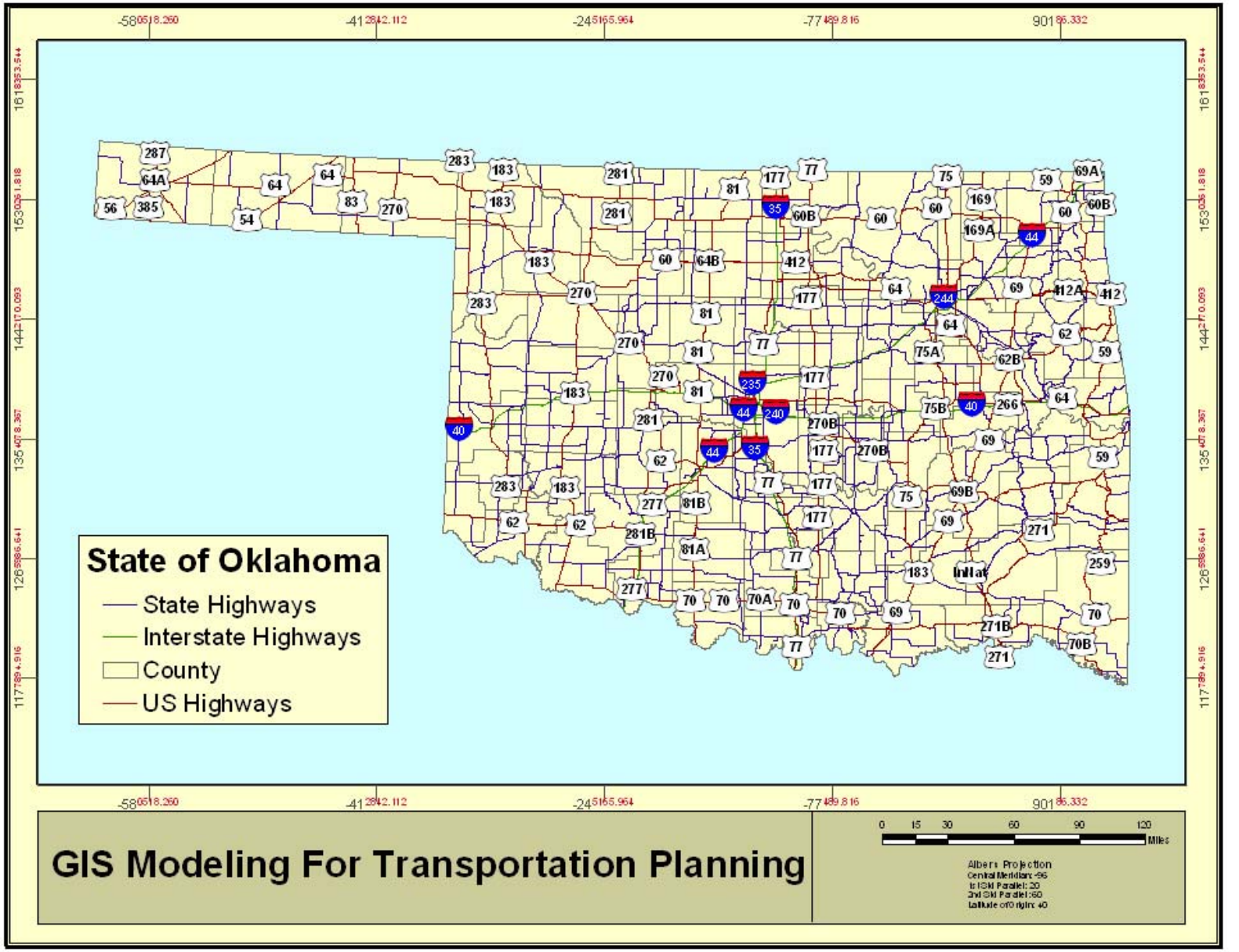

Figure 1. Study Area – State of Oklahoma

III. Travel Demand Modeling

Travel demand modeling deals with the process of estimating the infrastructure requirement of the future based on the current and projected interaction between the movement of people and materials between geographic locations (Shaw and Miller, 2001). The role of the GIS would be to guide the development of land use transportation systems to achieve beneficial economic, social and environmental outcomes.

Ideally, any Information system would enhance the flow of information through the organization. The first step in travel demand modeling is information management. This step deals with efficient data collection and storage. As a result, retrieval and presentation of information is made very easy. The second step is the process of converting a raw data into information through information manipulation procedures. Editing the geodatabase layers to demonstrate all the changes in the study area is achieved through transportation planning. There are different techniques to ensure which is allowed to make the changes and how the changes are affected. The GIS analytical functions can be used to explicitly scrutinize the transportation process being modeled or the problem being solved. The corrected data is finally used for analysis in the final stage.

An interesting approach to transportation planning is the equilibrium approach. The basic principle behind this approach is that the travel demand is viewed as a type of economic market that achieves a balance between the demand for travel and the supply of transportation services. All equilibrium approaches are based on this assumption but actually such a condition may never come true.

Activity based transportation modeling works on the principle that every travel is based on the need to travel. Transportation exists because individuals have the need to fulfill other activities, such as work, shopping, recreation, socializing, and others. In the long run, the modeling is done to meet the emerging needs due to the interactions of individuals with the environment trying to fulfill the activities through transportation.

This project deals with the collection of data and production of GIS layers related to transportation planning. We start with the demographic variables as people are the most important factors which influence transportation. The demographic variables are population, population density, education, employment, income, and transportation statistics. The variables are given names selected by the Department of Transportation (ODOT) as shown in Table 1. In the next phase of this investigation, we may analyze the collected data here using the equilibrium collected approach or activity-based approach.

Table 1. Description of Variables Used in Transportation Analysis

LE NAME	DESCRIPTION
CENSUS_ID	ID field from census dataset
COUNTY_NAME	Name of county
TOT_EMPLOYED	Total number of employed people
TOT_UNEMPLOYED	Total number of people with job
TOT_LABOR_FORCE	Total labor work force
TOT_EDUCATED	Total number of people educated
EDU_LEV_THRU_8GR	Educational attainment; Population 25 years and over; Less than 9th grade
EDU_LEV_9_11GR	Educational attainment; Population 25 years and over; 9th to 12th grade
EDU_HS_HSEQV	Educational attainment; Population 25 years and over; High school graduate (includes equivalency); Number
EDU_COLL_NO_DEG	Educational attainment; Population 25 years and over; Some college, no degree; Number
EDU_ASSOC_DEG	Educational attainment; Population 25 years and over; Associate degree; Number
EDU_BACH_DEG	Educational attainment; Population 25 years and over; Bachelor's degree; Number
EDU_GRAD_PRO_DEG	Educational attainment; Population 25 years and over; Graduate or professional degree; Number
TOT_COMMUTERS	Commuting to work; Workers 16 years and over; Number
COM_CTV_1	Commuting to work; Workers 16 years and over; Car, truck, or van -- drove alone; Number
COM_CTV_CARPOOL	Commuting to work; Workers 16 years and over; Car, truck, or van -- carpooled; Number
COM_PUB_TRANS	Commuting to work; Workers 16 years and over; Public transportation (including taxicab); Number
COM_WALKED	Commuting to work; Workers 16 years and over; Walked; Number
WORK_AT_HOME	Commuting to work; Workers 16 years and over; Worked at home; Number
TRAVEL_TIME_MIN	Commuting to work; Workers 16 years and over; Mean travel time to work (minutes); Number
MED_INCOME	Median household income
AGG_INCOME	Aggregate household income
TOTAL_AREA	Total Area of the County (Square miles)
POP(2010)	Projected Population of the County in 2010 (Number of people)
POP(2015)	Projected Population of the County in 2015 (Number of people)
POP(2020)	Projected Population of the County in 2020 (Number of people)
POP(2025)	Projected Population of the County in 2025 (Number of people)
POP(2030)	Projected Population of the County in 2030 (Number of people)
POP(2035)	Projected Population of the County in 2035 (Number of people)
DEN_2010	Population Density of the county in 2010 (Number of people per square mile)
DEN_2015	Population Density of the county in 2015 (Number of people per square mile)
DEN_2020	Population Density of the county in 2020 (Number of people per square mile)
DEN_2025	Population Density of the county in 2025 (Number of people per square mile)
DEN_2030	Population Density of the county in 2030 (Number of people per square mile)
DEN_2035	Population Density of the county in 2035 (Number of people per square mile)
PC_10TO15	Percentage of Population change from 2010 to 2015
PC_15TO20	Percentage of Population change from 2015 to 2020
PC_20TO25	Percentage of Population change from 2020 to 2025
PC_25TO30	Percentage of Population change from 2025 to 2030
PC_30TO35	Percentage of Population change from 2030 to 2035

IV. Population Analysis

The first variable is population, taken as a whole and not excluding any group of people based on age, sex, race, or origin. The population is the number of people living in seventy-seven counties of the state of Oklahoma. The projected population data from year 2010 to 2035 is obtained from the Oklahoma Department of Commerce (ODOC). The data obtained is in five year intervals. A methodology and model for population projection in Oklahoma was developed by ODOC and presented in a report. (OSDC, 2002).

The secondary source of data was the cartographic boundary file of Oklahoma. The shape file format for this feature is downloaded from the Environment Systems Research Institute (ESRI) website along with the FIPS code for Oklahoma counties. In order to compute the population density the project requires the area of each county. Therefore, the area in square miles for all the seventy-seven counties in Oklahoma is obtained from the United States census website.

The population data is represented in maps in two formats. One is the population density and other one is the percent change. The population data obtained was in five year intervals from year 2010 to 2035 for all the counties in Oklahoma. The data is subjected to initial exploratory analysis. The population data obtained in MS Excel is imported into ArcGIS and overlaid on the Oklahoma base map to see the population patterns. The map did not convey much information or pattern to the user. Later it was decided to compute the population density of each county in Oklahoma and then create a map using the population density values and not the raw population values. Population density was calculated for the years 2010, 2015, 2020, 2025, 2030 and 2035 using the following formula.

$$\text{Population density} = \frac{Population}{Area} \qquad (1)$$

Where population refers to individual population of each county in Oklahoma and area refers to area in square miles. Once the population density was computed, the excel file was saved as a database DB IV file and then imported to the ArcGIS environment.

This database was joined to the already added Oklahoma county shape file using the 'join' operation in ArcMap software. The FIPS code in the attribute tables of both the shape file and the database file acted as a primary key on which the join operation was performed. Now the computed population density values were added to the existing boundary file of Oklahoma and classification operation was performed. The classification was done using the manual classification method to have five classes in each map for the five year intervals respectively. The population density maps for the years 2010 to 2035 broken down in five year intervals are displayed below.

The second cartographic format is the percent change in population in five year interval from 2010 to 2015, 2015 to 2020 and so on as well as percent change in population for the entire time period from 2010 to 2035. Percent change in population for two time period is computed using the following equation.

$$\text{Percent Change in population} = \frac{Population_{y} * 100}{Population_{x}} - 100$$

Population *y* refers to the greatest year of the two years considered and population *x* refers to the smallest. This percent change is calculated for the time period 2010-2015, 2015-2020, 2020-2025, 2025-2030, 2030-2035, respectively, and appropriate maps are produced. The percent

change for the entire time horizon from year 2010- 2035 is also computed and displayed as a map in ArcMap.

Table 2 shows the population density for year 2010, 2015, 2020, 2025, 2030, and 2035. This table also presents the percent change from 2010 to 2035 over every five year time increment. These two sets of data are plotted for each Oklahoma county in Figures 2 through 7 and Figures 8 through 12.

Table 2a. Population Density

COUNTIES	TOTAL AREA	POP (2010)	POP (2015)	POP (2020)	POP (2025)	POP (2030)	POP (2035)
Adair	577.03	24700	26700	28800	30900	32900	34900
Alfalfa	881.44	5900	5900	5900	5900	5900	5900
Atoka	990.00	15500	16500	17400	18300	19300	20200
Beaver	1817.58	5900	5900	6000	6100	6100	6100
Beckham	904.14	21300	22200	23200	24200	25200	26200
Blaine	938.88	12600	13200	13700	14300	14900	15500
Bryan	943.43	40700	42800	44900	47000	49200	51300
Caddo	1290.31	30800	31400	32100	32600	33100	33500
Canadian	905.17	97300	102200	106800	110800	114200	117500
Carter	833.72	47400	48700	50200	51500	52900	54200
Cherokee	776.40	50400	54200	57900	61600	65300	69000
Choctaw	800.68	15600	15800	16000	16200	16300	16500
Cimarron	1841.17	3200	3300	3400	3400	3500	3500
Cleveland	558.34	231400	240800	248600	255700	262500	268600
Coal	521.30	6600	7100	7600	8100	8600	9100
Comanche	1083.82	123600	127900	132000	135800	139200	142200
Cotton	641.94	6600	6600	6700	6700	6800	6900
Craig	762.71	16500	17400	18300	19200	20000	20900
Creek	969.77	72000	74600	77000	79100	80900	82700
Custer	1002.00	27700	28500	29000	29600	30200	30900
Delaware	792.33	43400	46700	49900	53100	56200	59400
Dewey	1008.26	4600	4500	4500	4500	4500	4500
Ellis	1231.84	3800	3800	3700	3700	3700	3600
Garfield	1059.94	59200	60100	61000	61800	62500	63200
Garvin	813.66	27500	27900	28200	28400	28700	28900
Grady	1105.30	48800	50600	52300	53800	55300	56600
Grant	1003.61	5100	5100	5200	5200	5300	5300
Greer	643.66	5900	5900	5900	5900	5900	5900
Harmon	538.56	3300	3300	3300	3400	3400	3500
Harper	1040.96	3400	3400	3400	3400	3400	3400
Haskell	625.27	13500	14400	15300	16300	17200	18200
Hughes	814.64	15700	16500	17500	18400	19300	20200
Jackson	804.15	30100	31000	31900	32700	33400	34000
Jefferson	773.83	6600	6600	6700	6700	6800	6800
Johnston	658.29	11600	12300	13000	13700	14500	15200
Kay	945.12	49100	50000	50800	51500	52100	52700
Kingfisher	905.96	15300	16200	17100	18000	18900	19700
Kiowa	1030.66	9900	9900	9900	10000	10000	10000
Latimer	729.12	11000	11200	11500	11800	12100	12400

COUNTIES	TOTAL AREA	POP (2010)	POP (2015)	POP (2020)	POP (2025)	POP (2030)	POP (2035)
Le Flore	1608.03	51500	53500	55500	57300	59100	60900
Lincoln	965.62	34700	36300	37800	39200	40400	41700
Logan	748.92	38700	41100	43500	45700	47800	49900
Love	531.94	10500	11400	12300	13100	14000	14900
Major	580.13	32900	35700	38400	41000	43500	46000
Marshall	1901.32	35600	36400	37200	37900	38500	39100
Mayes	712.48	21700	23000	24300	25600	27000	28500
McClain	957.87	7400	7500	7500	7500	7500	7500
McCurtain	426.95	16900	18900	20800	22800	24800	26800
McIntosh	683.51	42100	44200	46300	48400	50300	52400
Murray	424.92	13800	14400	15000	15700	16400	17000
Muskogee	838.99	70900	72100	73300	74500	75500	76400
Noble	742.44	12000	12300	12600	12800	13000	13200
Nowata	580.87	12000	12800	13700	14500	15400	16200
Okfuskee	628.91	11900	12000	12200	12300	12500	12600
Oklahoma	718.31	701400	719000	735400	751100	765600	778100
Okmulgee	702.32	42100	43600	45200	46600	47900	49300
Osage	2303.80	47500	49300	50900	52200	53400	54500
Ottawa	484.73	34900	36100	37300	38400	39600	40800
Pawnee	594.87	18200	19200	20200	21100	22000	22900
Payne	697.13	77500	80800	83400	86300	89600	92900
Pittsburg	1377.85	45300	46300	47400	48300	49200	50200
Pontotoc	725.45	36300	37000	37700	38300	39000	39700
Pottawatomie	793.26	70000	72500	74800	77100	79300	81400
Pushmataha	1422.78	13000	13900	14700	15500	16300	17200
Roger Mills	1146.46	3400	3400	3400	3400	3400	3400
Rogers	711.44	80100	85100	90000	94400	98500	102400
Seminole	640.57	25200	25600	26000	26300	26700	27000
Sequoyah	714.88	43500	45900	48200	50400	52600	54700
Stephens	891.12	42900	43100	43400	43600	43800	44000
Texas	2048.81	26300	29500	32700	36000	39200	42500
Tillman	879.21	9200	9300	9400	9500	9600	9700
Tulsa	587.02	598900	615500	631400	646000	658500	669000
Wagoner	590.99	65100	69000	72700	76000	79000	81900
Washington	424.15	49700	50300	50800	51100	51300	51600
Washita	1009.07	11900	12100	12300	12400	12600	12700
Woods	1290.07	9200	9200	9200	9200	9300	9300
Woodward	1246.01	19200	19600	20000	20300	20600	20800

Table 2b. Percent Change in Population from 2010-35.

COUNTIES	DEN 2010	DEN 2015	DEN 2020	DEN 2025	DEN 2030	DEN 2035
Adair	42.81	46.27	49.91	53.55	57.02	60.48
Alfalfa	6.69	6.69	6.69	6.69	6.69	6.69
Atoka	15.66	16.67	17.58	18.48	19.49	20.40
Beaver	3.25	3.25	3.30	3.36	3.36	3.36
Beckham	23.56	24.55	25.66	26.77	27.87	28.98
Blaine	13.42	14.06	14.59	15.23	15.87	16.51
Bryan	43.14	45.37	47.59	49.82	52.15	54.38
Caddo	23.87	24.34	24.88	25.27	25.65	25.96
Canadian	107.49	112.91	117.99	122.41	126.16	129.81
Carter	56.85	58.41	60.21	61.77	63.45	65.01
Cherokee	64.91	69.81	74.57	79.34	84.11	88.87
Choctaw	19.48	19.73	19.98	20.23	20.36	20.61
Cimarron	1.74	1.79	1.85	1.85	1.90	1.90
Cleveland	414.44	431.28	445.25	457.96	470.14	481.07
Coal	12.66	13.62	14.58	15.54	16.50	17.46
Comanche	114.04	118.01	121.79	125.30	128.43	131.20
Cotton	10.28	10.28	10.44	10.44	10.59	10.75
Craig	21.63	22.81	23.99	25.17	26.22	27.40
Creek	74.24	76.93	79.40	81.57	83.42	85.28
Custer	27.64	28.44	28.94	29.54	30.14	30.84
Delaware	54.78	58.94	62.98	67.02	70.93	74.97
Dewey	4.56	4.46	4.46	4.46	4.46	4.46
Ellis	3.08	3.08	3.00	3.00	3.00	2.92
Garfield	55.85	56.70	57.55	58.31	58.97	59.63
Garvin	33.80	34.29	34.66	34.90	35.27	35.52
Grady	44.15	45.78	47.32	48.67	50.03	51.21
Grant	5.08	5.08	5.18	5.18	5.28	5.28
Greer	9.17	9.17	9.17	9.17	9.17	9.17
Harmon	6.13	6.13	6.13	6.31	6.31	6.50
Harper	3.27	3.27	3.27	3.27	3.27	3.27
Haskell	21.59	23.03	24.47	26.07	27.51	29.11
Hughes	19.27	20.25	21.48	22.59	23.69	24.80
Jackson	37.43	38.55	39.67	40.66	41.53	42.28
Jefferson	8.53	8.53	8.66	8.66	8.79	8.79
Johnston	17.62	18.68	19.75	20.81	22.03	23.09
Kay	51.95	52.90	53.75	54.49	55.13	55.76
Kingfisher	16.89	17.88	18.88	19.87	20.86	21.74
Kiowa	9.61	9.61	9.61	9.70	9.70	9.70
Latimer	15.09	15.36	15.77	16.18	16.60	17.01
Le Flore	32.03	33.27	34.51	35.63	36.75	37.87
Lincoln	35.94	37.59	39.15	40.60	41.84	43.18

Table 2b. Percent Change in Population from 2010-35 (continued).

