2040 NEBRASKA

Good Life. Great Journey.

STATEWIDE TRANSPORTATION PLAN

# Influences on Transportation’s Future in Nebraska

**April 16, 2020**

This technical memorandum comprises the efforts of Task 4 of the Nebraska Department of Transportation’s Statewide 2040 Transportation Plan. Contained in this memorandum are data and information relating to the future influences on transportation in the State of Nebraska.

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# 1 Introduction

# 1 Introduction

The future of transportation in Nebraska will be impacted by a variety of factors that will determine how, where, and why people move on the system, the efficiency of goods movement throughout the state, and the projects and programs the Nebraska Department of Transportation (NDOT) advances to improve and maintain a multimodal transportation system. Each of these factors - deemed "influences" throughout this document - impacts the systems at varying rates, degrees of significance, and geographical area. This technical memo examines the historic and projected trends for the various influences identified to determine potential tipping points that will inform scenarios included in the 2040 Statewide Transportation Plan.

## 1.1 What is an Influence?

An influence is an object or an event that is likely to disrupt the status quo of the transportation system in Nebraska. Where possible, influences also have an identifiable trend. Throughout the process of identifying influences for this document, trends were considered to contain two components: predictable trends and uncertainties.

## 1.2 How were the Influences identified?

In order to assess the future of transportation in Nebraska for the development of the 2040 Statewide Transportation Plan, NDOT personnel and stakeholders were asked to identify influences that will impact the transportation system over the next 20 years. The process of identifying the selected influences began by brainstorming the possible influences with NDOT personnel at the initial project kickoff meeting. Additional NDOT personnel were then led through a facilitated discussion related to potential influences impacting Nebraska and the formulation of scenarios based on influences. Feedback on an initial list of potential influences was then shared with the Statewide Advisory Committee (SAC) for feedback from their perspective.

## 1.3 Identified Influences

Following the feedback from NDOT personnel and stakeholders, ten influences were identified as being the most likely to disrupt the Nebraska transportation system between 2020 and 2040. The influences are generally categorized around three themes: social and economic, technology, and external influences.

# 2 Social & Economic Influences

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Social and economic influences identified through the stakeholder engagement process for the 2040 Statewide Transportation Plan fit within two overarching social and economic themes: shifting demographics and technology's impact on the economy. The increasing proportion of the population that is over the age of 65 and the continued urbanization of the state represent population changes in Nebraska that will significantly impact the transportation statewide. Economically, the rapid shifts in technology adoption have enabled the expansion of services available on a digital platform, increased automation, and the next generation of work.

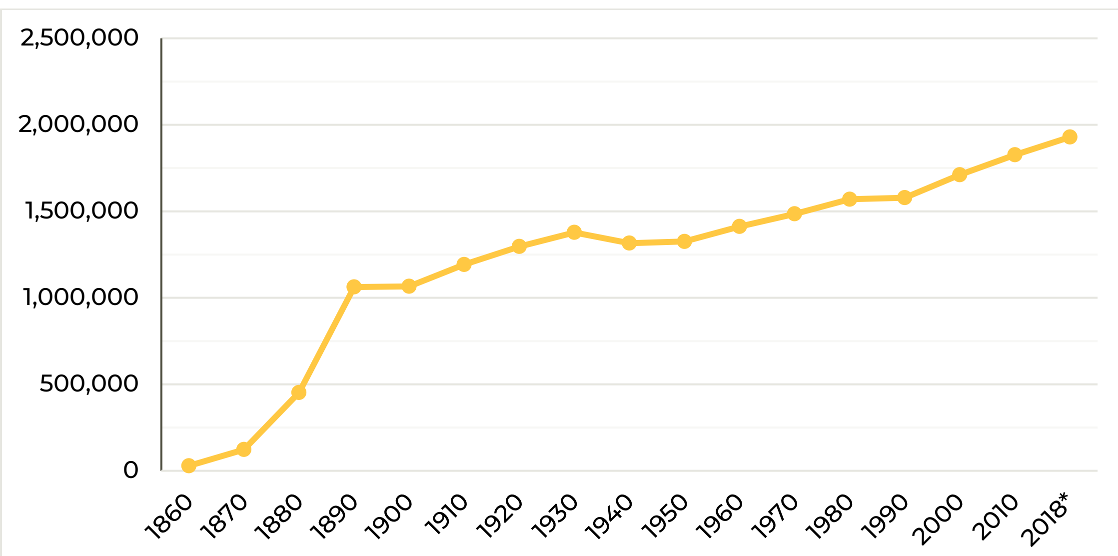
## 2.1 Aging Population

The number of people age 65 and older in the United States has been steadily increasing since the 1960s. The nation is set to experience even faster and more significant demographic changes as the baby boomer generation (those born between 1946 and 1964) retires and birth rates and in-migration declines. An aging population comes with a wide variety of housing, healthcare, and workforce changes that influence the transportation network.

### 2.1.1 Trends

Nebraska's population has consistently grown from decade to decade. Since the 1960s Nebraska's population has increased by nearly 500 thousand people. Despite a gradual decline in national population growth rates, Nebraska population has steadily grown since the 1990s, as shown in **Figure 2-1**.

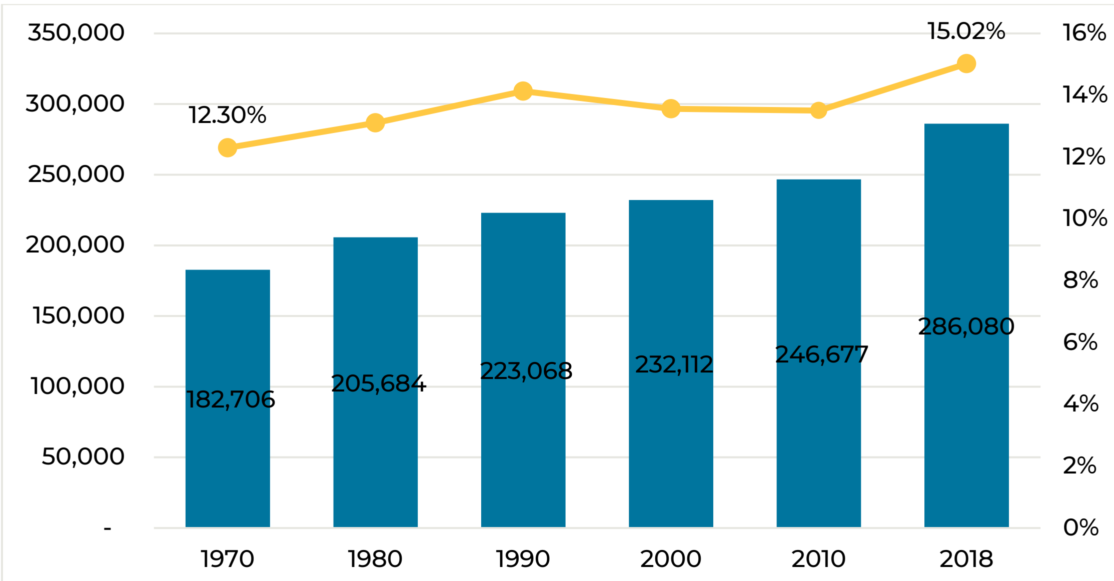
**Figure 2-1: Nebraska Population 1860 - 2018**




Source: U.S. Census Bureau
*Population for 2018 is based on census estimates (versus census counts for all other years)

Within this population growth, the number and portion of those 65 and older have steadily grown from 12 percent of the state population to over 15 percent between 1970 and 2018. **Figure 2-2** shows absolute estimates and proportions for Nebraskans ages 65 and over.

**Figure 2-2: Nebraska 65+ Population 1970-2018**




Source: U.S. Decennial Censuses 1970-2010, 2018 ACS 5-Year Estimates, U.S. Census Bureau

The growing senior population has been accompanied by slight growth in the number of younger people moving to the state in pursuit of education and economic opportunity. More out-of-state youth are choosing to pursue higher education opportunities in Nebraska; between 2000 and 2016 (the latest data available) the number of individuals from other states pursuing higher education in Nebraska increased by 22 percent over the previous decade. Student migration from non-neighboring states has experienced the largest increase with Minnesota, California, and Illinois accounting for the largest in-migration. Yet, retaining these young people continues to be a problem for Nebraska. Recent graduates under the age of 30 have trended towards out-migration with an average annual net migration of -1,500 since 2000.[1] While working through the influence of an aging population, the attraction and retention of other generations will influence the human resources available to Nebraska's future.

An aging population influences the state transportation system through three primary pressure points: where those 65 and over live, the demand for health care, and changes in personal mobility.

**Geography:** The geographic distribution of those 65 and over determines the ease to which services can be provided. Rural populations specifically are often harder to serve due to proximity challenges, a limited pool of caregivers, and fewer economic opportunities. As a result, rural citizens 65 and older experience limited services, resources, and social connections.[2]

As of 2018, Nebraska's rural counties were proportionally older than urban counties with 19 percent aged 65 and older compared to 12.9 percent of urban county residents.[3] Nebraska's State Unit on Aging identifies the rural population 65 and older as a priority focus in the 2019-2023 Nebraska State Plan on Aging. The plan sets goals to increase service coordination, transportation funding, and targeted outreach in rural areas.[4] However, serving older rural populations has proven to be difficult. Between 2010 and 2019, 48 nursing homes were closed throughout the state and all but three were in rural communities.[5]

**Health Care:** Access to healthcare is both a critical concern for individuals over the age of 65 and a critical concern for the national economy. Nebraska's existing healthcare system may pose some challenges for an aging population, particularly for those aging in rural areas. As of 2018, all counties other than the most urban (Douglas and Lancaster) have been state-designated as having shortages in some form of primary care (family doctors, pediatricians, internal medicine, obstetrician-gynecologists) and 13 of 93 counties have no primary care doctor.[6]

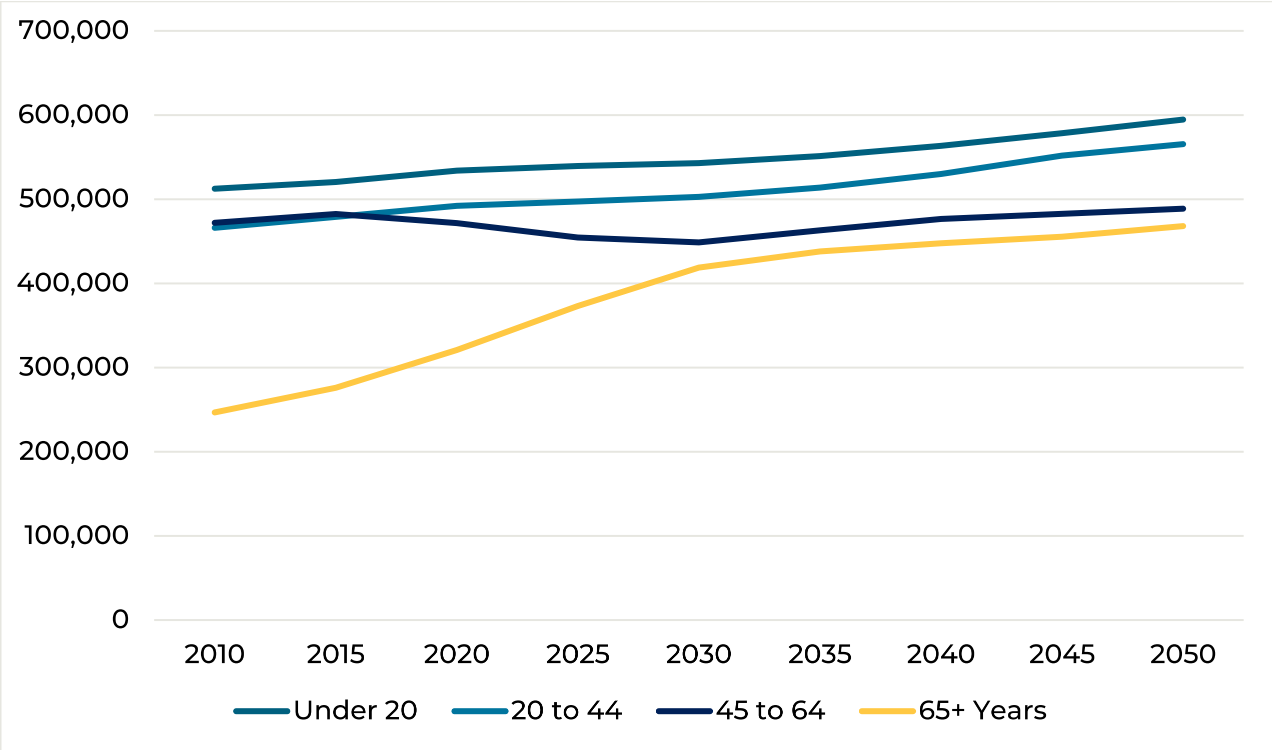
Digital technologies, however, have started to influence the provision of healthcare and may hold promise for a future, older population. Telemedicine, or the remote diagnosis and treatment of patients by telecommunications technology, is a growing practice across the nation. A 2018 survey of United States (U.S.) healthcare consumers and physicians found 90 percent of physicians view virtual care positively but only 14 percent had video-visit capabilities.[7] If video visits are not possible, many patients are still benefiting from remote patient monitoring (RPM). RPM is the use of technology to transmit information between patients and physicians including reminder software applications (referred to as apps), voice assistants, or monitoring devices.

**Mobility:** An aging population also means aging drivers and different mobility needs for those who advance past their ability to drive. Americans today are living longer, healthier lives and outliving their ability to drive safely by an average of seven to 10 years. Across the nation, drivers over the age of 65 have the highest crash death rate per mile driven aside from teen drivers.[8] Nebraska's Strategic Highway Safety Plan (SHSP) identified a growing number of older driver-related crashes between 2012 and 2015, rising from 564 to 656. Public transit is one alternative transportation option for aging Nebraskans. Walkable streets and other transportation alternatives are being considered across the state. Grand Island, NE was the first community in the state to join the AARP's *Network of Age-Friendly States and Communities* where members focus on creating more walkable streets and expanding housing and transportation options to help people age in place.[9]

### 2.1.2 The Future

The University of Nebraska - Omaha's (UNO) Center for Public Affairs Research projected Nebraska's population to 2050 using historic U.S. Census data. Based on these projections, over the next 30 years, the age group 65 and over experiences the largest growth. **Figure 2-3** shows the projected population change by age group until 2050.