COUNTIES	DEN 2010	DEN 2015	DEN 2020	DEN 2025	DEN 2030	DEN 2035
Logan	51.67	54.88	58.08	61.02	63.83	66.63
Love	19.74	21.43	23.12	24.63	26.32	28.01
Major	56.71	61.54	66.19	70.67	74.98	79.29
Marshall	18.72	19.14	19.57	19.93	20.25	20.56
Mayes	30.46	32.28	34.11	35.93	37.90	40.00
McClain	7.73	7.83	7.83	7.83	7.83	7.83
McCurtain	39.58	44.27	48.72	53.40	58.09	62.77
McIntosh	61.59	64.67	67.74	70.81	73.59	76.66
Murray	32.48	33.89	35.30	36.95	38.60	40.01
Muskogee	84.51	85.94	87.37	88.80	89.99	91.06
Noble	16.16	16.57	16.97	17.24	17.51	17.78
Nowata	20.66	22.04	23.59	24.96	26.51	27.89
Okfuskee	18.92	19.08	19.40	19.56	19.88	20.03
Oklahoma	976.46	1000.96	1023.79	1045.65	1065.84	1083.24
Okmulgee	59.94	62.08	64.36	66.35	68.20	70.20
Osage	20.62	21.40	22.09	22.66	23.18	23.66
Ottawa	72.00	74.47	76.95	79.22	81.69	84.17
Pawnee	30.59	32.28	33.96	35.47	36.98	38.50
Payne	111.17	115.90	119.63	123.79	128.53	133.26
Pittsburg	32.88	33.60	34.40	35.05	35.71	36.43
Pontotoc	50.04	51.00	51.97	52.79	53.76	54.72
Pottawatomie	88.24	91.40	94.29	97.19	99.97	102.61
Pushmataha	9.14	9.77	10.33	10.89	11.46	12.09
Roger Mills	2.97	2.97	2.97	2.97	2.97	2.97
Rogers	112.59	119.62	126.50	132.69	138.45	143.93
Seminole	39.34	39.96	40.59	41.06	41.68	42.15
Sequoyah	60.85	64.21	67.42	70.50	73.58	76.52
Stephens	48.14	48.37	48.70	48.93	49.15	49.38
Texas	12.84	14.40	15.96	17.57	19.13	20.74
Tillman	10.46	10.58	10.69	10.81	10.92	11.03
Tulsa	1020.24	1048.52	1075.60	1100.47	1121.77	1139.65
Wagoner	110.15	116.75	123.01	128.60	133.67	138.58
Washington	117.18	118.59	119.77	120.48	120.95	121.66
Washita	11.79	11.99	12.19	12.29	12.49	12.59
Woods	7.13	7.13	7.13	7.13	7.21	7.21
Woodward	15.41	15.73	16.05	16.29	16.53	16.69

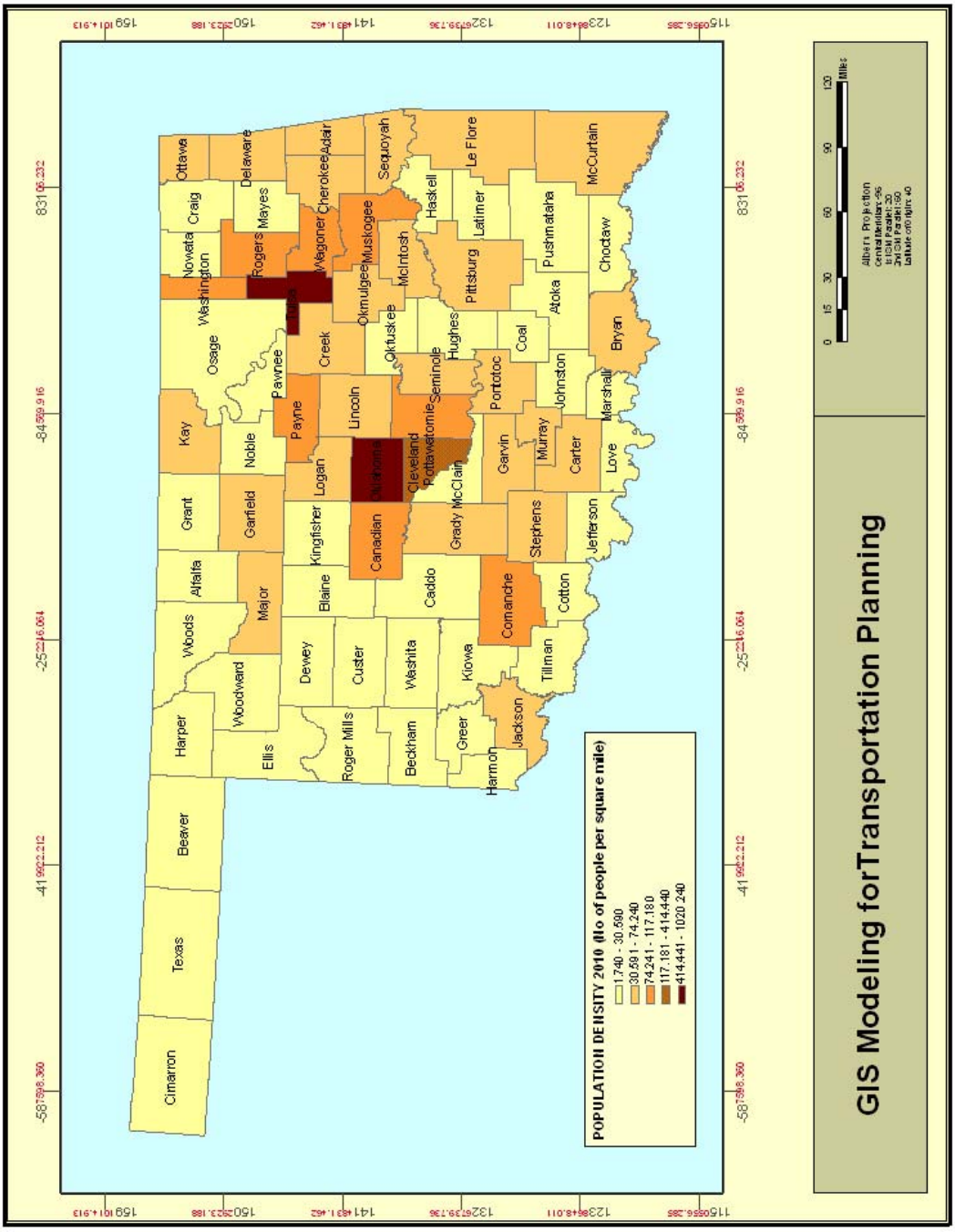

Figure 2. Population Density for Oklahoma Counties in 2010.

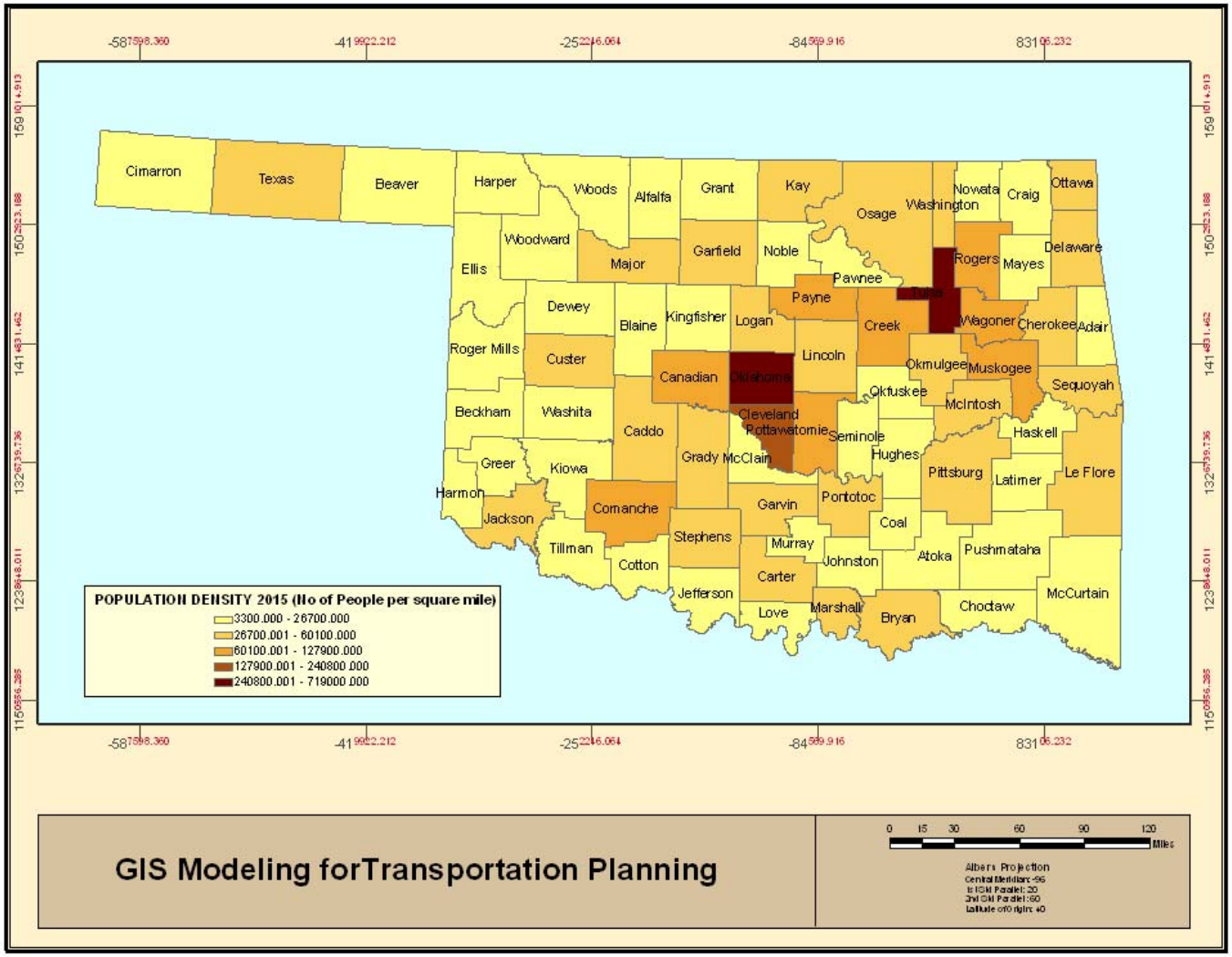

Figure 3. Population Density for Oklahoma Counties in 2015.

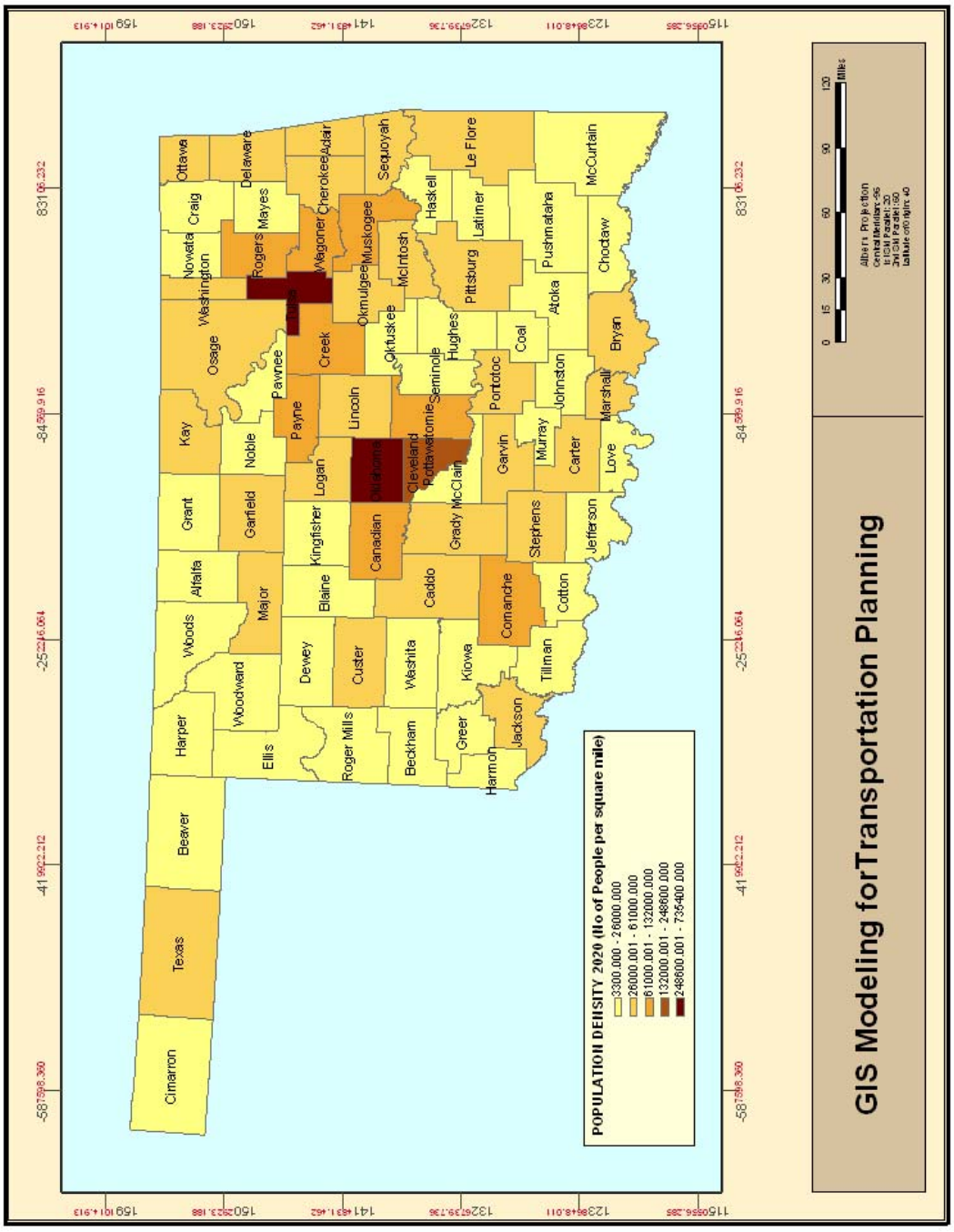

Figure 4. Population Density for Oklahoma Counties in 2020.

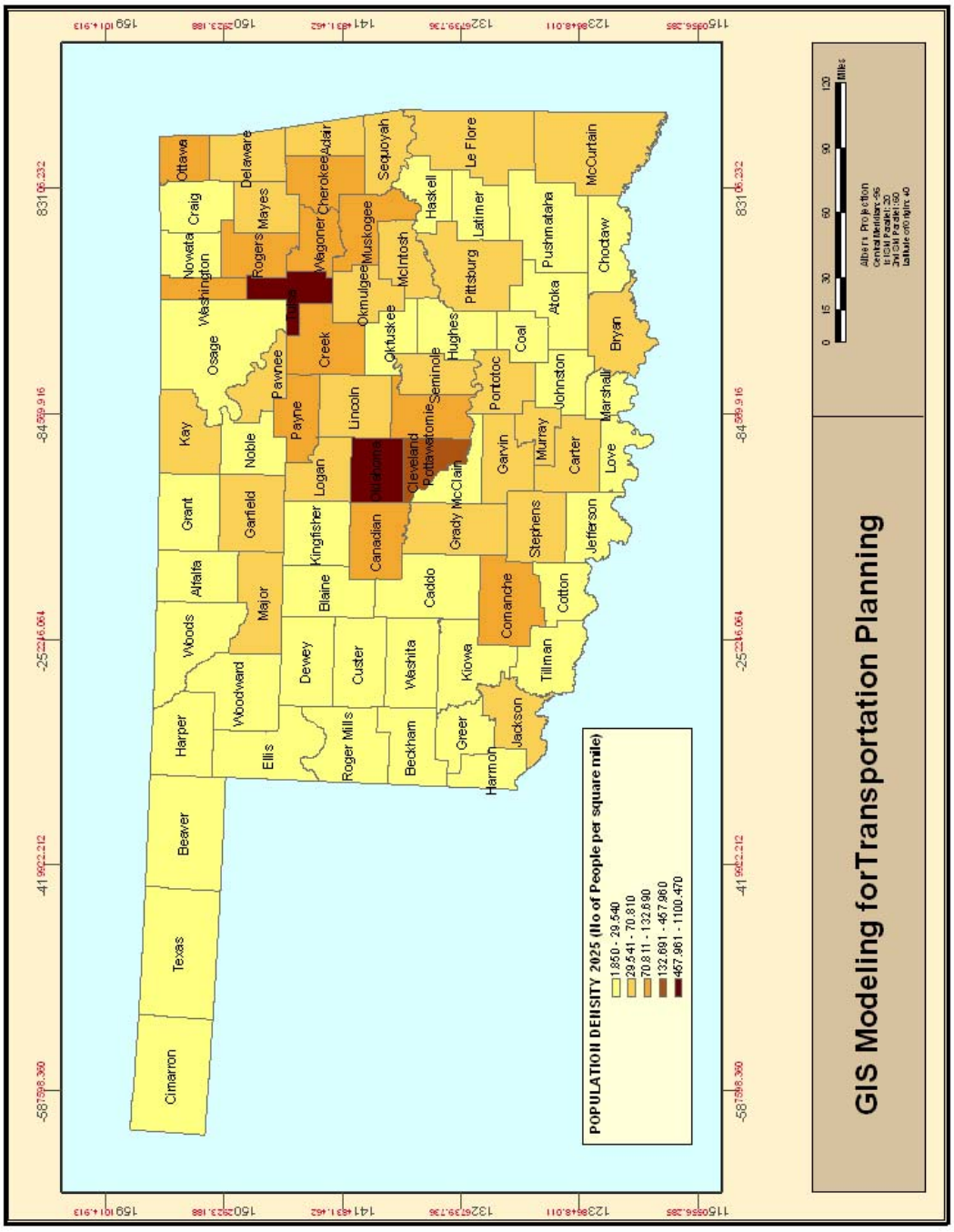

Figure 5. Population Density for Oklahoma Counties in 2025.