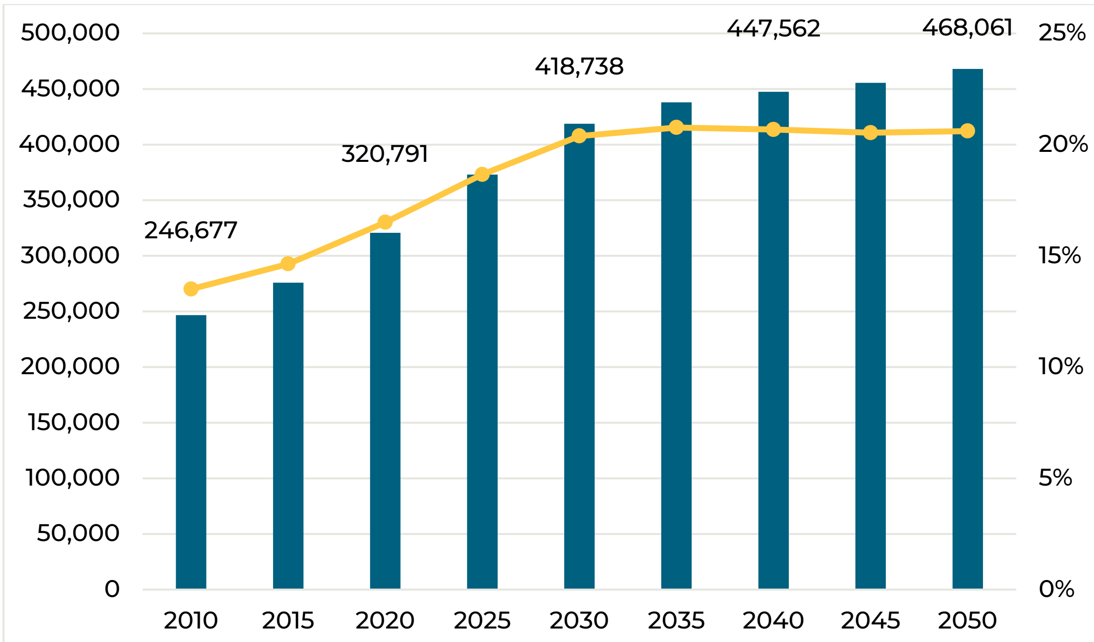
**Figure 2-3: Nebraska Population Projection by Age**




Source: U.S. Census Bureau; University of Nebraska – Omaha, Center for Public Affairs Research

**Figure 2-4** shows the projected growth for just the population aged 65 and older. The largest growth is expected to occur between 2020 and 2030. By 2050, those aged 65 and older will represent nearly 21 percent of Nebraska's population.

**Figure 2-4: Nebraska Population 65 and over Projection**




Source: U.S. Census Bureau; University of Nebraska – Omaha, Center for Public Affairs Research

The working-age population (age 18-64) is also expected to increase through 2050 but at a slower rate. In 2010 the estimated ratio of workforce age population to retirement age population was 5:1. By 2050, the same ratio is expected to decrease to 3:1.[10] However, the proportion of those 65 and over to those under 65 may be impacted by future in-migration. The future attraction and retention of other generations is a policy leverage point for the state to minimize or alter the economic and workforce consequences of an aging population.

The needs of a future, older Nebraska can be served in a variety of manners. The methods of meeting these needs will have implications for the transportation system. Given data on existing population and natural aging, these projections provide realistic expectations of the number of those 65 and older in Nebraska In 2040. However, where the older population will live, the healthcare they will have access to, and their mobility options they will have are less clear.

**Geography:** The mobility options of those 65 and older in Nebraska will vary depending on where they live, but the geographic distribution of a future, older, Nebraska population is not known. A 2018 AARP survey shows 76 percent of adults age 50 or older want to stay in their communities as they age (also known as aging-in-place) but only 46 percent expect they will be able to stay in their current home.[11] If financially free from the workforce, retirees may move to locations that suit their lifestyle, health, or family needs. The 2018 AARP survey found that adults considering staying in their communities or relocating as they age cite affordable housing, transportation, equal opportunities, and jobs/job training as extremely or very important.[12] Others may seek new housing opportunities that provide needed support. The Population Research Bureau predicts the baby boomer generation could result in more than a 50 percent increase (1.2 million in 2017 to 1.9 million in 2030) in the number of older Americans requiring nursing home care.

Population projections estimate nearly 36 percent of small rural Nebraska county (defined as the 64 counties without a city of 5,000 residents or more) populations will be residents age 65 and older by 2050.[13] To-date, maintaining senior facilities in rural areas has been difficult, yet the University of Nebraska-Lincoln's 2007 Rural Poll found that 62 percent of rural Nebraskans prefer to age-in-place.[14]

**Health Care:** A growing population of those 65 and over will increase the patient demand on a national healthcare system that already experiences labor shortages. By 2025, national healthcare is expected to be short of half a million home aides, 100,000 nursing assistants, 100,000 lab technicians, 29,000 nurse practitioners, and more. With shortages more pronounced in rural areas where it is harder to recruit.[15]

Some economic and technological advances may be able to ease the burden on healthcare needs. Telemedicine, for example, can provide access to a doctor for regular checkups, diagnosis of common issues like colds, prescription refill consultation, and to answer patient questions. These advances may be most useful in rural areas where healthcare facilities are not financially feasible due to small demand. However, without technology solutions, alternative transportation access to healthcare will be needed. These services are more limited or more costly in many rural areas.

**Mobility:** With more drivers 65 and over on the road, roadway safety is a concern for Nebraska's future. Beyond the personal automobile, however, a growing population may also call for alternatives to driving.

Some economic and technological advances may be able to replace or ease the burden on mobility needs. E-commerce and door-to-door delivery can ease shopping needs. These advances may be most useful in rural areas where alternative transportation options are limited or more costly. Automated vehicles may be another influence that interacts and impacts the aging population providing a mobility option.

### 2.1.3 Transportation Consequences

Nebraska's transportation network will be impacted by two primary areas of consequence due to the aging population:

**Mode Choice:** The mobility choices of an older population are influenced by the intersection of ability, preference, and access. In these late years, this means an older population may create more demand for transit, paratransit, pedestrian facilities, accessible infrastructure, and access to health and human services.

**Funding:** The economic impact of the aging population stems, principally, from the retirement of a large cohort of the workforce. Although the working age population is also growing, Nebraska's unemployment has been consistently low in recent decades. As a result, filling workforce needs may be difficult. A shortage of workers can slow economic growth or business may choose to locate in markets with more available employees. The rate of future slowdown remains a question.

Most literally, a smaller workforce might mean fewer people making a regular commute. But also, if the economy slows, consumer mode choice may change due to transportation cost, preference, or availability. The movement of goods may slow if retirees have less disposable income. Lastly, there is a direct relationship between the economy and transportation funding and any economic impact will result in changes to tax revenue and the resulting budgets for transportation.

In summary, an aging population will have consequences for Nebraska's commute patterns, demand on alternative and accessible transportation, funding, and population distribution. The extent of these impacts may be altered by policy, planning, or several emerging technology influences.

## 2.2 Urbanization

Cities across the world are experiencing faster and more dramatic growth than their rural counterparts. In the United States, approximately 84 percent of the population lives in urban areas. Up from 64 percent in 1950, urban populations will continue to experience most of the population growth in the nation. By 2050, 89 percent of the U.S. population is expected to live in an urban area.[16] Cities, often hubs of economic and cultural resources, create travel demand for both goods and people. As a result, the amount of growth and the land use pattern of growth in Nebraska's urban areas will have implications for the transportation network.

There are numerous ways to define 'urban'. Since future population data is integral to the urbanization discussion, most of this section will use county-level data as established by UNO's Center for Public Affairs Research's population projections. The authors of the report group Douglas County, Lancaster County and Sarpy County as the "Big Three" relatively densely populated counties.

### 2.2.1 Trends

As mentioned previously, Nebraska's population has steadily grown in the last few decades, increasing from 1.58 million in 1990 to just over 1.9 million in 2018. Most of this growth (95 percent) has concentrated in the three largest, urban counties of Douglas, Lancaster, and Sarpy. Home to Omaha (Douglas), Lincoln (Lancaster) and southern Omaha metropolitan statistical area cities of Bellevue, La Vista and Papillion (Sarpy), these urban counties now account for 54.8 percent of Nebraska's total population.[17]

Four major pressure points define urbanization's relevancy for Nebraska transportation: mode choice, land use, movement of goods, and rural disparities.

**Mode Choice:** Expected growth in urban areas is paired with the possibility for modes other than single-occupancy vehicles to be more attractive to, and convenient for, individuals and more efficient to provide for companies and organizations. More compact land use patterns allow more individuals to reach more destinations in a smaller area with infrastructure (sidewalks, transit vehicles, etc.) that can be shared by more people. Across the nation, cities are rethinking transportation and both public and private entities are investing in pedestrian and bicycle facilities, bike-share, public transit, and ride-hailing.

A full description of emerging transportation options is outlined in **Section 3.1 Innovation in Transportation Choices** Given the density and market size of urban areas, Nebraska's cities are often the first to gain access to these technologies and more aggressively adopt them as new transportation options. In addition to new mobility options, urban Nebraska also has long-standing fixed-route public transit. Urban transit agencies in Nebraska provide 90 percent of the total ridership for the state and provided almost six million trips in fiscal year 2019.

**Land Use:** The type of development in urban areas, whether densification or sprawl, impacts the mobility options.

The City of Omaha is bordered to the east by the Missouri River and the Nebraska-Iowa border, to the south by the Douglas County border with Sarpy County and to the north by the Ponca Hills. As such, Omaha has historically concentrated expansion to the west, with a lower-density development and suburban focus. Numerous annexations have supported the continuous low-density development and growth of the Omaha land area.

Outside of the Omaha city limits, the cities in Sarpy County have provided a competitive suburban alternative to Omaha. Adjacent to Omaha, the cities of Bellevue, La Vista, and Papillion are the most populous Sarpy cities and since

1970, La Vista and Papillion have nearly tripled their population. The unincorporated suburban areas throughout Sarpy County have also experienced expansive growth particularly in Sanitary Improvement Districts (SIDs) and rural subdivisions.[18]

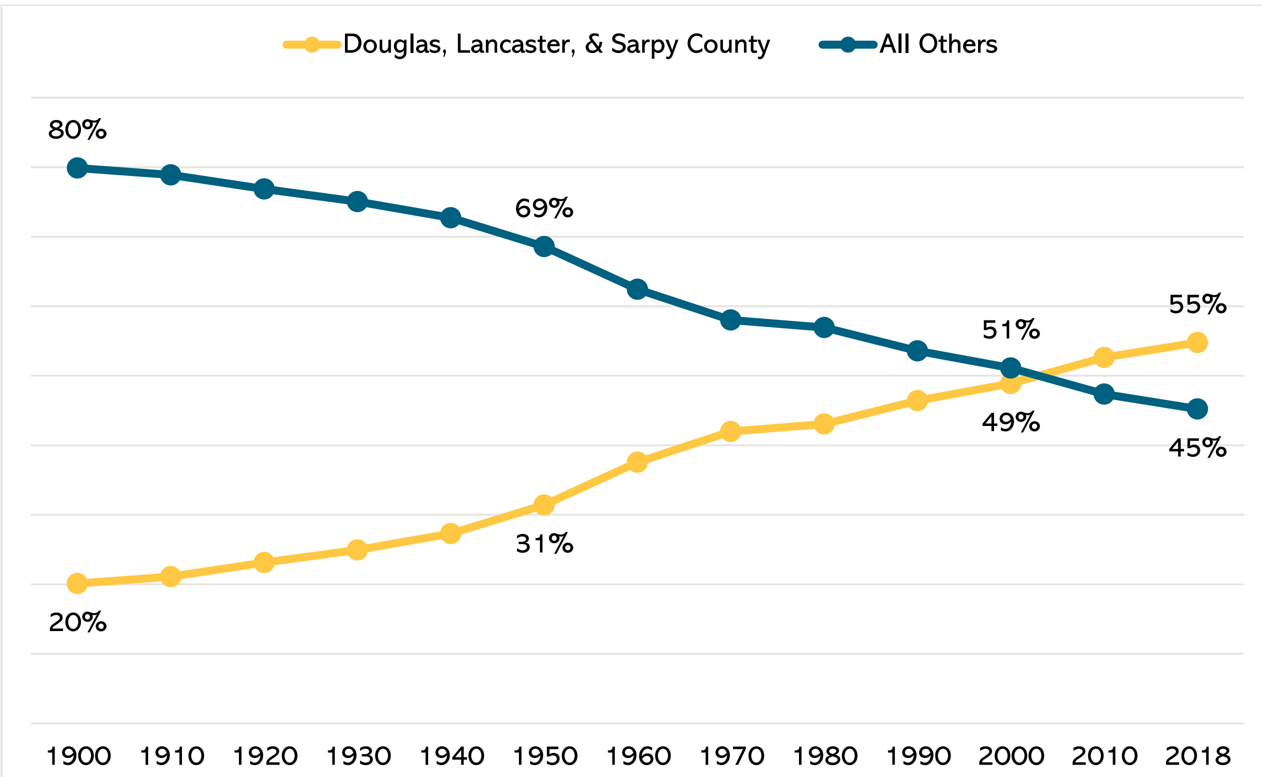
Alternatively, Lancaster County has maintained a relatively consistent population density since the 1970s (~3,000 persons per acre). Pockets of greater density have concentrated near older neighborhoods and Downtown Lincoln. In recent decades, 90 percent of the county population has consistently lived within the City of Lincoln while the remaining 10 percent population has started to shift from rural areas to small towns.[19]

**Goods Movement:** A 2017 survey by global logistics company United Parcel Service (UPS) asked large and small businesses to understand how they conduct business in cities. Most respondents (81%) noted urbanization and e-commerce impacting their business. Top concerns for the movement of goods in urban areas included potentially costly air quality protection measures and traffic congestion. The ability to meet e-commerce customer expectations also appeared as a concern; rising expectations as it relates to service level (faster and more flexible deliver options, for example) not only add more vehicles to the road and create more congestion but also adds complicates the ability to find parking spaces and compete for traffic lanes.[20]

**Rural Disparities:** Growth in Nebraska's urban areas has come at the loss of population in rural areas (

**Figure** 2-5). In 1990, 66 of Nebraska's 93 counties had populations less than 10,000. Between 1990 and 2018, all but nine of those counties have lost population (10.33% population loss across the 66 counties). During that same period, Nebraska's three urban counties captured 95 percent (+310,800) of all state population growth (+326,000). Rural areas, with residents more widely spread, require additional transportation infrastructure and human services to serve residents.