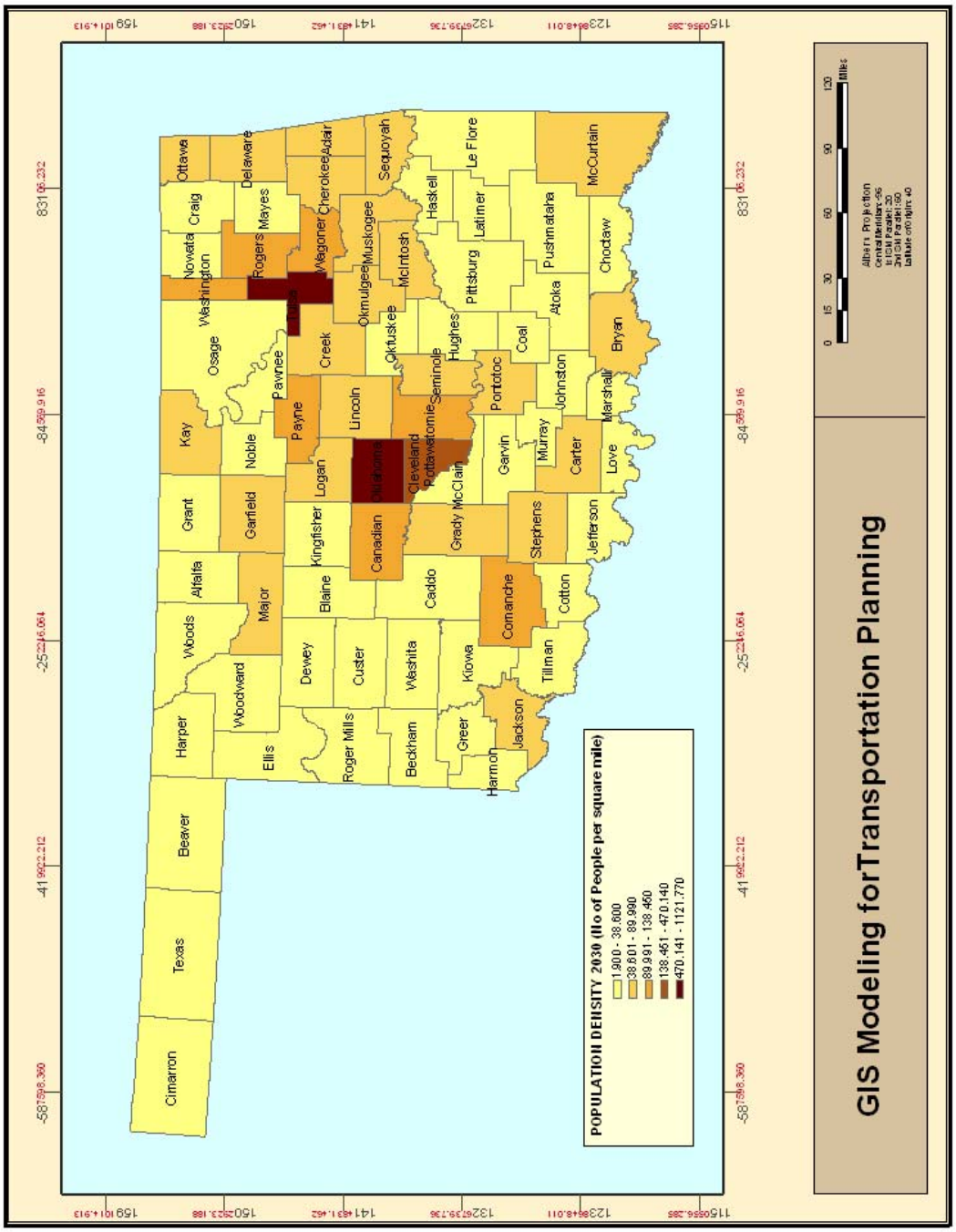

Figure 6. Population Density for Oklahoma Counties in 2030.

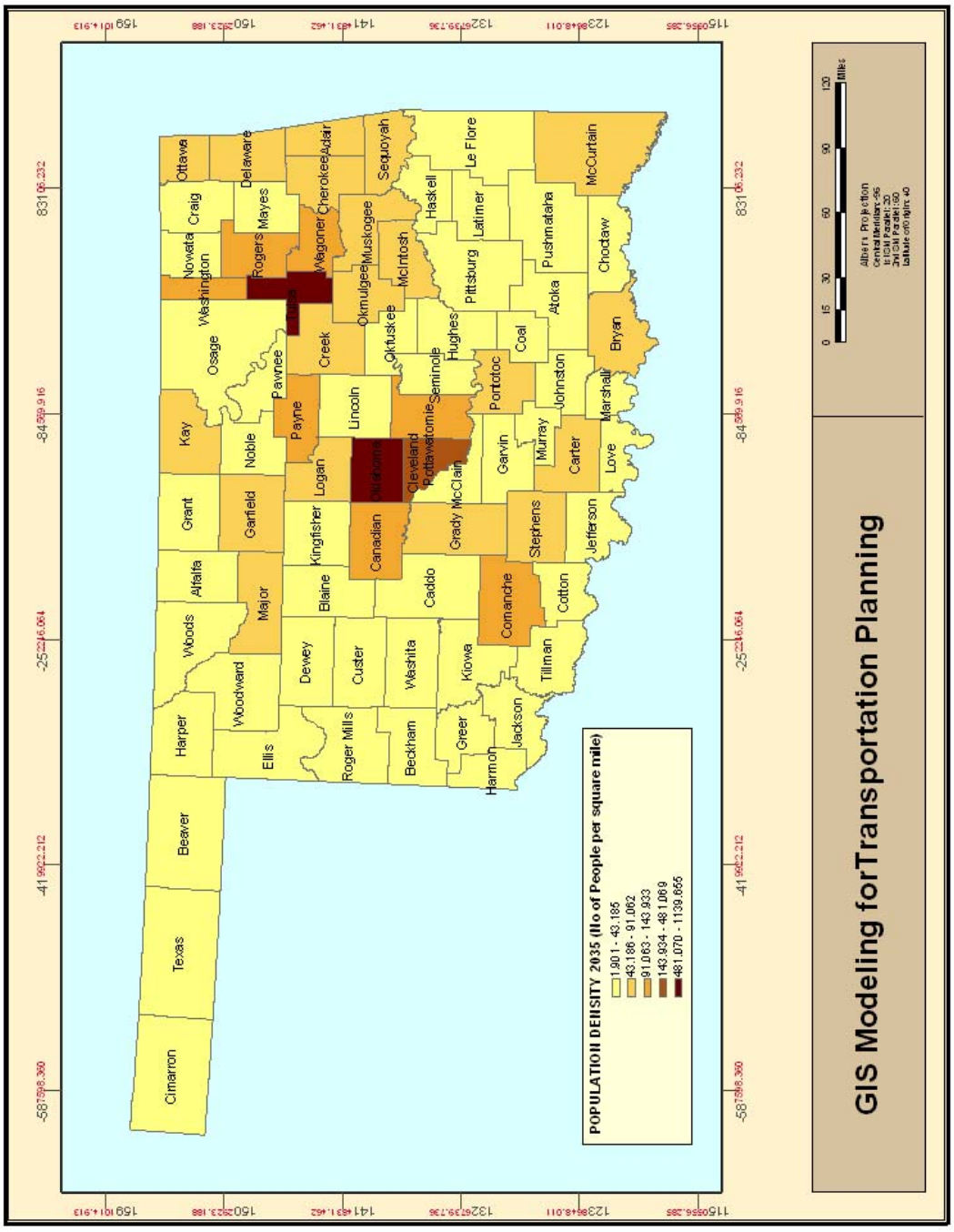

Figure 7. Population Density for Oklahoma Counties in 2035.

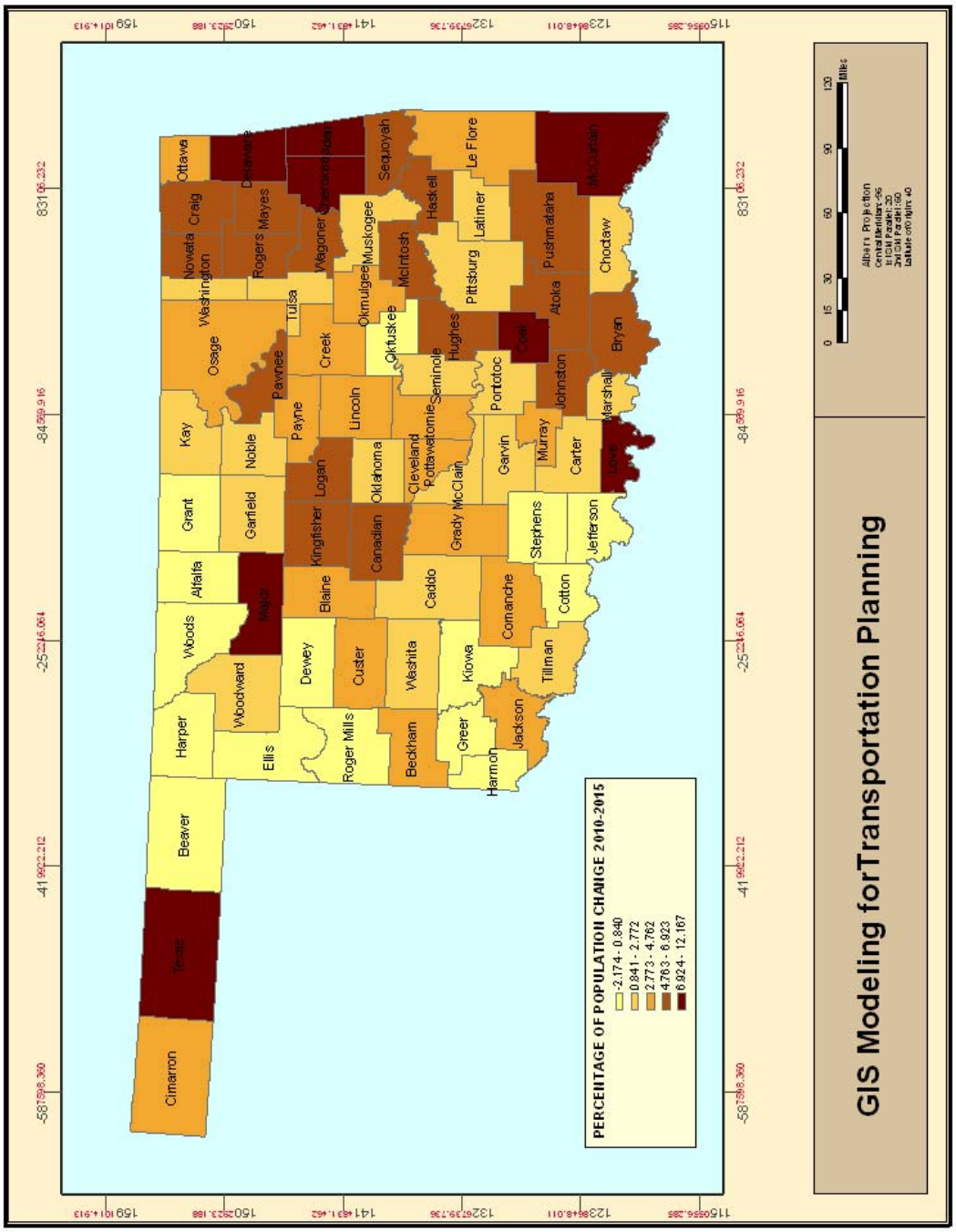

Figure 8. Percent Change in Population from 2010-2015 in Oklahoma.

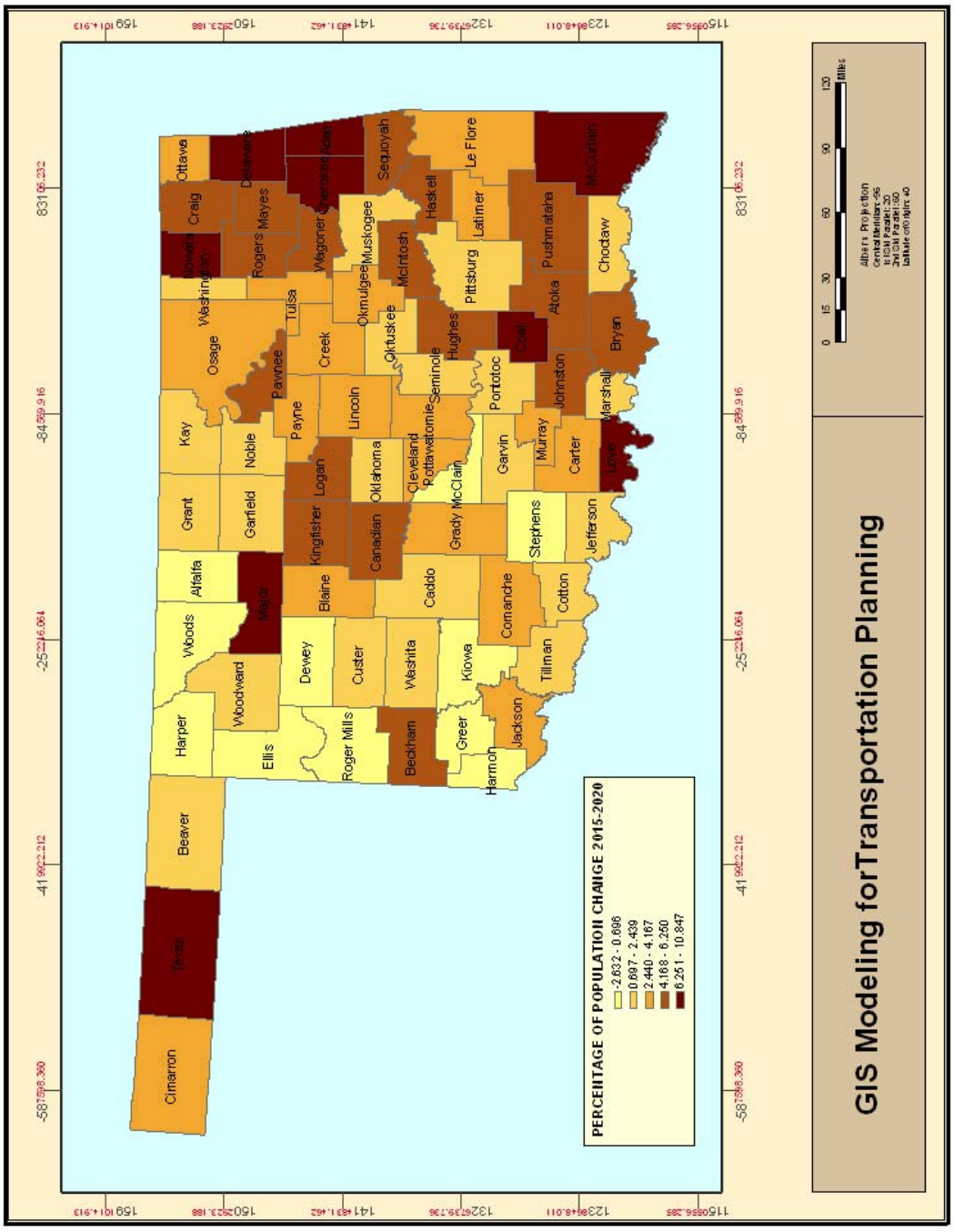

Figure 9. Percent Change in Population from 2015-2020 in Oklahoma.

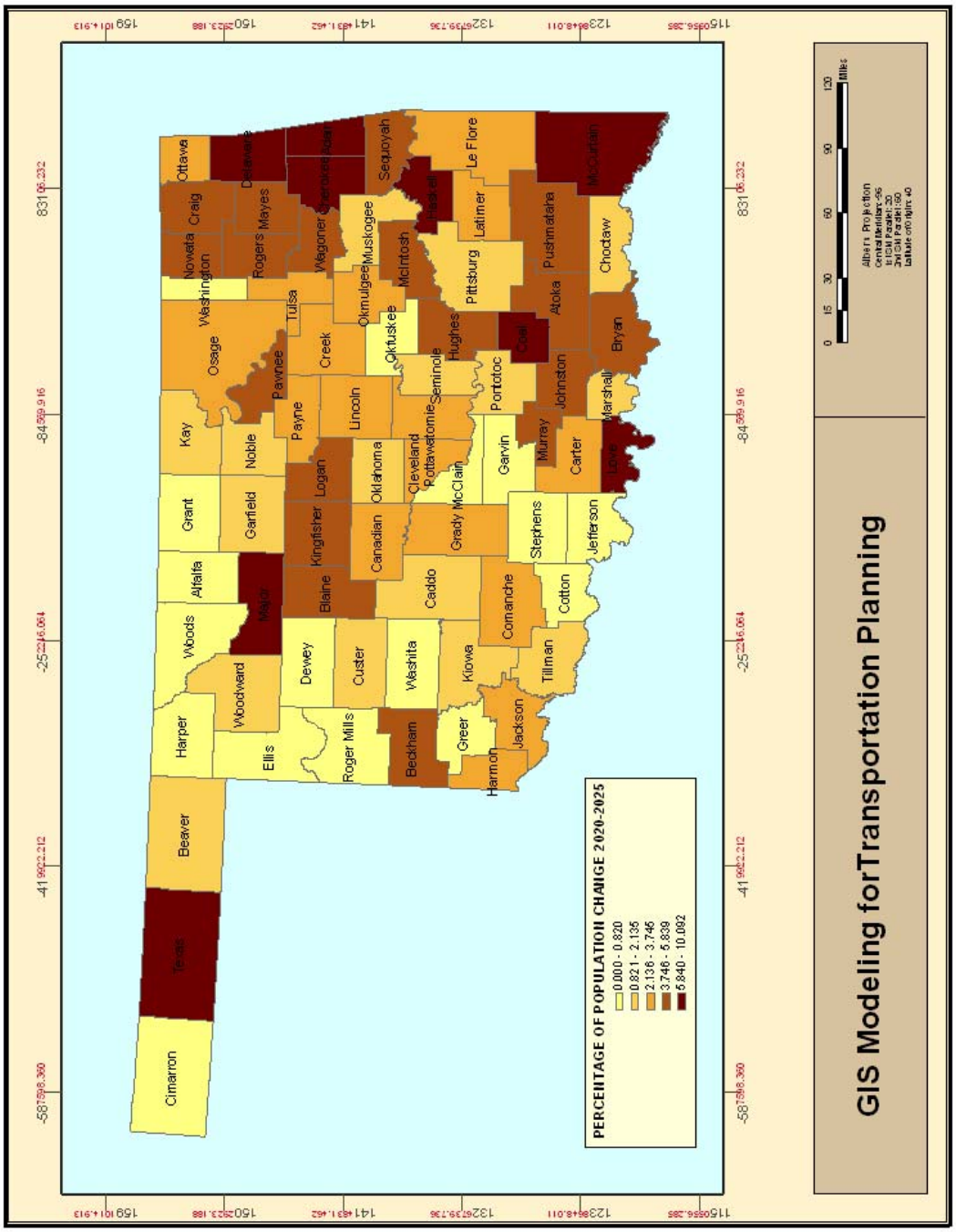

Figure 10. Percent Change in Population from 2020-2025 in Oklahoma.