**Figure 2-5: Population Change 1900-2010 (Douglas, Lancaster, and Sarpy County vs. All Others)**

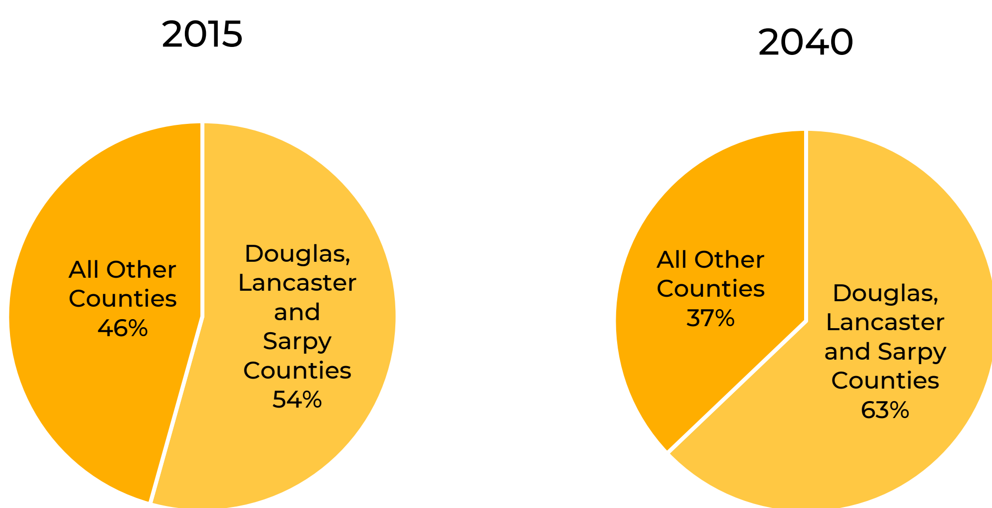



Source: UNO Center for Public Affairs Research, 'Nebraska Historical Populations' (using U.S. Census Data)[21]

### 2.2.2 The Future

The UNO Center for Public Affairs Research population projections also include geographic boundaries that can provide insight into the rural-urban split. The analysis estimates Nebraska's population growing by approximately 330,000 people between 2015 and 2040. As experienced in recent decades, this growth is concentrated in urban areas. By 2040, 63 percent of Nebraska's population will be in the states three most urban counties (Douglas, Lancaster, and Sarpy Counties) shown in **Figure 2-6**. These three counties will grow to 1.36 million residents, a total of 337,000 new residents.

**Figure 2-6: Population Distribution, 2015 and 2040 (Douglas, Lancaster, and Sarpy County vs. All Other Counties)**



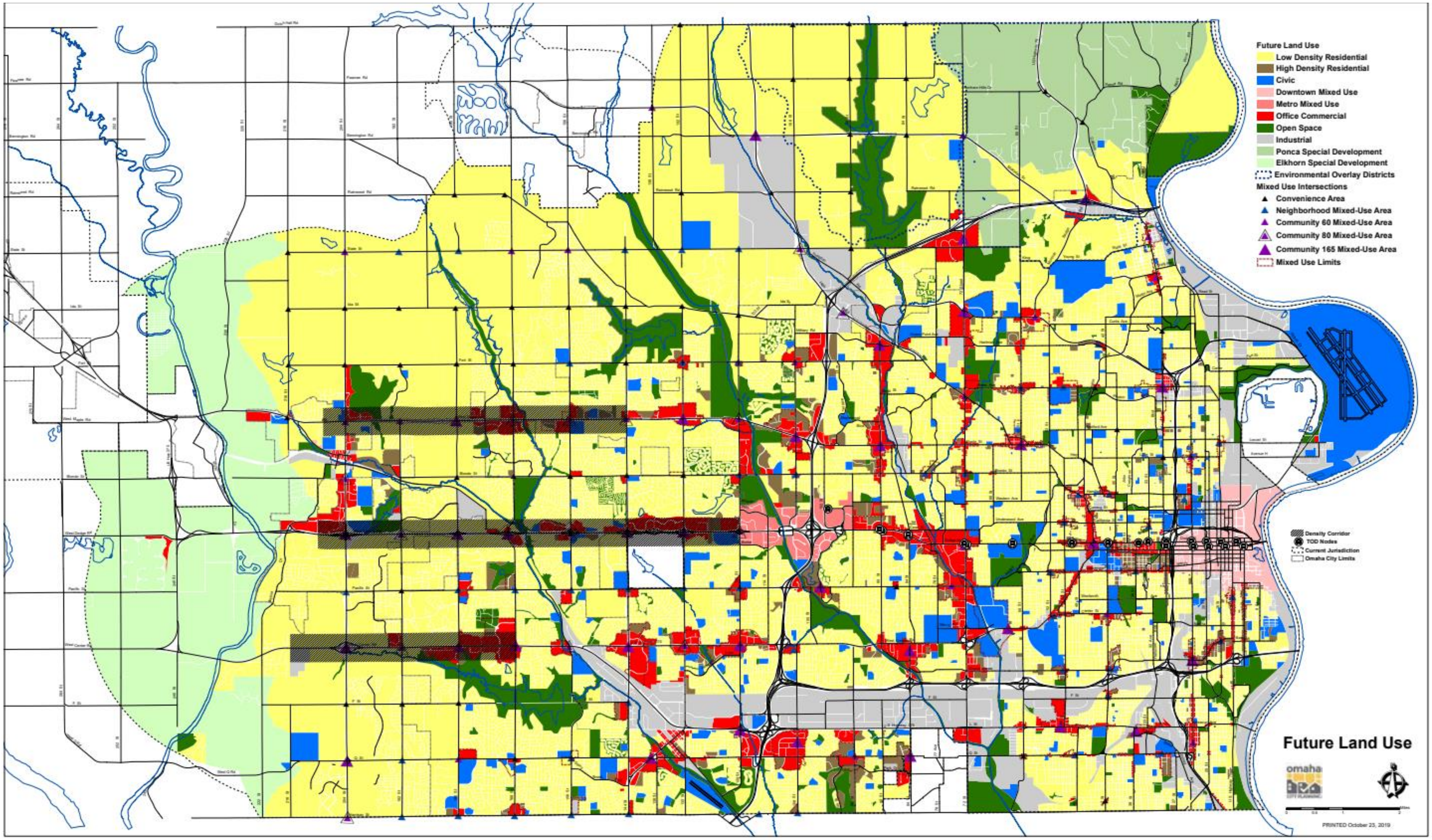

Source: UNO Center for Public Affairs Research

**Mode Choice:** The future mode choices of Nebraska's growing urban areas are hard to predict but the number of transportation options is increasing. As more transportation options become available and cities make concentrated efforts to design and support alternative modes of driving, some transportation changes should be expected. **Section 3.1 Innovation in Transportation Choices** covers emerging modes in more details; as noted, emerging modes are likely to concentrate in urban areas. Advancements in automated and connected technology will likely increase the available mode options and create a wide-spread impact. Transit and the ride-hailing model, for example, will likely be more cost-effective with automated technology removing operator costs, allowing these modes to reach more people. Urban areas are also the testing ground for smart and connected infrastructure which can serve as a tool to manage the operations of multiple modes in urban corridors.

**Land Use:** The Omaha Master Plan, developed in the early 2000s, proposed a future growth pattern averaging 4.4 dwelling units per acre to accommodate all projected growth through 2040. Much of this growth is projected to be continuous with existing westward expansion and low density. The westward growth brings Omaha closer to Lincoln and increases the distance Omaha residents are traveling to get to economic hubs like downtown. Low density development also increases the reliance on personal vehicle trips which would create more travel demand. However, the plan does callfor investment in a mass transit system and urban design standards that make walking and biking more appealing, especially in higher density and mixed use neighborhoods. **Figure 2-7** shows the future land use map for Omaha with light yellow representing low density development.