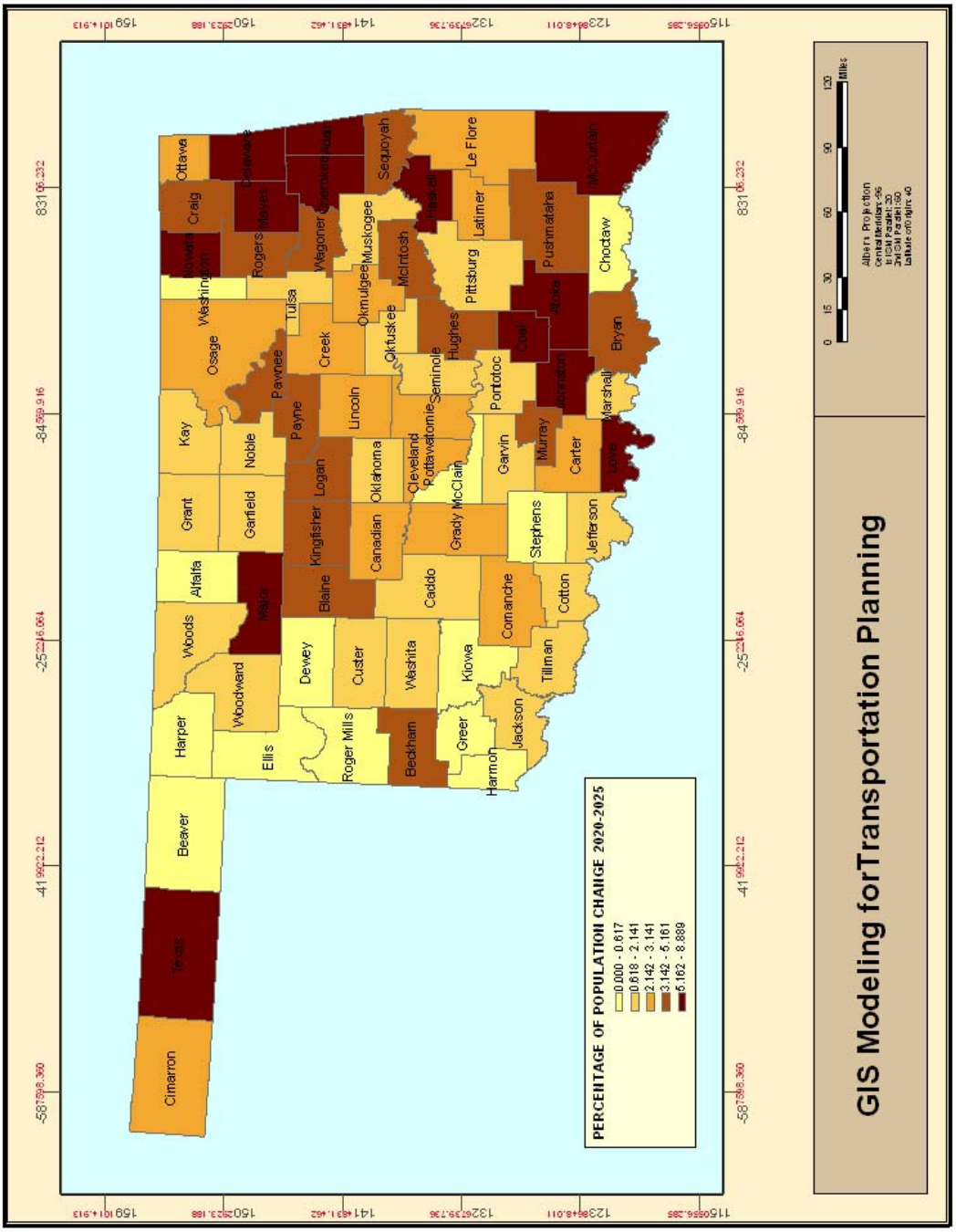

Figure 11. Percent Change in Population from 2025-2030 in Oklahoma.

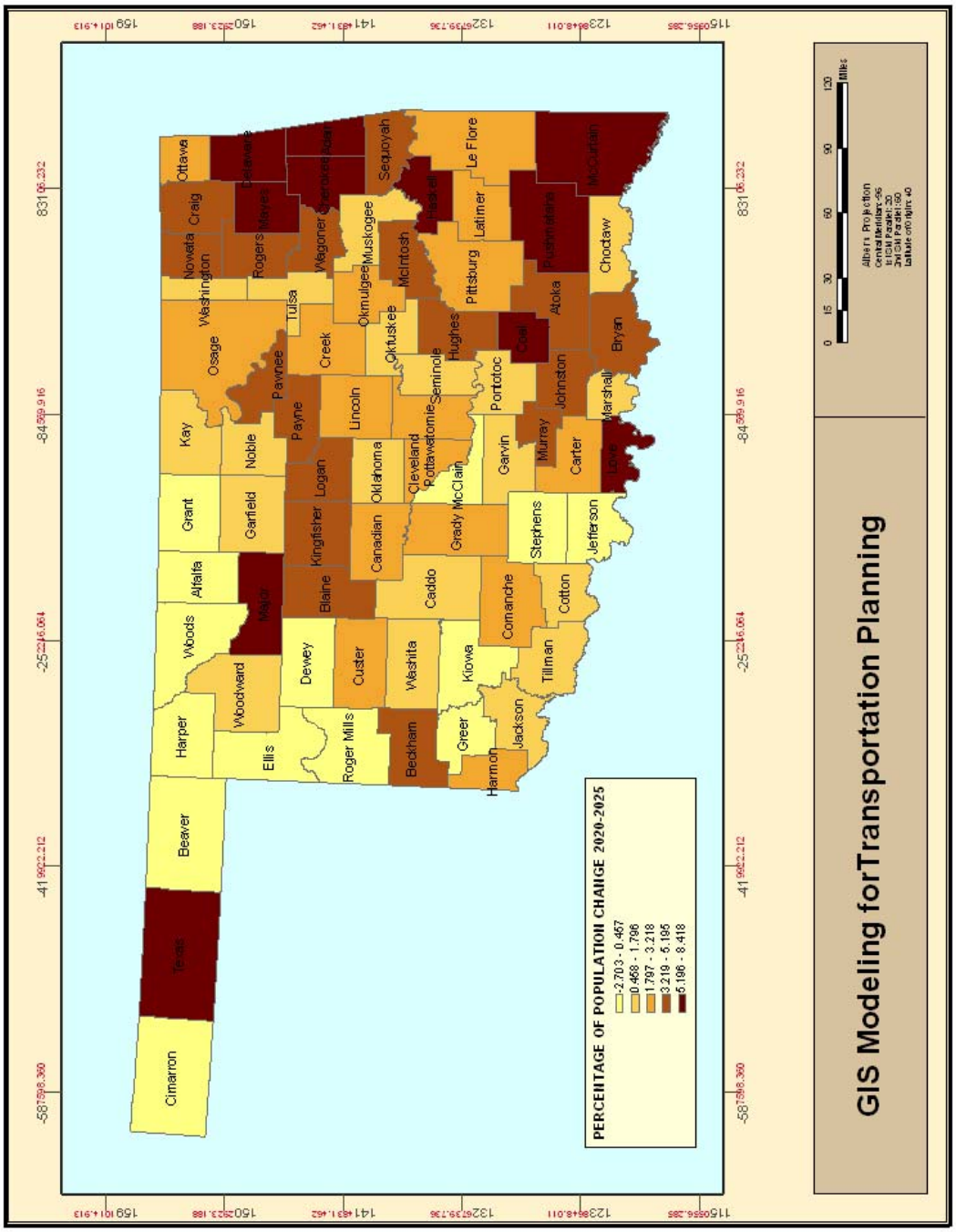

Figure 12. Precent Change in Population from 2030-2035 in Oklahoma.

V. Education Analysis

The education variable represents the potential available for work and is taken from census 2000 data. The number of people involved with educational institutions (either as students or faculty or staff) is large in certain locations. Such places would require a special consideration when transportation planning is being performed.

Maps reveal that Canadian, Comanche, Creek, Muskogee, Rogers and Payne counties have a higher number of educated people after Oklahoma and Tulsa counties.

Table 3 presents county name, total educated people, people with education level less than ninth grade, people with education level ninth to twelfths grades, people with education level up to high school, people with education level with college degree, people with education level bachelors degree, and people with education level with graduate degree. The data is plotted in GIS for each Oklahoma county (see Figures 13 through 19).

Table 3. Education Analysis

COUNTY NAME	TOTAL EDUCATED	EDU LEVEL THRU 8 GRADE	EDU LEVEL 9-11 GRADE	EDU HS HSEQV	EDU COLLEGE NO DEGREE	EDU ASSOC DEGREE	EDU BACHELOR DEGREE	EDU GRAD PRO DEGREE
Adair	12764	1872	2383	4860	2178	224	795	452
Alfalfa	4543	261	582	1854	1060	107	496	183
Atoka	9377	1109	1761	3742	1541	277	623	324
Beaver	3898	235	498	1414	912	152	504	183
Beckham	12968	1071	2054	4506	2758	571	1229	779
Blaine	8118	698	1290	3344	1413	233	727	413
Bryan	23175	2007	3819	7371	4991	847	2592	1548
Caddo	19020	1665	2928	7701	3524	498	1830	874
Canadian	56207	1760	5387	17961	15941	3420	8521	3217
Carter	30195	1864	5083	11097	6440	1145	3126	1440
Cherokee	25237	2094	3789	7630	5201	956	3345	2222
Choctaw	10210	1200	1963	3750	1947	344	647	359
Cimarron	2077	252	235	655	501	67	282	85
Cleveland	126569	3277	11744	33829	34749	7506	22278	13186
Coal	3964	526	717	1467	678	86	285	205
Comanche	67220	2766	7214	21176	19474	3744	8762	4084
Cotton	4436	298	723	1740	944	109	504	118
Craig	10197	718	1633	4152	2069	555	734	336
Creek	43523	3024	6722	17425	8998	2256	3397	1701
Custer	15156	1118	1728	4766	3673	414	2095	1362
Delaware	25549	1658	4634	9461	5148	1243	2112	1293
Dewey	3310	231	439	1350	676	65	387	162
Ellis	2918	176	373	1116	624	68	413	148
Garfield	38067	2054	4718	13552	8449	1851	4930	2513
Garvin	18263	1916	3014	7371	3261	507	1505	689
Grady	29172	1820	4172	11159	6709	1103	2916	1293
Grant	3500	179	320	1368	881	184	419	149
Greer	4302	318	684	1562	913	282	383	160
Harmon	2192	321	486	706	362	51	173	93
Harper	2507	192	257	911	601	65	318	163
Haskell	7762	997	1576	2530	1372	488	561	238
Hughes	9762	983	1864	3819	1878	275	616	327
Jackson	17270	1253	2361	4644	4244	1579	1980	1209
Jefferson	4710	512	934	1760	918	89	340	157
Johnston	6759	776	1315	2056	1305	406	554	347
Kay	31106	1536	4401	10330	6893	2268	4086	1592
Kingfisher	8984	596	1096	3479	2040	323	1082	368
Kiowa	6963	610	966	2524	1511	320	690	342
Latimer	6716	651	1111	2339	1278	532	487	318
Le Flore	30966	3408	5773	10857	5607	1809	2308	1204
Lincoln	20746	1352	3306	8723	4289	767	1554	755
Logan	21195	1076	2849	7330	5017	874	2674	1375
Love	5931	554	1013	2453	1102	167	402	240
McClain	18069	1273	2460	6645	4066	783	2111	731
McCurtain	21875	2507	4222	7913	3919	953	1553	808
McIntosh	13787	1307	2610	4714	2578	773	1085	720
Major	5191	462	648	2098	1087	146	574	176
Marshall	9078	918	1714	3112	1899	396	717	322
Mayes	24849	1854	4090	9458	5214	1214	2050	969
Murray	8566	659	1544	3068	1660	359	742	534

Table 3. Education Analysis (continued)

COUNTY NAME	TOTAL EDUCATED	EDU LEVEL THRU 8 GRADE	EDU LEVEL 9-11 GRADE	EDU HS HSEQV	EDU COLLEGE NO DEGREE	EDU ASSOC DEGREE	EDU BACHELOR DEGREE	EDU GRAD PRO DEGREE
Muskogee	44890	3253	7944	14304	9727	2767	4664	2231
Noble	7635	422	989	3065	1663	292	876	328
Nowata	7092	548	1138	3030	1312	387	522	155
Okfuskee	7904	959	1458	3134	1284	338	468	263
Oklahoma	420823	23814	49734	109475	109298	21724	70118	36660
Okmulgee	25225	2105	4268	8900	5067	2011	1969	905
Osage	29417	1762	4059	10700	6864	1736	2971	1325
Ottawa	21510	1723	3500	7436	4436	1793	1747	875
Pawnee	10997	616	1714	4424	2359	556	868	460
Payne	37237	1519	3422	9946	8180	1437	7002	5731
Pittsburg	30162	2693	4472	11017	6020	2068	2550	1342
Pontotoc	22031	1471	3325	6983	4824	620	2776	2032
Pottawatomie	41142	2358	6176	14653	9517	2071	4060	2307
Pushmataha	7861	1015	1418	2780	1395	279	593	381
Roger Mills	2396	153	344	925	504	92	264	114
Rogers	45152	1968	5536	14805	11345	3857	5471	2170
Seminole	15988	1399	2883	5566	3310	896	1159	775
Sequoyah	24980	2664	4778	8721	4867	1225	1657	1068
Stephens	29111	1866	4838	10858	5803	913	3467	1366
Texas	11776	1737	1567	3370	2623	395	1608	476
Tillman	6141	792	1213	2107	1111	149	549	220
Tulsa	359386	15755	37954	95321	88683	24977	66429	30267
Wagoner	36895	1621	5281	13216	8759	2328	4195	1495
Washington	32905	1233	3621	10563	7151	1852	5452	3033
Washita	7613	445	1099	2973	1689	259	790	358
Woods	5993	398	638	1912	1466	156	999	424
Woodward	11992	723	1685	4575	2706	477	1364	462

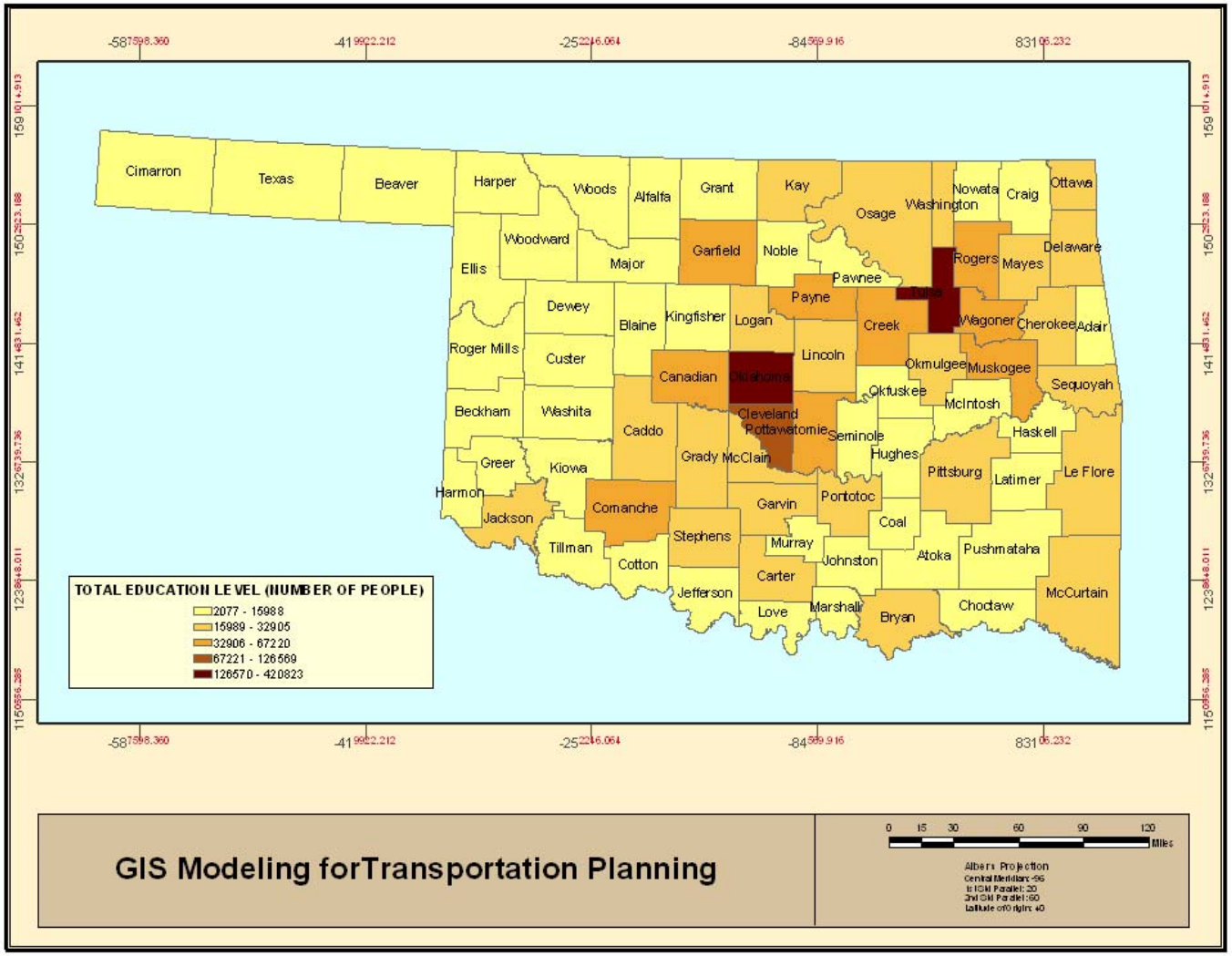

Figure 13. Total number of educated people.

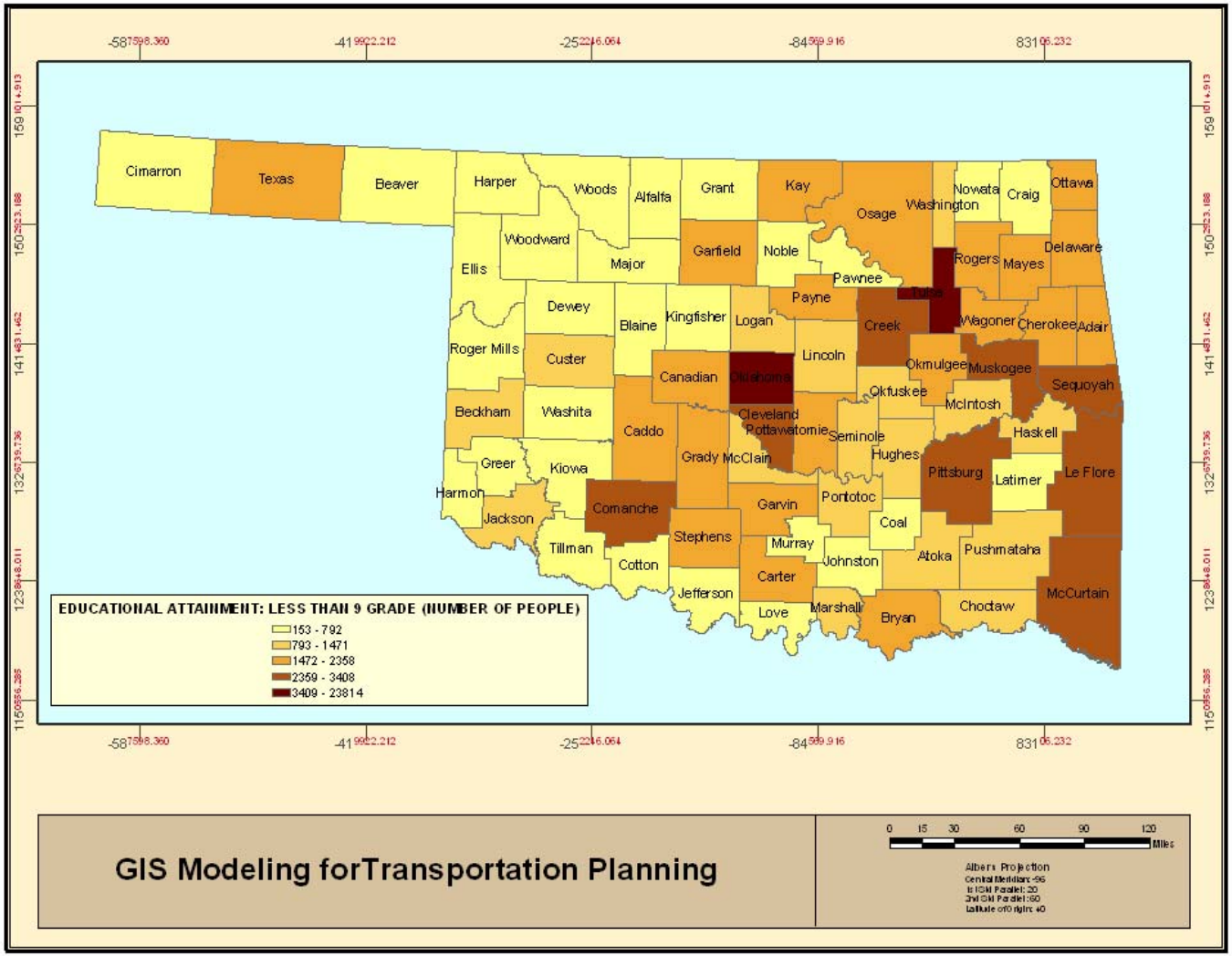

Figure 14. Total number of people with education less than ninth grade.

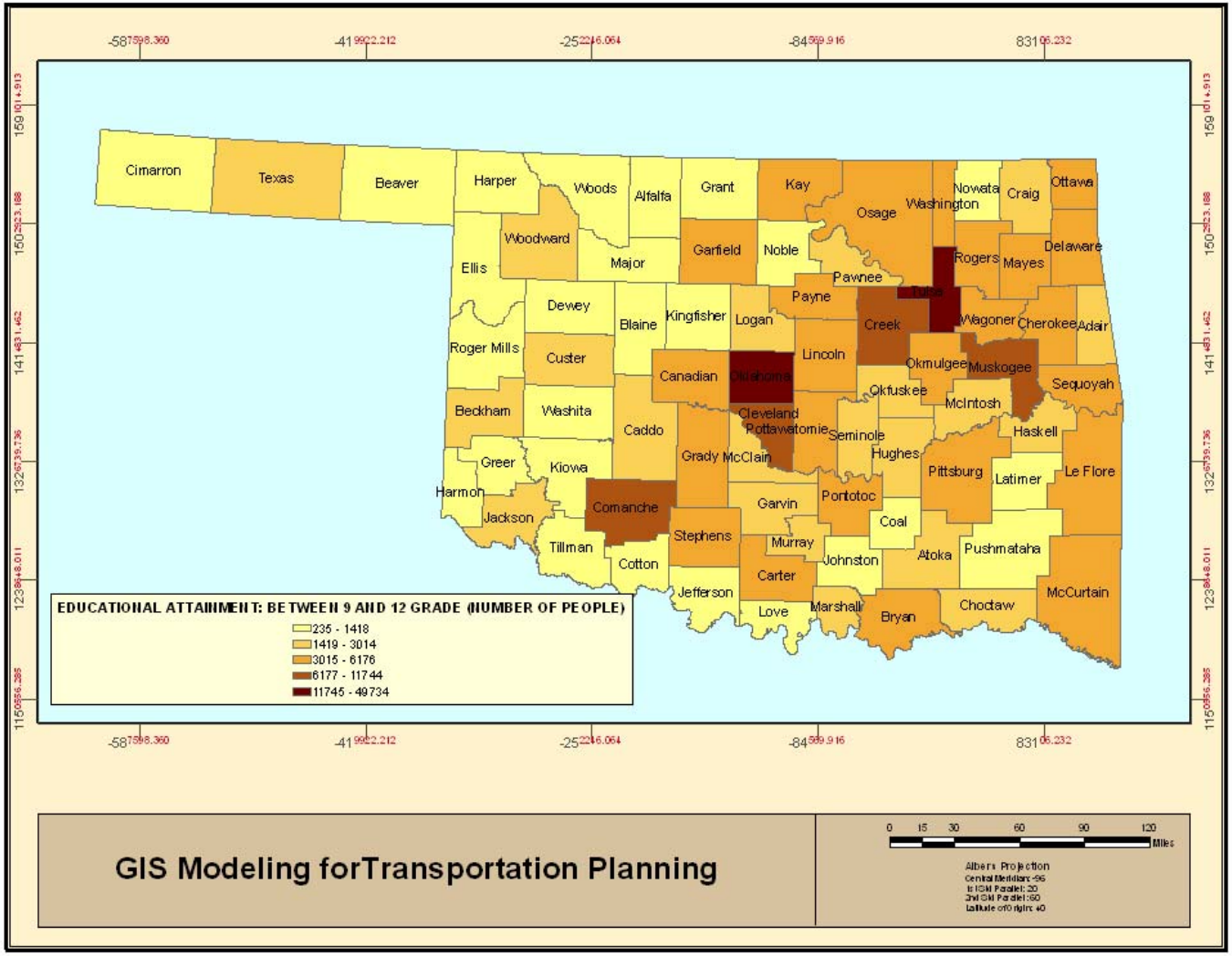

Figure 15. Total number of people educated between ninth and twelfth grade.

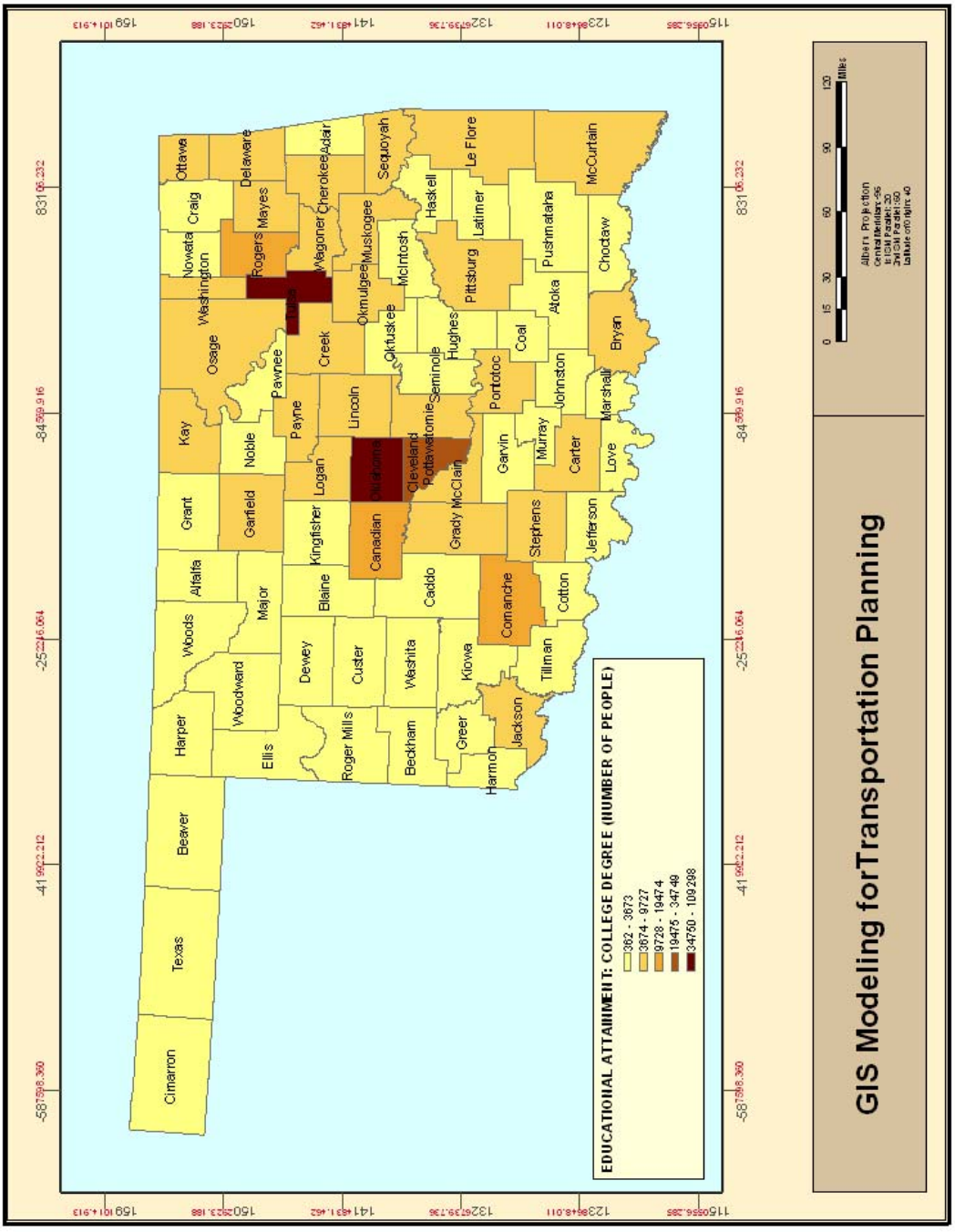

Figure 16. Total number of people educated up to high school.

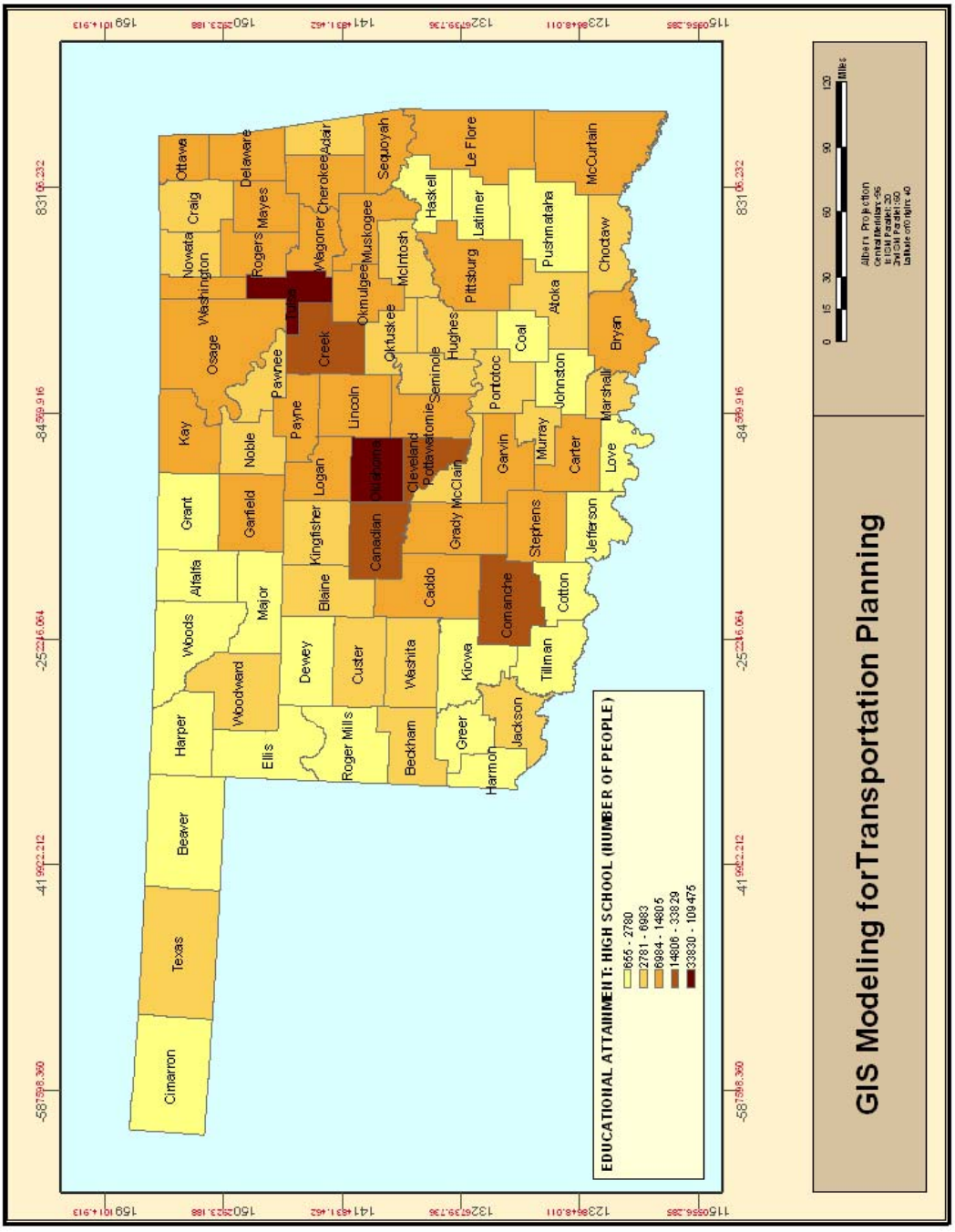

Figure 17. Total number of people educated with a college degree.

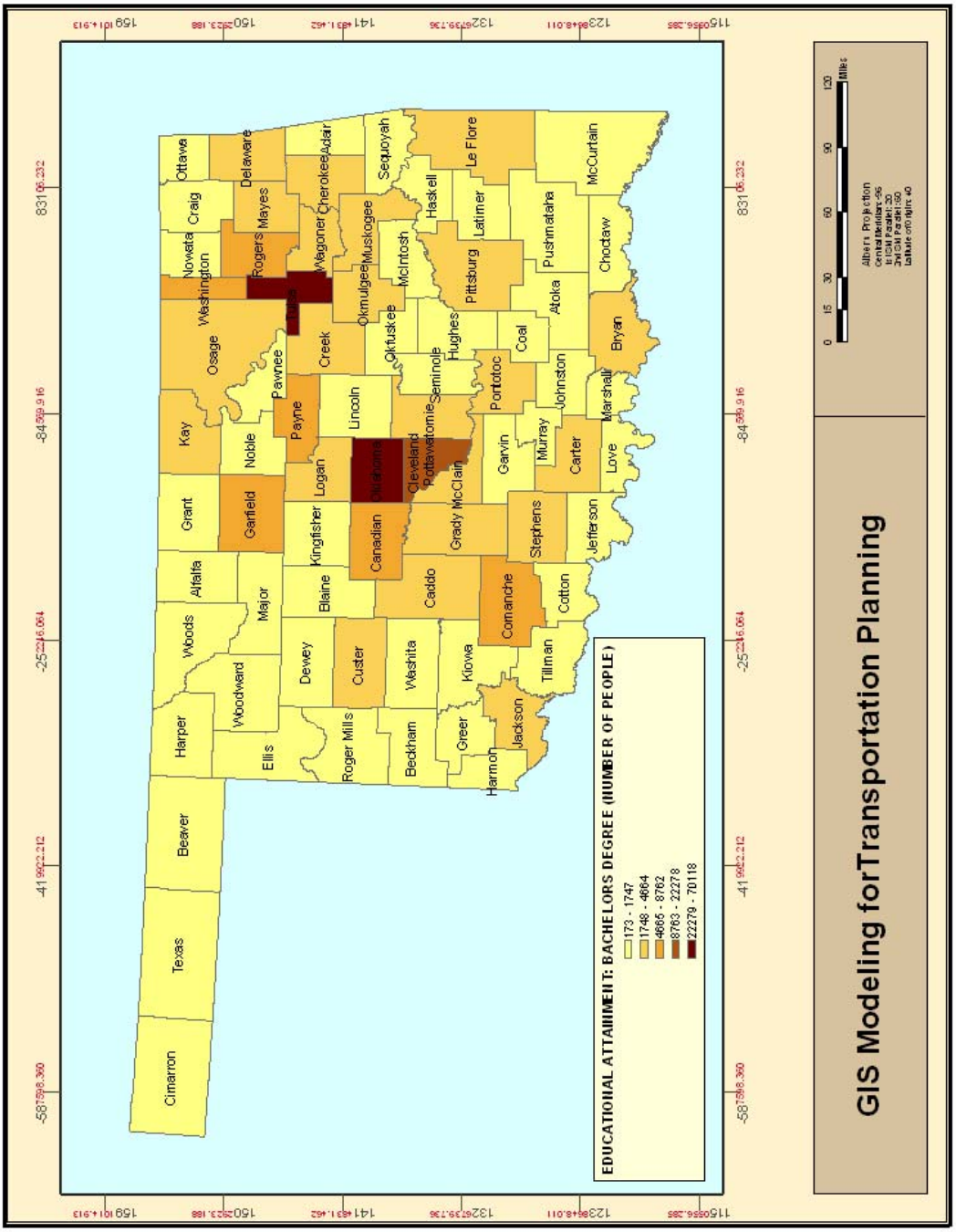

Figure 18. Total number of people with Bachelor's degree.

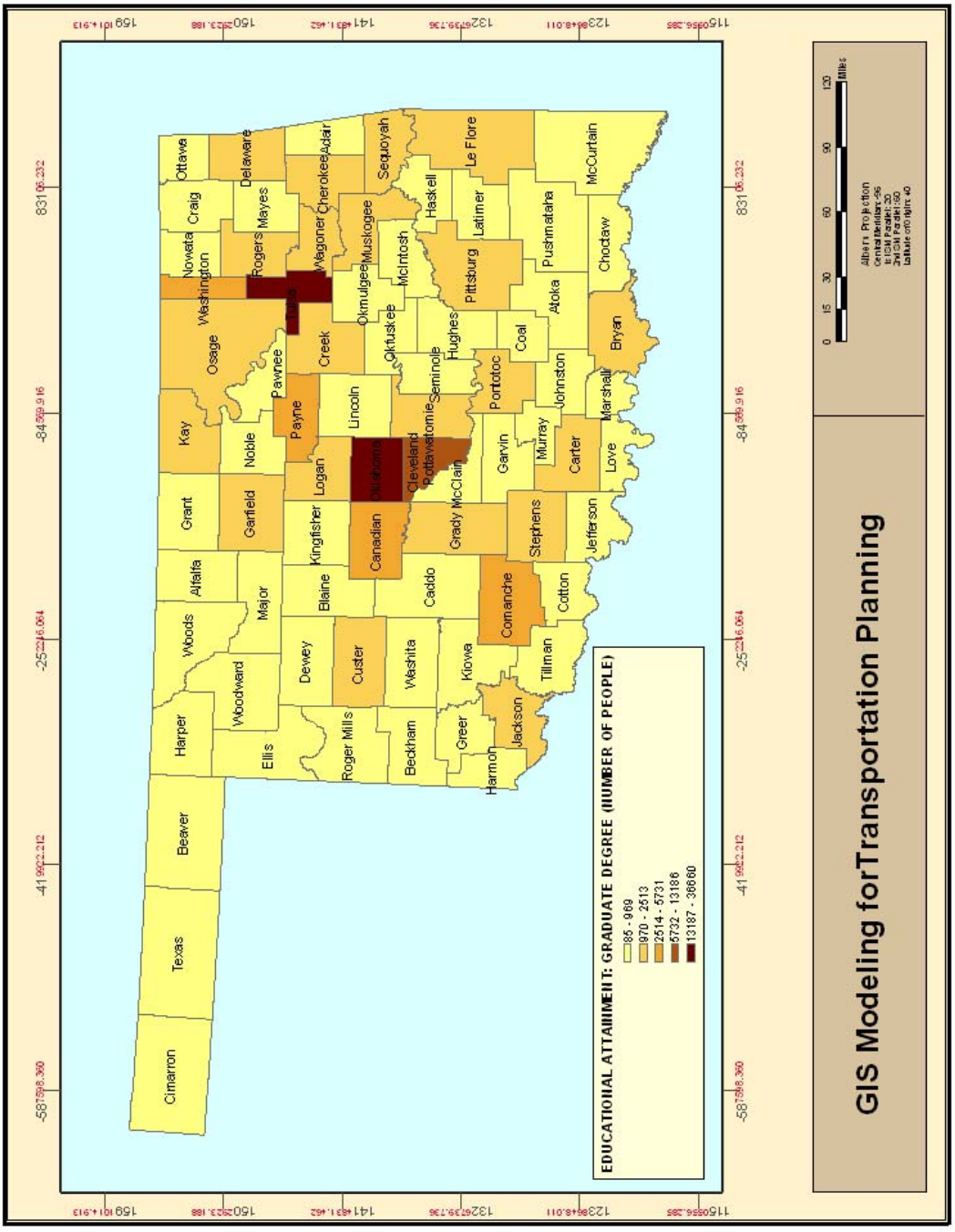

Figure 19. Total number of people with graduate degree.