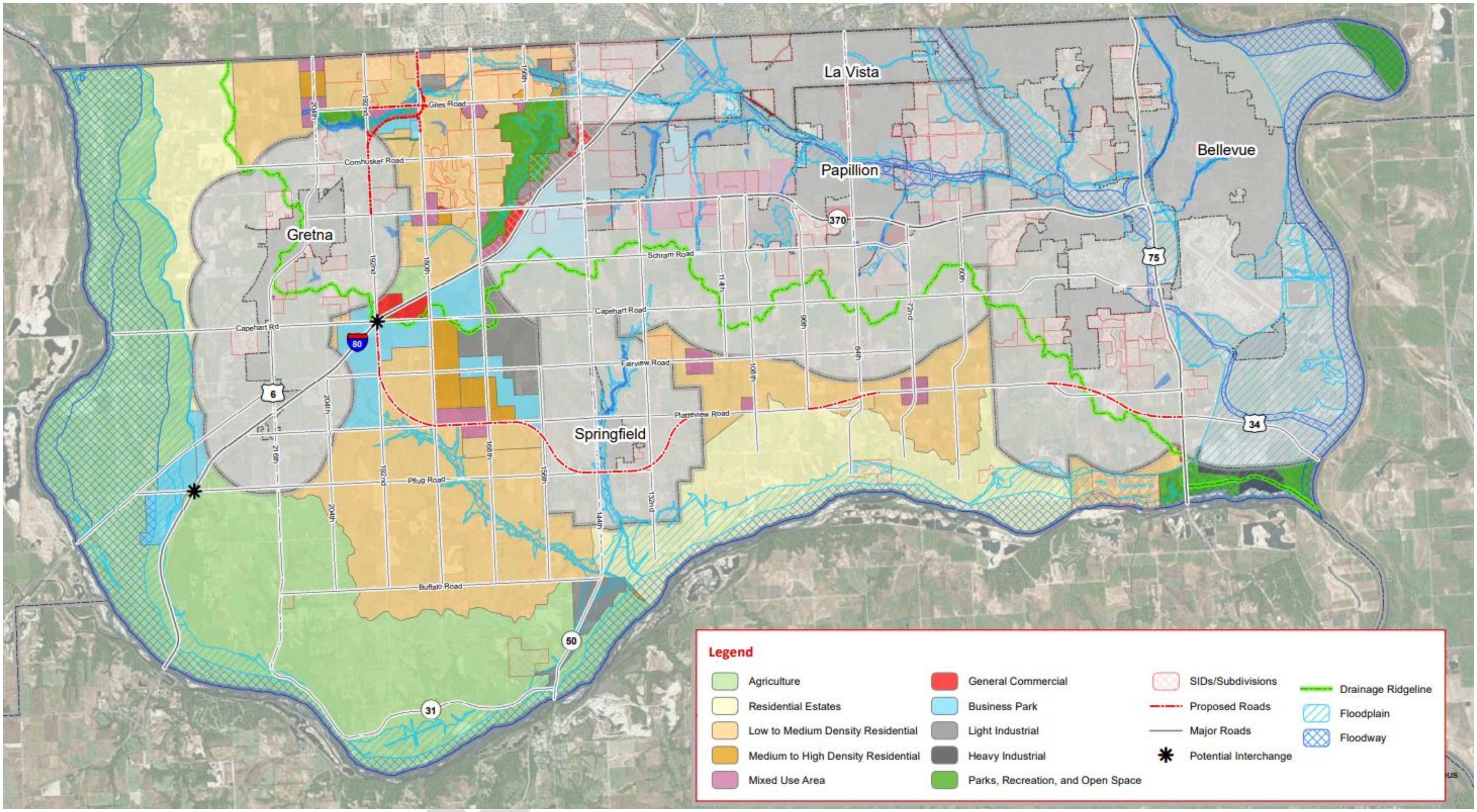
Sarpy County's future land use plan concentrates growth in line with existing development near the Douglas County (Omaha) border. Future expansion is anticipated to be contiguous to the east and southeast. The southern Sarpy County border with Cass County is entirely buffered by a conservation zone, which limits southern growth (see **Figure 2-8** for reference). Focusing development around existing cities and near Omaha will help transportation planning but a prevalence of lower density land use will increase demand on the transportation system.

## Figure 2-7: Omaha Future Land Use Map




Source: Omaha Comprehensive Plan

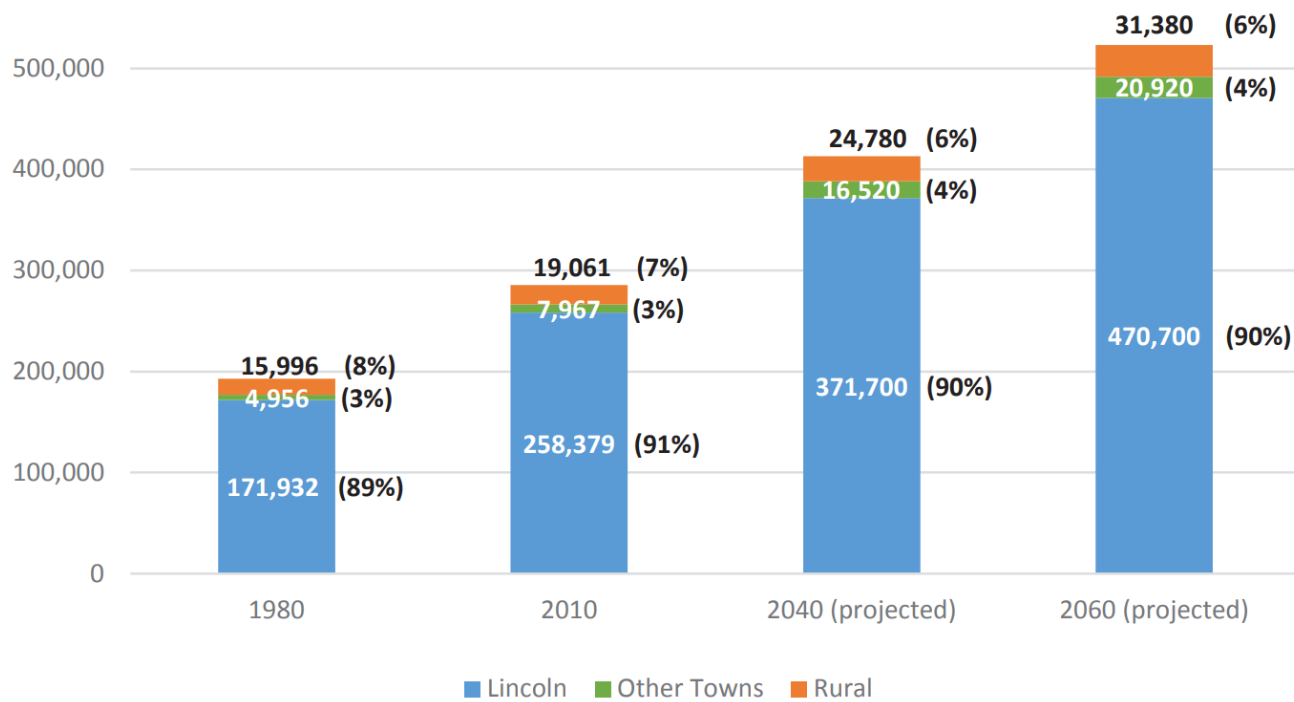
**Figure 2-8: Sarpy County Future Land Use Map**




Source: Sarpy County Comprehensive Plan

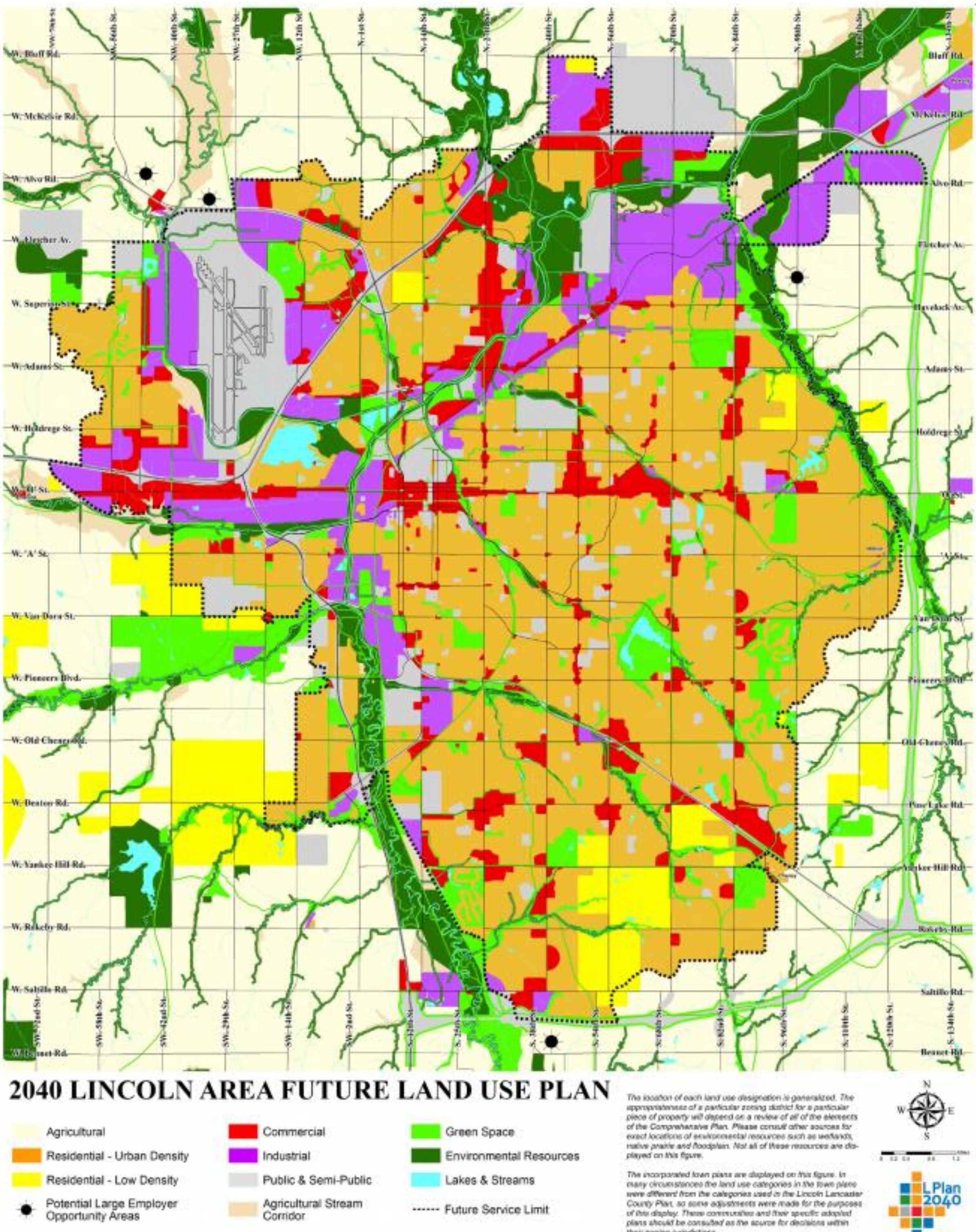
The City of Lincoln and Lancaster County's 2016 joint comprehensive plan assumes an urban residential density of three dwelling units per acre to accommodate future growth through 2040. The future land use map distributes upcoming growth, 2025 growth, and 2040 growth evenly across the city's peripheral and concentrates long-term growth (2060) first in the east and southeast before eventual even expansion to the north and west. Lincoln and Lancaster County anticipate the area of transition from one land use to another will be gradual and encourages the integration of compatible land uses, rather than a strict segregation of different land uses (**Figure 2-10**). Evenly distributed growth and mixed uses will also help evenly distribute transportation needs on existing infrastructure. **Figure 2-9** from the Lincoln/Lancaster Comprehensive Plan shows past and expected future population distribution.

**Figure 2-9: Lancaster County Population Distribution 1980-2060**




Souce: LPlan 2040: Lincoln/Lancaster 2040 Comprehensive Plan

**Figure 2-10: Lincoln Area Future Land Use Map**




Source: Lincoln/Lancaster County Comprehensive Plan

**Goods Movement:** More people living in urban areas comes hand-in-hand with more goods moving to and through the same concentrated area. Additionally, urban customers tend to be more affluent and order more goods online.[22] Meeting these delivery needs on the local level will look different from the needs of the highway freight. Technological innovations such as delivery robots and mobile food deliver applications join numerous e-commerce home delivery services to bring goods to urban doorsteps. These services can create bottlenecks and congestion on the local street level.

**Rural Disparities:** The UNO's Center for Public Affairs Research estimates counties with less than 5,000 residents will experience a nearly 20.5 percent population loss by 2040. These communities represent 14.4 percent of Nebraska's population today and will drop to just under 10 percent by 2040.

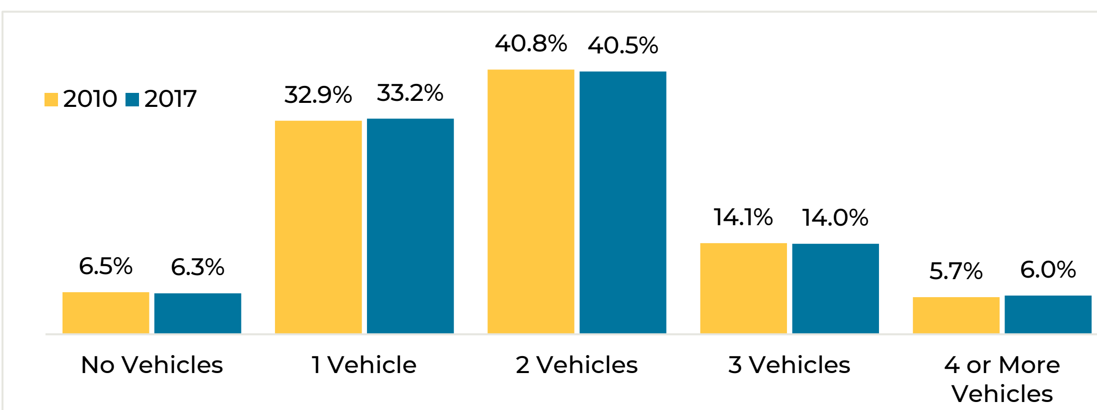
### 2.2.3 Transportation Consequences

Urbanization will continue to shift the demand on the transportation system – where people are going to and coming from. The trend of urbanization permeates all other influences in this report and will relate to all discussed transportation consequences. A few primary areas of concern arise.