VI. Employment Analysis

The primary reason people travel is to commute to the work environment. This besides other daily activities, people perform to maintain their living standards. The employment variable gives us the basic understanding of needed infrastructural development. The projections on the future employment growth would provide us with the data required to prepare for development of infrastructure. The amount of labor force available in any unit of area is directly related to the amount of development that is possible; this in turn indicates the extent of stress that could be laid on the existing infrastructure of the area.

Employment is a very good indicator of the transportation requirements of any city. The data for the employment is collected from the Oklahoma Employment Security Commission (OESC) website for year 2006. Three variables related to employment are used to prepare the maps. These are (1) total number of Employed people in the state, (2) total number of unemployed people in the state, and (3) total labor force available for work in the state.

The collected data is organized in an excel sheet with variables named as required by the Oklahoma Department of Transportation, shown in Table 1. The Excel sheet is then converted as a DB VI file which is compatible with the goedatabase of ArcGIS. A table joint operation is performed to attach the database with the GIS layer of County Map of Oklahoma. The thematic map representing the different pattern of employment is generated by classifying the employment into different unique categories based on the “natural breaks” or “equal interval method”.

Final thematic maps reveal that the area surrounding Oklahoma City and Tulsa had the highest density of jobs. This makes sense because these two cities are the urban centers in the state of Oklahoma and as a result they are the business hubs generating a large number of jobs.

Table 4 shows the people employed and the people unemployed for each Oklahoma county. Figures 20 and 21 present these two variables in the GIS maps.

Table 4. Employment Analysis

COUNTY NAME	TOTAL EMPLOYED	TOTAL UNEMPLOYED	TOTAL LABOR FORCE
Adair	10190	450	10640
Alfalfa	2170	90	2260
Atoka	5470	350	5810
Beaver	2850	80	2930
Beckham	10120	250	10370
Blaine	4610	190	4800
Bryan	19380	620	20000
Caddo	10990	600	11600
Canadian	50450	1,660	52120
Carter	23720	830	24540
Cherokee	20180	860	21030
Choctaw	6170	340	6510
Cimarron	1200	50	1250
Cleveland	116440	3,780	120220
Coal	2270	150	2420
Comanche	43710	1,840	45550
Cotton	3220	100	3320
Craig	6440	290	6730
Creek	31160	1,240	32400
Custer	12900	400	13300
Delaware	16480	760	17240
Dewey	2300	80	2380
Ellis	2150	50	2200
Garfield	28170	810	28980
Garvin	13060	440	13500
Grady	22910	1,100	24010
Grant	2200	90	2280
Greer	1910	100	2010
Harmon	1380	50	1420
Harper	1750	60	1800
Haskell	5070	230	5290
Hughes	4650	270	4930
Jackson	11880	400	12280
Jefferson	2260	110	2370
Johnston	4650	190	4850
Kay	20540	1,010	21550
Kingfisher	7770	200	7970
Kiowa	3590	180	3770
Latimer	3810	180	3990
Le Flore	20620	1,030	21650
Lincoln	14390	570	14960
Logan	17850	650	18490
Love	4790	140	4930
McClain	14450	520	14960
McCurtain	12750	820	13570
McIntosh	7670	420	8090

Table 4. Employment Analysis (continued)

COUNTY NAME	TOTAL EMPLOYED	TOTAL UNEMPLOYED	TOTAL LABOR FORCE
Major	3730	100	3830
Marshall	5990	240	6230
Mayes	16620	720	17340
Murray	7570	230	7800
Muskogee	27090	1,600	28690
Noble	5420	190	5610
Nowata	4440	210	4650
Okfuskee	4110	230	4340
Oklahoma	325210	12,690	337890
Okmulgee	16230	840	17070
Osage	20370	830	21200
Ottawa	15610	830	16430
Pawnee	7630	320	7960
Payne	32390	1,100	33490
Pittsburg	20450	830	21270
Pontotoc	19470	620	20090
Pottawatomie	30100	1,290	31390
Pushmataha	5180	210	5400
Roger Mills	1700	50	1740
Rogers	39410	1,370	40780
Seminole	9540	560	10100
Sequoyah	17390	990	18380
Stephens	20200	680	20880
Texas	8600	280	8880
Tillman	3290	150	3440
Tulsa	289910	10,280	300190
Wagoner	31620	1,130	32750
Washington	24480	850	25330
Washita	5480	170	5650
Woods	3930	210	4140
Woodward	11040	270	11320

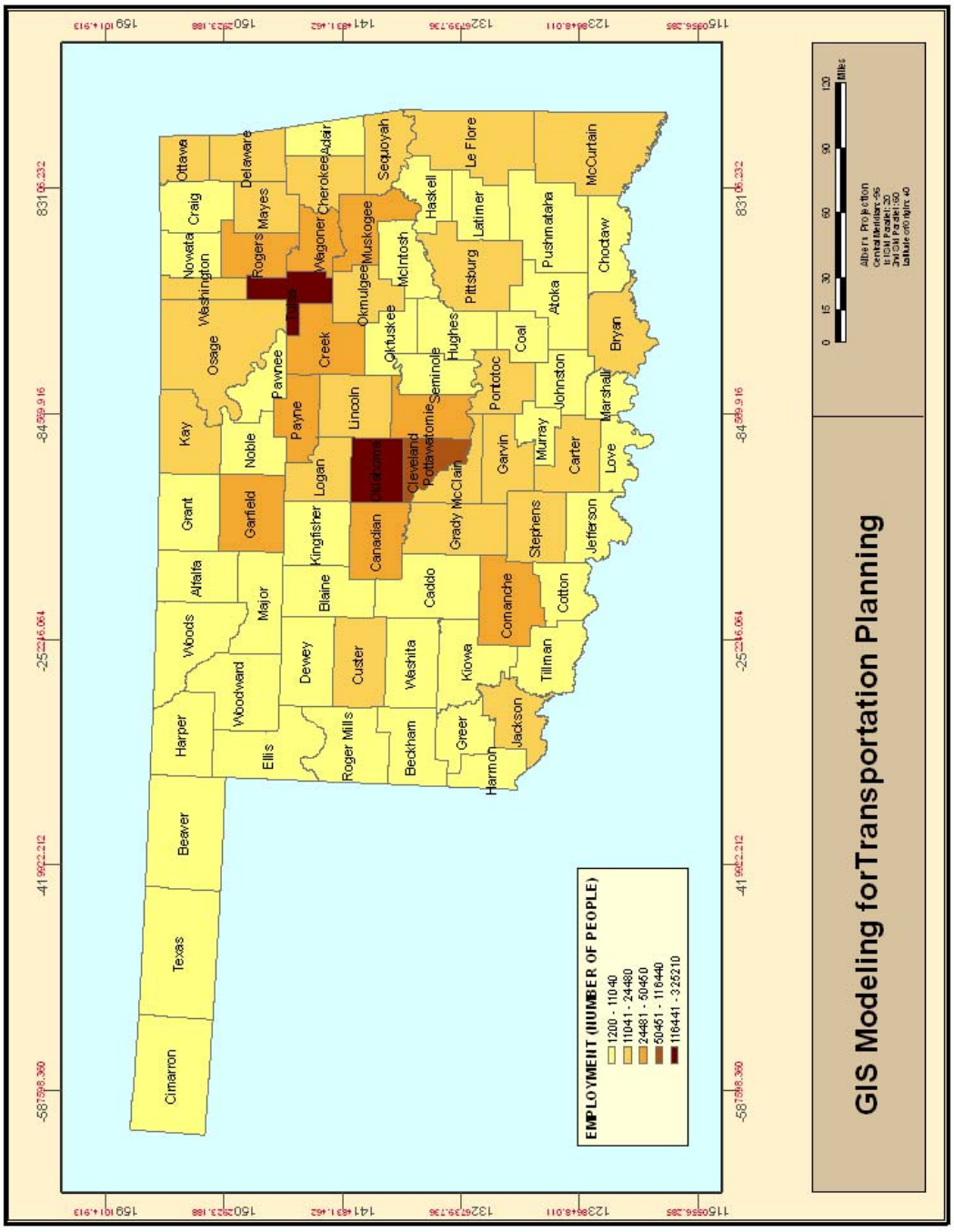

Figure 20. Total number of employed people.

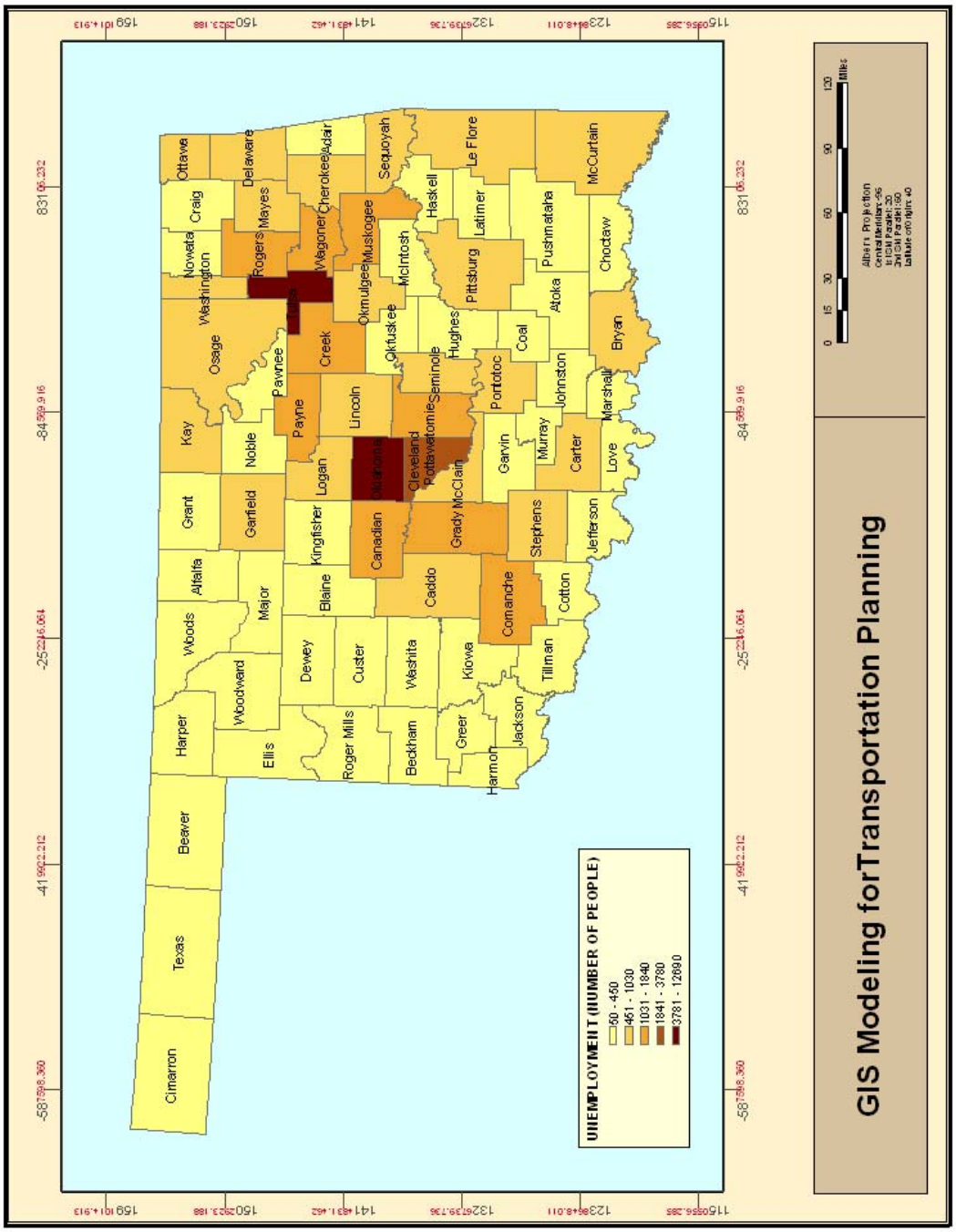

Figure 21. Total number of unemployed people.

VII. Income Analysis

The financial power of the public represents their ability to travel. Wealthy people tend to travel more than others simply because they can afford to do so. This variable gives us a clear indication of the financial boom likely to occur. It would be appropriate to prioritize the up gradation of the transportation infrastructure based on the income levels. The data is based on the 2000 census.

Table 5 presents medium income and total income for each county. Two maps based on the median income and the aggregate income for each county are produced in Figures 22 and 23. Surprising the places in the panhandle like Texas, Beaver, and Harper counties seem to have a fairly high median household income. This can be due the fact that the population in these counties is considerable low.

Table 5. Income Analysis

COUNTY_NAM	MED_INCOME	AGG_INCOME
Adair	24881	231208400
Alfalfa	30259	82209600
Atoka	24752	160965800
Beaver	36715	101587800
Beckham	27402	274117900
Blaine	28356	153876200
Bryan	27888	512898400
Caddo	27347	389864800
Canadian	45439	1685873700
Carter	29405	688848900
Cherokee	26536	562129400
Choctaw	22743	185978000
Cimarron	30625	49258600
Cleveland	41846	4100608400
Coal	23705	71890500
Comanche	33867	1661933600
Cotton	27210	96756400
Craig	30997	231932100
Creek	33168	1074301600
Custer	28524	398503300
Delaware	27996	567323200
Dewey	28172	73782800
Ellis	27951	66598500
Garfield	33006	985606500
Garvin	28070	399998300
Grady	32625	714845900
Grant	28977	78836700
Greer	25793	74720800
Harmon	22365	43096800
Harper	33705	63878500
Haskell	24553	161555700
Hughes	22621	167649100
Jackson	30737	432167900
Jefferson	23674	83968600
Johnston	24592	142138700
Kay	30762	784914800
Kingfisher	36676	247159200
Kiowa	26053	143039700
Latimer	23962	134369600
Le Flore	27278	641038500
Lincoln	31187	472322200
Logan	36784	577427000
Love	32558	146072000
McClain	37275	499919000
McCurtain	24162	459790400
McIntosh	25964	318062300
Major	30949	129014800

Table 5. Income Analysis (continued)

COUNTY_NAM	MED_INCOME	AGG_INCOME
Marshall	26437	195336400
Mayes	31125	583130200
Murray	30294	198067400
Muskogee	28438	1016592700
Noble	33968	188263500
Nowata	29470	149217400
Okfuskee	24324	141407200
Oklahoma	35063	12722310200
Okmulgee	27652	549527500
Osage	34477	742934000
Ottawa	27507	472448700
Pawnee	31661	251689700
Payne	28733	1050383000
Pittsburg	28679	639440800
Pontotoc	26955	507155100
Pottawatomie	31573	1025932000
Pushmataha	22127	147853600
Roger Mills	30078	57830500
Rogers	44471	1329515100
Seminole	25568	341029600
Sequoyah	27615	516429700
Stephens	30709	700923400
Texas	35872	315287600
Tillman	24828	128293200
Tulsa	38213	11747959500
Wagoner	41744	1040554600
Washington	35816	988324200
Washita	29563	176982100
Woods	28927	152466500
Woodward	33581	301385300

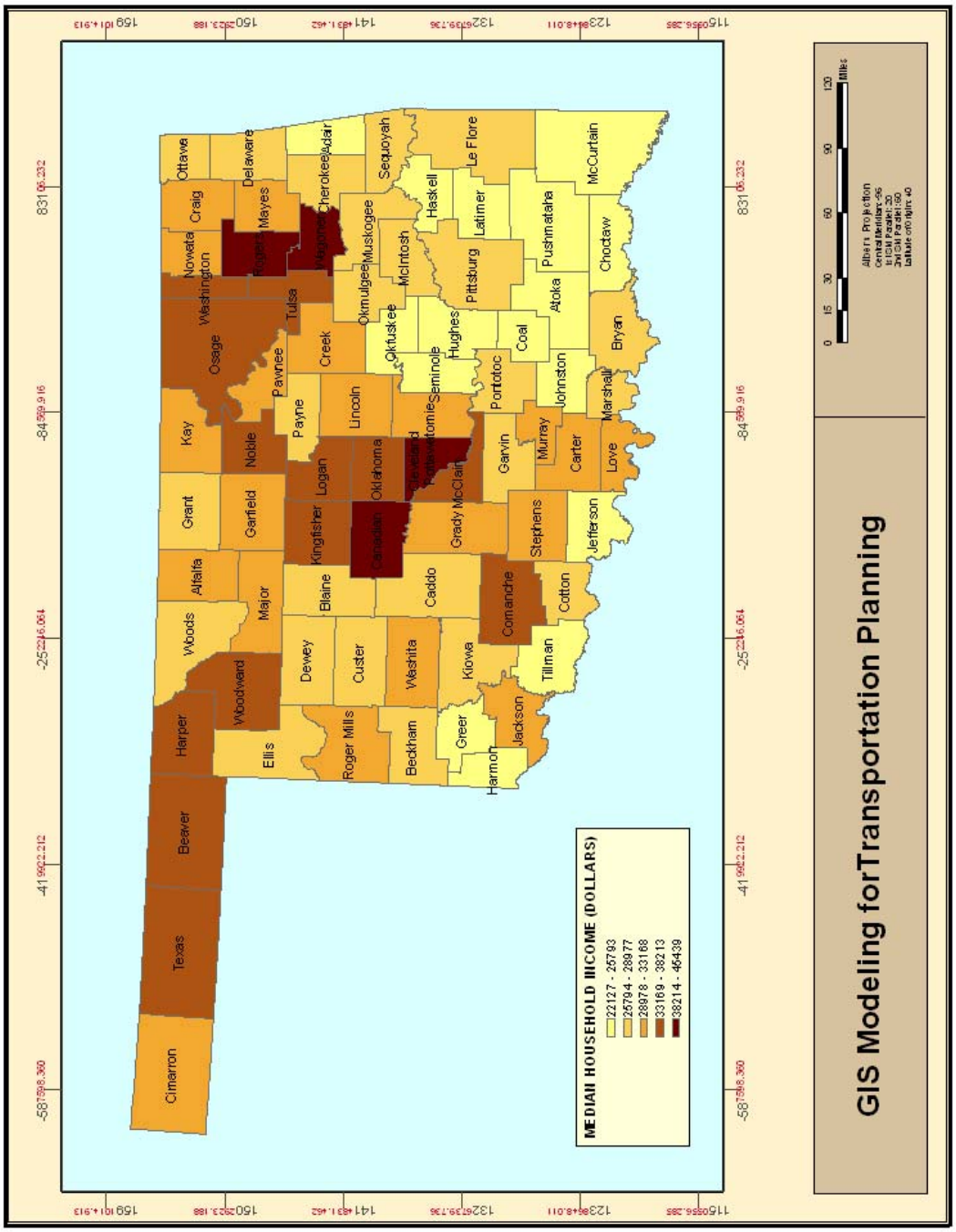

Figure 22. Median Household income.

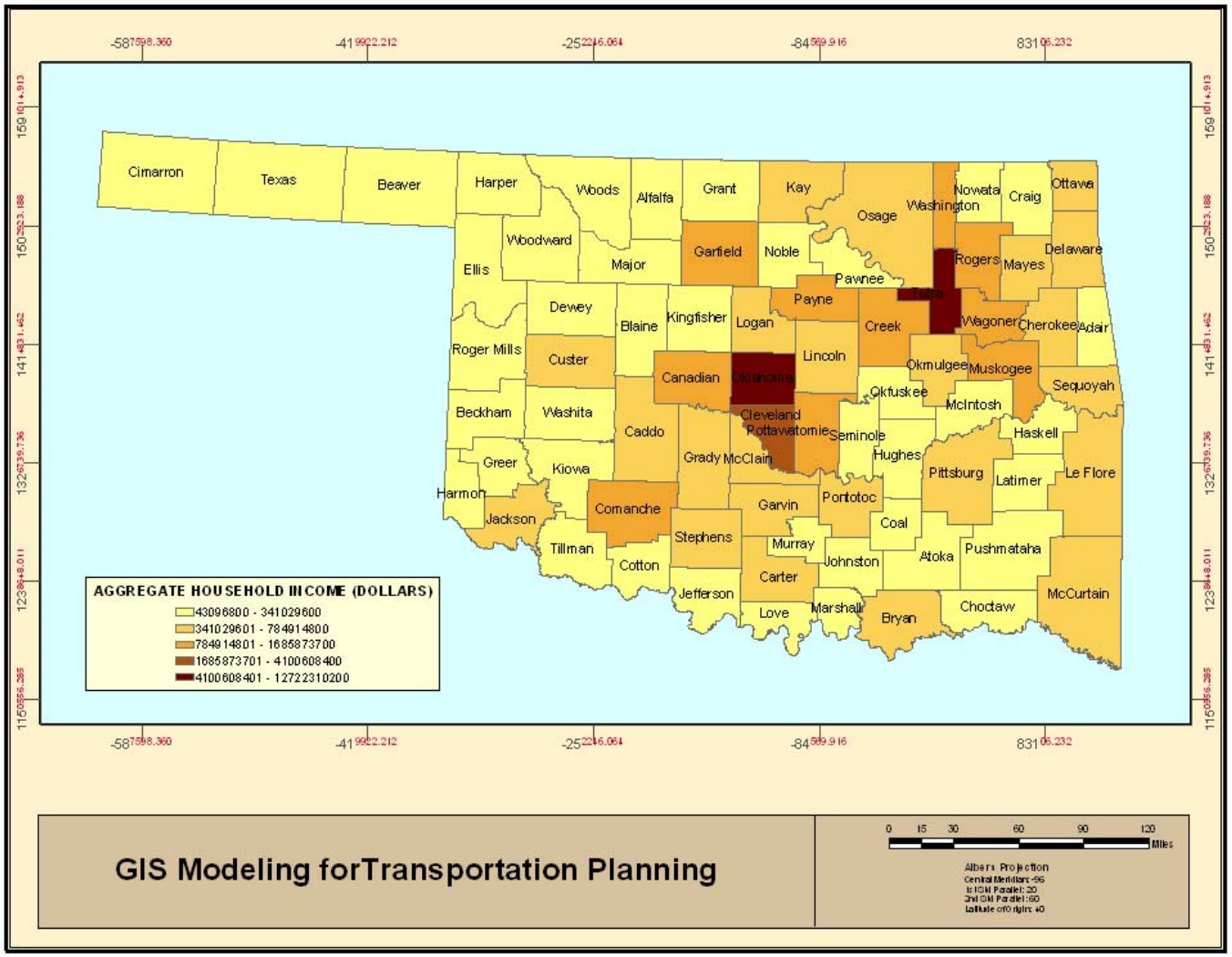

Figure 23. Aggregate household income.

VIII. Transportation Entities Analysis

The variable related to commuting is collected from the website of the U.S. Census Bureau from the detailed tables of Census 2000. The subdivisions of this variable related to transportation include five variables.

1. Total number of people traveling to work.

   The higher the number of people, the more will be the emphasis on the transportation infrastructure development.

2. The number of people traveling alone.

   An ideal transportation system would require lesser number of people to travel alone. This represents inefficiency in terms of economy and pollution. The model should be designed in such a way that more people are encouraged to consider traveling together either through car pooling or through public transit.

3. The number of people commuting through public transit and carpooling.

4. The number of people who work at home.

   This number should essentially be removed from the variable of total number of people traveling to work, because they do not represent any stress on the infrastructure. The government should encourage working at home through incentives. The Information technology and communication jobs, in particular, can be performed at home. However the number of such practices in Oklahoma is expected to be very small, because of an option that is still being experimented by the business world.

Surprising the data reveals the number of people involved at home is relative large. A comparison of all the maps on the basis of percentages would provide the common bench mark.

5. Mean travel time

   The value of this variable is what any transportation planning is dedicated to reduce.

Table 6 shows different modes of traveling using the transportation infrastructure as well as the mean travel time. This information is plotted by each county in Oklahoma in Figures 24 through 30.

Table 6. Transportation Entities Analysis

COUNTY NAME	TOTAL COMMUTERS	COM CTV 1	COM CTV CARPOOL	COM PUB TRANS	COM WALKED	WORK AT HOME	TRAVEL TIME MIN
Adair	8215	5848	1770	64	142	295	25.8
Alfalfa	2330	1841	256	5	89	124	18.1
Atoka	4749	3634	727	19	123	179	29.5
Beaver	2684	2170	291	8	68	119	21.1
Beckham	7735	6142	1110	9	173	221	18.4
Blaine	4462	3602	542	4	127	141	19.1
Bryan	15382	12321	2312	15	282	320	23.7
Caddo	11211	8701	1693	30	250	427	23.6
Canadian	43206	36975	4330	47	386	1200	22.9
Carter	18939	15425	2376	74	263	563	23.7
Cherokee	17489	12799	3237	79	544	600	24.6
Choctaw	5591	4358	857	12	93	199	24.9
Cimarron	1389	1032	202	2	63	70	14.8
Cleveland	104629	87891	10463	377	1909	2692	22.3
Coal	2245	1615	430	15	47	111	24.3
Comanche	51684	37903	7199	494	3767	1171	16.9
Cotton	2668	2169	346	3	48	76	25.3
Craig	6277	4849	894	10	142	289	23.2
Creek	28817	23303	3898	24	483	827	26
Custer	12192	9810	1591	26	312	311	15.7
Delaware	14477	10941	2323	57	357	616	25.5
Dewey	2103	1646	250	2	73	119	22.9
Ellis	1915	1458	219	0	79	133	18.7
Garfield	26712	21801	3256	81	514	799	17.7
Garvin	11318	8904	1646	30	189	427	23.4
Grady	20290	16395	2706	18	278	674	26.9
Grant	2308	1722	279	0	79	207	21.1
Greer	2038	1730	190	4	31	56	17.8
Harmon	1250	979	183	6	37	36	14.6
Harper	1702	1329	206	5	64	82	18.9
Haskell	4533	3280	801	25	98	296	28.7
Hughes	4862	3764	764	14	155	141	25
Jackson	12531	10247	1398	48	362	213	14.4
Jefferson	2564	1911	448	8	53	104	27.5
Johnston	4112	3076	769	8	109	106	24.9
Kay	20039	16239	2564	25	417	632	16.1
Kingfisher	6567	5352	834	4	119	244	22.5
Kiowa	4106	3245	596	4	121	122	18.3
Latimer	3899	2947	569	0	138	159	22.1
Le Flore	18813	14540	3059	49	369	574	23.6
Lincoln	13716	10557	2337	4	206	516	31
Logan	15744	12273	2168	25	373	722	28.5
Love	3840	2990	625	7	79	90	26.8
McClain	12862	10371	1706	5	103	569	27.3
McCurtain	13019	10105	1991	37	256	444	23.7

Table 6. Transportation Entities Analysis (continued)

COUNTY NAME	TOTAL COMMUTERS	COM CTV 1	COM CTV CARPOOL	COM PUB TRANS	COM WALKED	WORK AT HOME	TRAVEL TIME MIN
McIntosh	7146	5338	1111	45	151	401	27.5
Major	3571	2745	453	2	78	234	20.1
Marshall	5214	3977	853	2	145	181	23.6
Mayes	16242	12939	2204	28	370	573	25.7
Murray	5461	4322	807	0	91	203	21
Muskogee	26773	20933	4344	83	423	719	21.7
Noble	5272	4389	586	0	77	142	19
Nowata	4448	3298	741	12	74	274	26.7
Okfuskee	4054	2868	805	4	138	199	27.1
Oklahoma	305058	246348	38761	2571	5326	8665	20.9
Okmulgee	15329	11777	2283	35	399	614	27.3
Osage	18916	15119	2762	45	267	566	25.3
Ottawa	13934	10898	1999	21	358	463	21.1
Pawnee	7151	5525	1191	11	131	231	30.6
Payne	33894	25634	4046	67	2442	1110	16.8
Pittsburg	16352	13257	2328	19	137	463	20.6
Pontotoc	15389	12468	2201	9	270	332	18
Pottawatomie	27763	22466	3909	46	478	596	25
Pushmataha	4195	3106	742	9	107	175	26.8
Roger Mills	1603	1189	205	4	49	135	24.7
Rogers	32891	27242	4126	32	272	1082	25.4
Seminole	9386	7247	1439	11	270	319	23.7
Sequoyah	15596	12251	2485	37	213	391	27.4
Stephens	17571	14422	2287	7	274	405	21.2
Texas	9419	7023	1666	39	209	276	16.6
Tillman	3446	2786	487	8	55	94	20.9
Tulsa	271055	218997	33571	2451	5015	8612	19.7
Wagoner	26958	22400	3325	29	196	801	26.6
Washington	20989	16546	3228	39	313	584	20.1
Washita	4986	3900	664	2	127	232	21.2
Woods	4190	3390	409	2	171	148	12.6
Woodward	8326	6721	1015	3	200	321	19.8

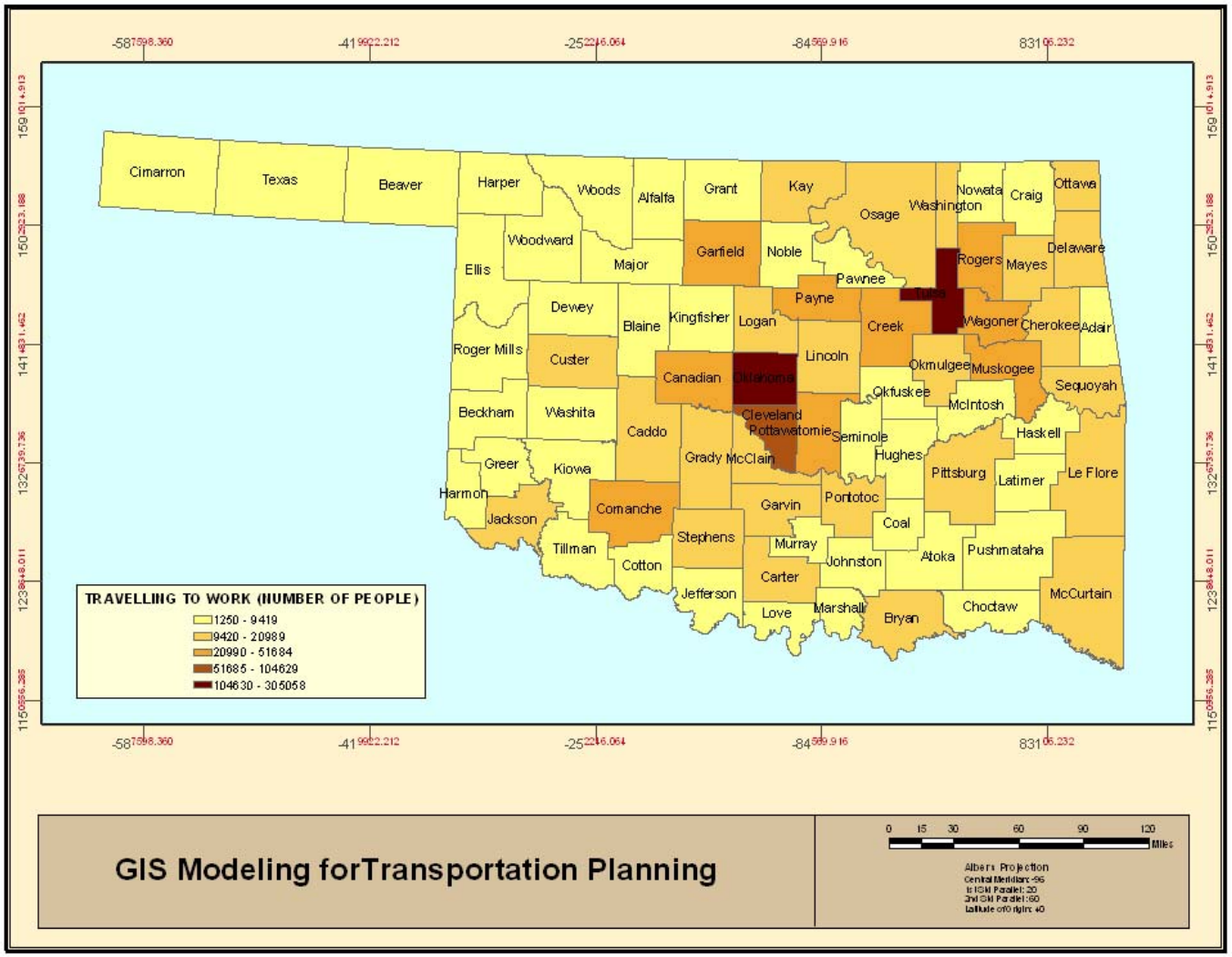

Figure 24: Total number of people traveling to work.

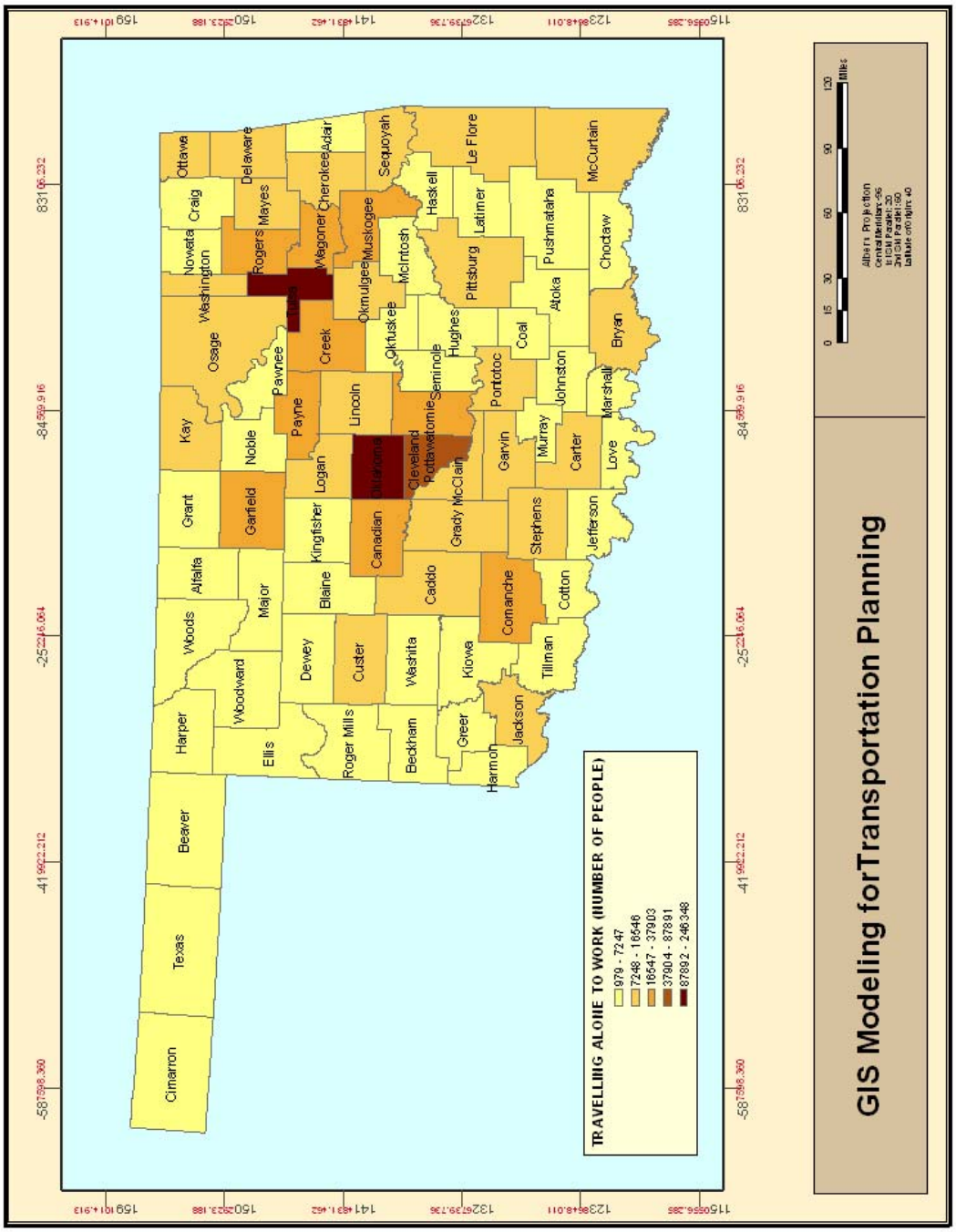

Figure 25. Total number of people traveling alone to work.

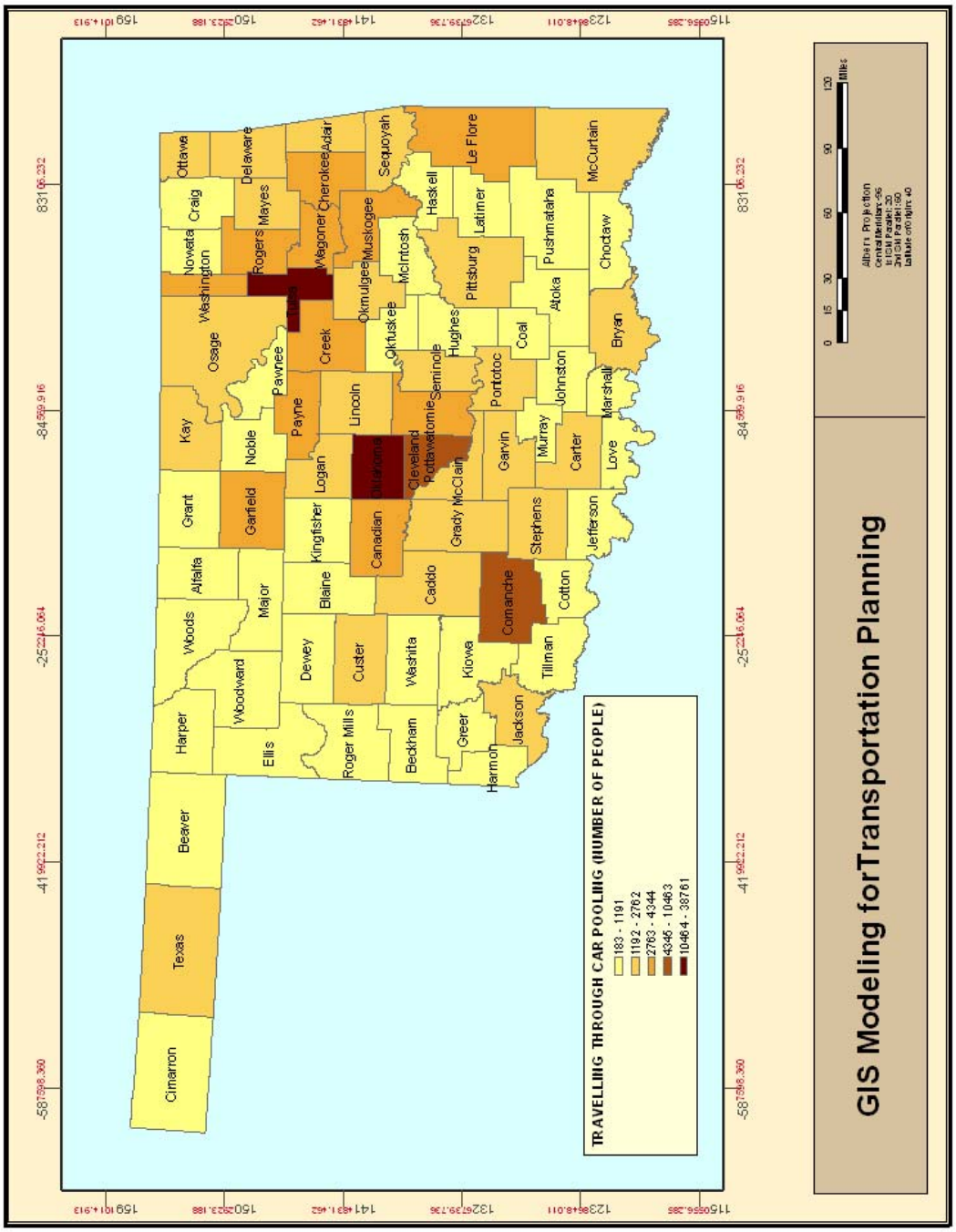

Figure 26. Total number of people traveling by carpooling to work.

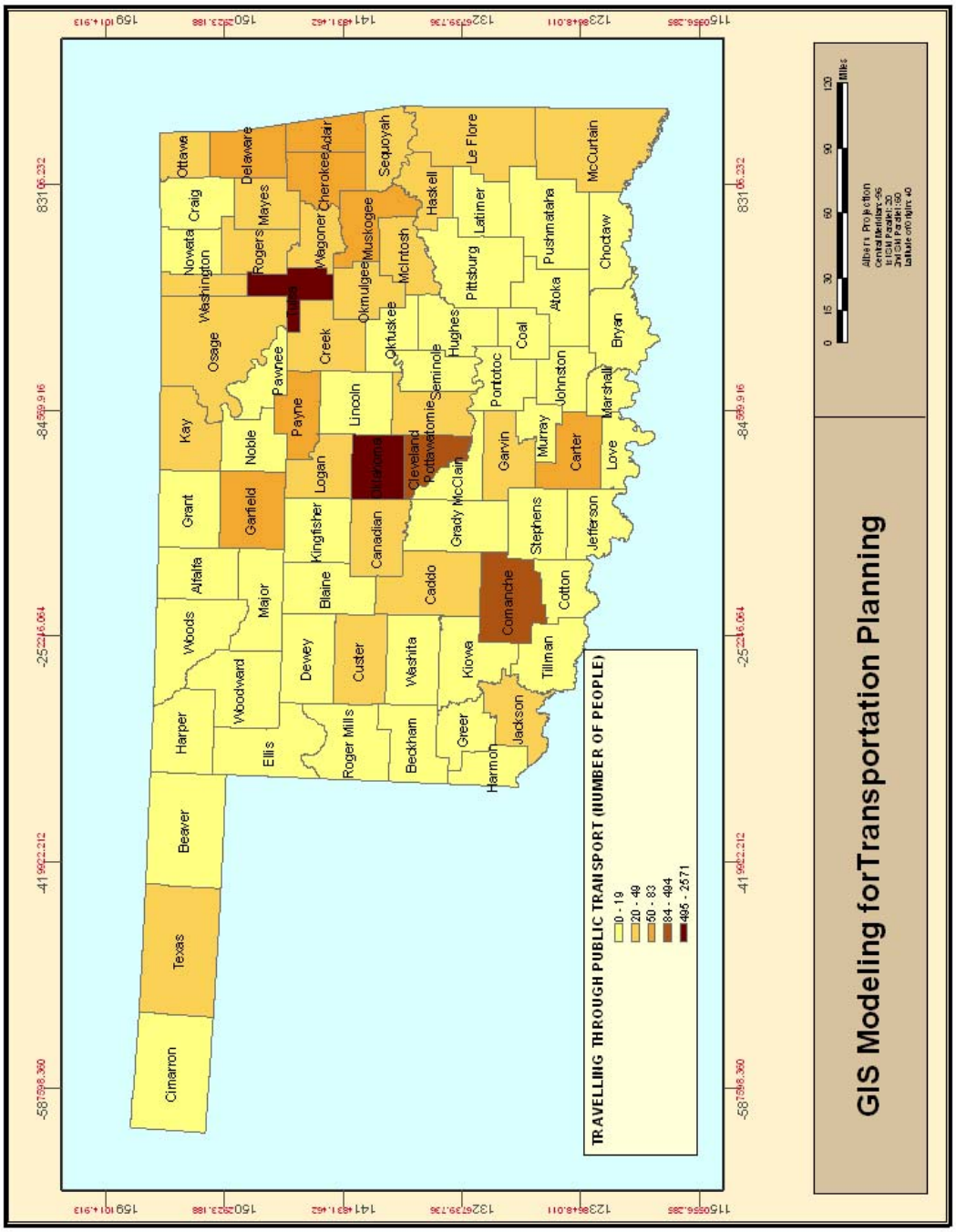

Figure 27. Total number of people traveling by public transport to work.

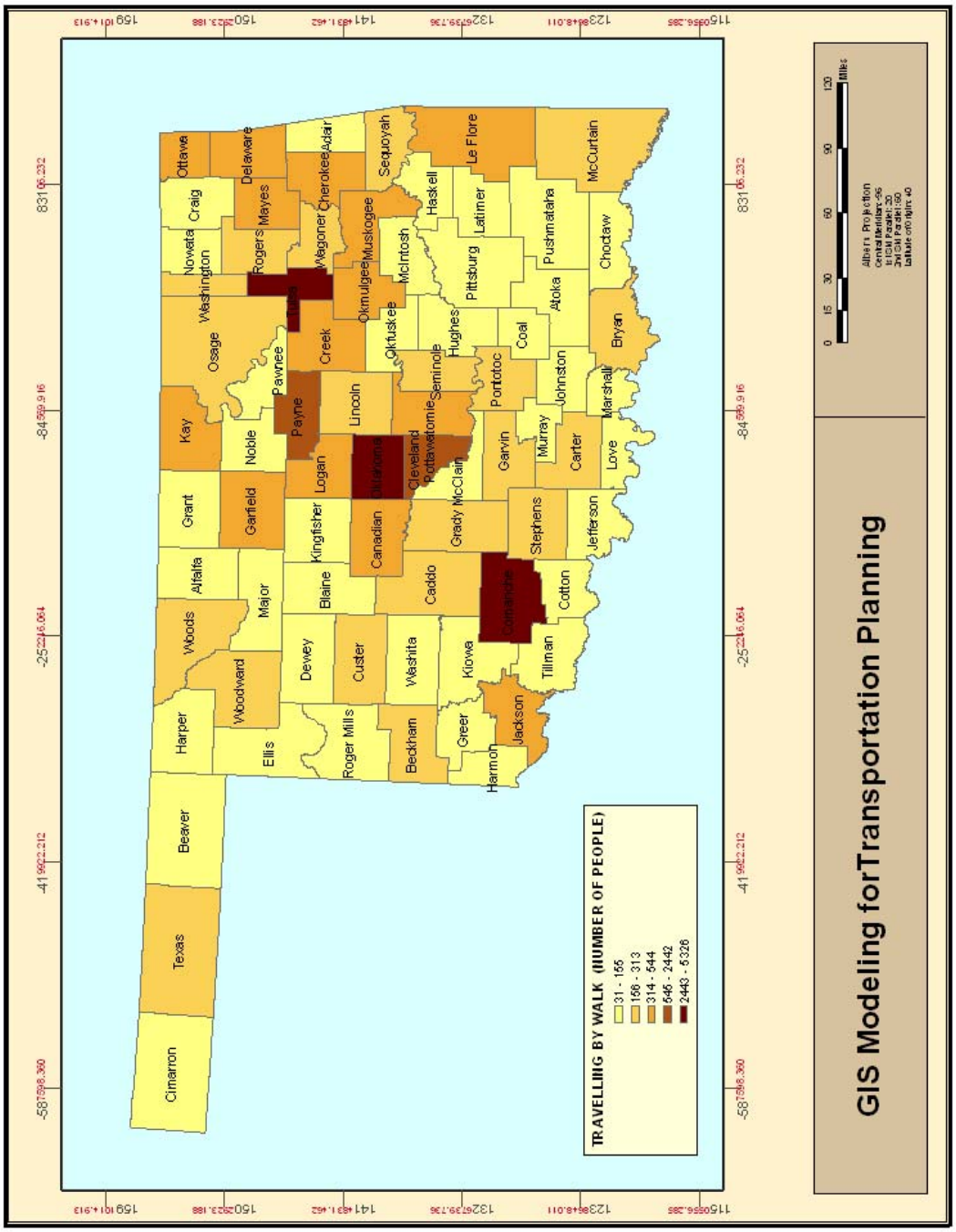

Figure 28. Total number of people walking to work.

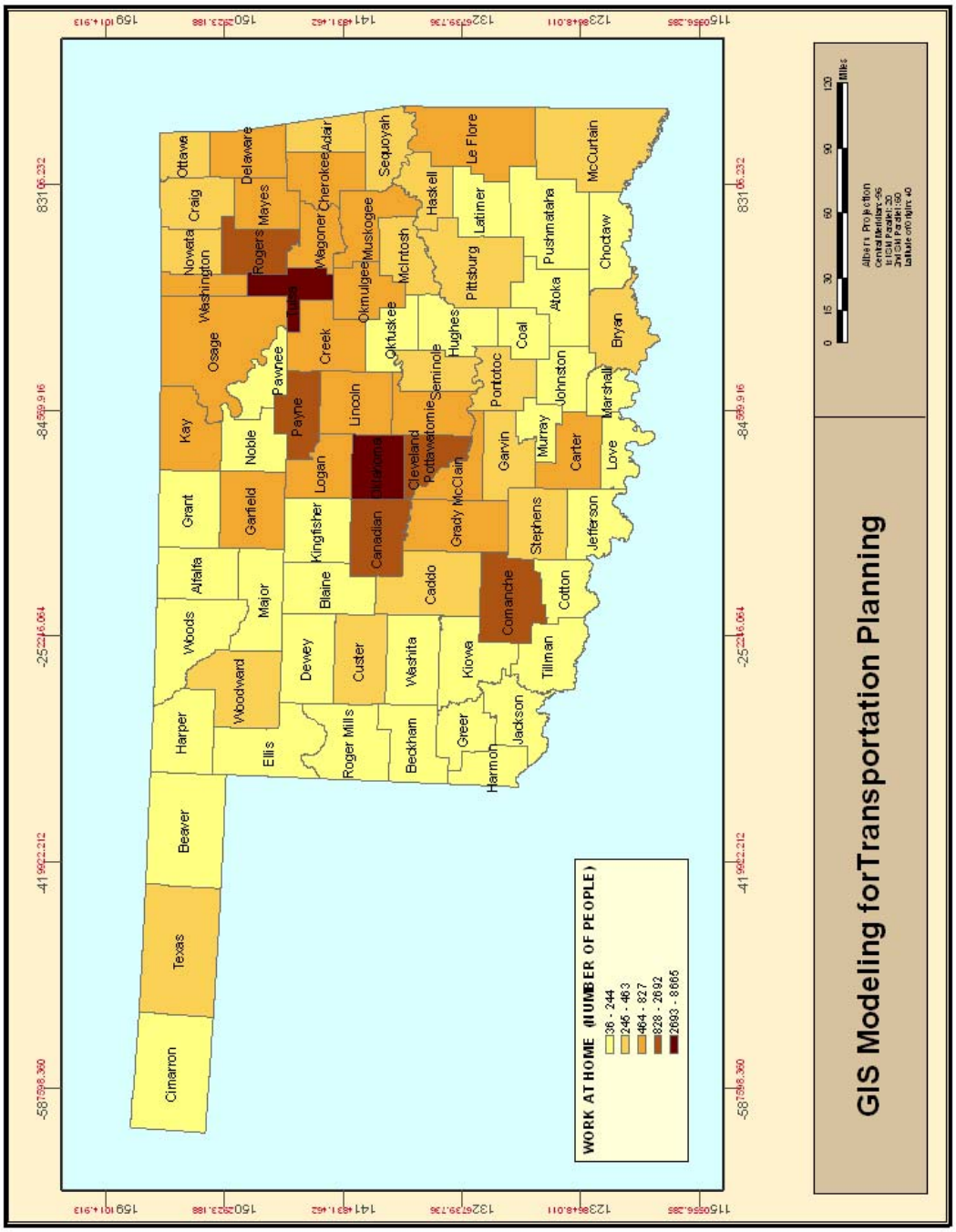

Figure 29. Total number of people working at home.

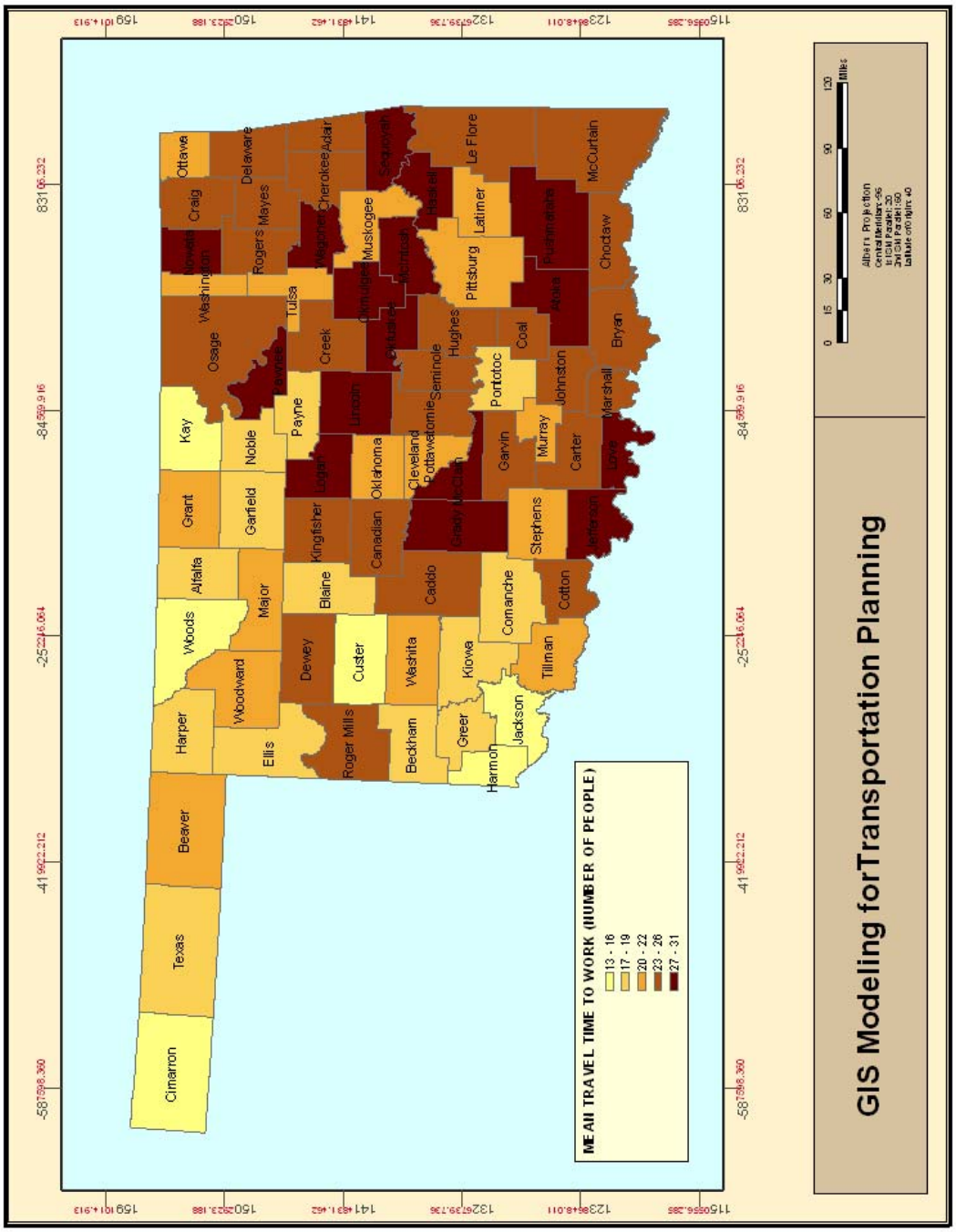

Figure 30. Mean travel time to travel between work and home.

IX. Tasks Completed

The follow tasks are completed:

Task 1 – To obtain and review the current GIS base map and convert to ArcGIS system.	Done
Task 2 – To obtain economic and census information.	Done
Task 3 – To create and overlay of spatial data related to transportation, population and other socioeconomic factors on ODOT base map.	Done
Task 4 – To generate spatial statistics, including population density, education level of population, income level, and employment.	Done
Task 5 – To create corporate maps for use in long range planning for 2010-35.	Done
Task 6 – To prepare the final report and transfer data to ArcGIS to ODOT.	Done

X. Results

The following maps result from this project:

1. Maps for population density and percent change in population are presented for different counties in Oklahoma for the years 2010 through 2035.
2. Maps for different education levels are shown for actual data from the 2000 census.
3. Maps for people employed and unemployed are included in this report based on the census from the year 2006.
4. Maps for median household income and total household income are shown based on the census from the year 2000.
5. Maps for various modes of using the transportation system are shown together with the mean travel time for transportation.

XI. References

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