**Car Ownership and Mode Shift:** A greater density and a growing number of transportation options in urban areas create unknown expectation for car ownership. Ownership could decrease and mode share skew or more evenly distribute across alternative transportation options. This expectation fits in more dense, multi-use land-use scenarios. To-date, Omaha's development does not support this trend.

Nebraska's three largest, most urban counties have seen minor changes in household vehicle ownership in recent years. There has been a slight increase in single-vehicle households but also slightly more households with four or more vehicles (**Figure 2-11**).

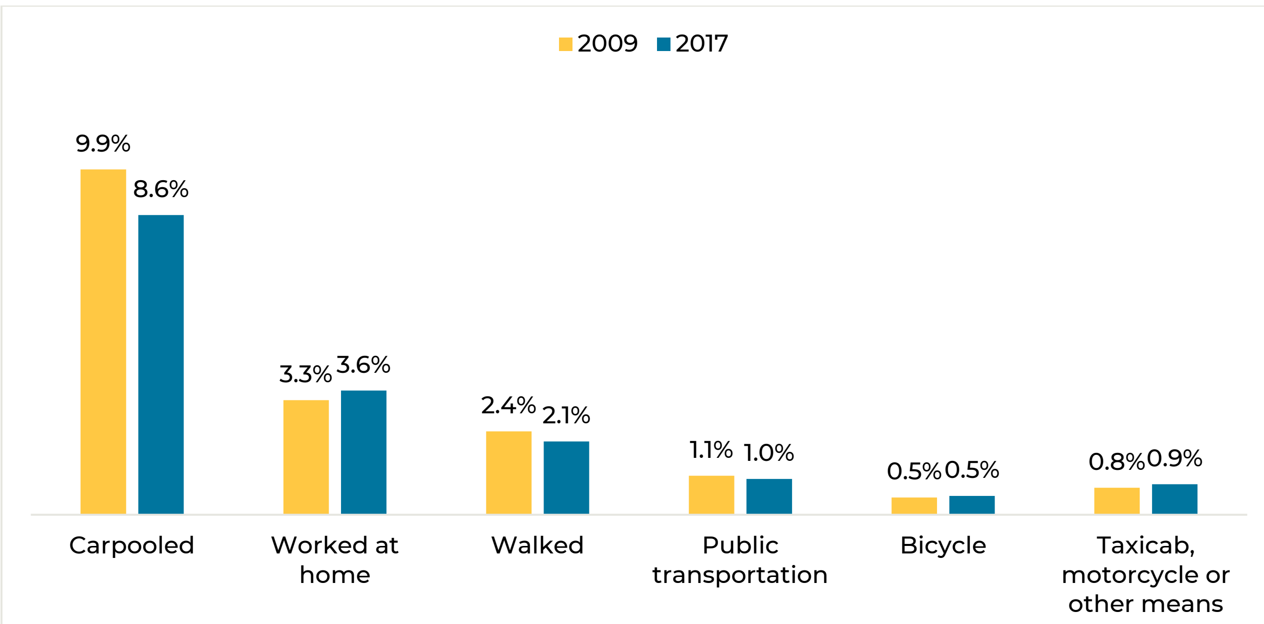
**Figure 2-11: Vehicle Availability by Household, Douglas, Lancaster and Sarpy Counties, 2010 and 2017**




Source: U.S. Census Bureau

In addition to stable household vehicle ownership, the commute mode split in Douglas, Lancaster and Sarpy County has seen steady or slightly decreasing rates of walking and transit use for work commutes between 2009 and 2017 (according to American Community Survey data from the U.S. Census Bureau, **Figure 2-12**). Driving alone is the most popular commute mode (83.3%) and has increased in all three counties (+1.6% in Douglas, +0.8% in Lancaster, and +0.6% in Sarpy). Commuting trips are only a portion of an individual's travel; changes in the way individuals complete other trips (social, shopping, etc.) are also important and provide opportunities for mode shift but data on these travel patterns is limited.

**Figure 2-12: Douglas, Lancaster and Sarpy County Commutes (percent of all workers age 16+), 2009 and 2017**




Source: U.S. Census Bureau

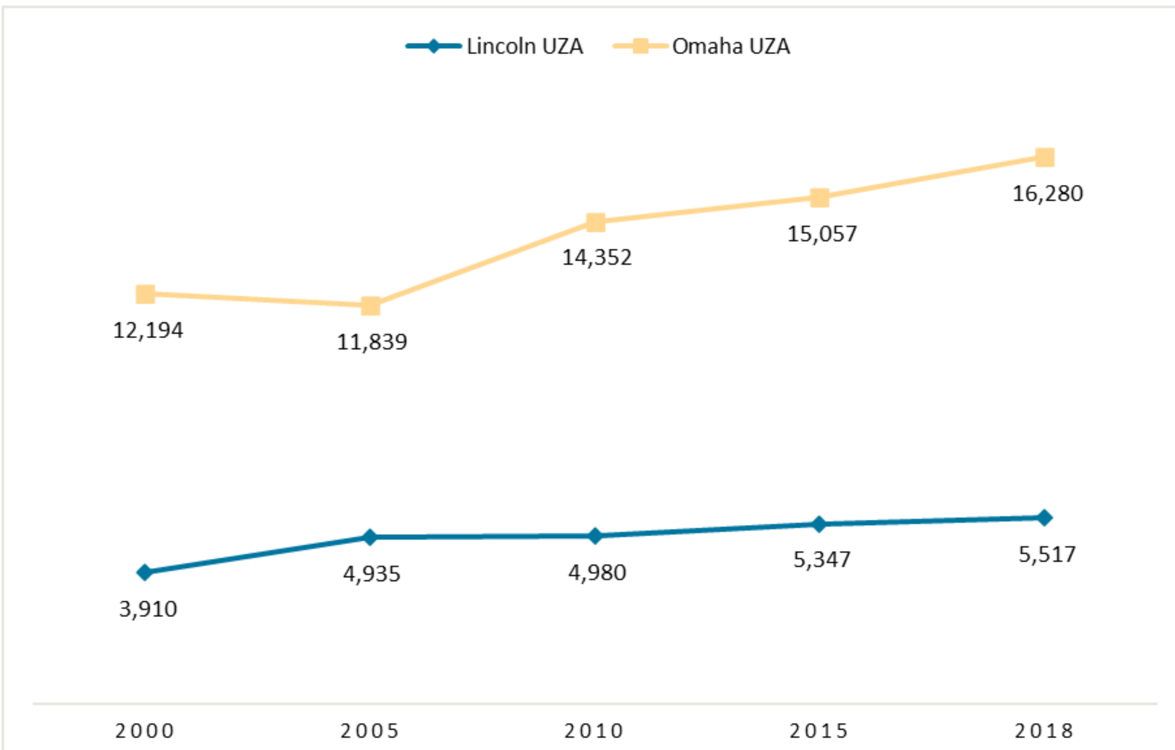
**Vehicle Miles Traveled (VMT):** Like car ownership and mode split, the urbanization impact on VMT is dependent on numerous factors: the number of people, the number of transportation options, public transit funding, gas prices, cultural trends, economic factors, freight movement, weather patterns, and more. In 2018, 9.36 million vehicle miles were traveled on Nebraska's urban highway system,[i] representing 44.6 percent of all statewide VMT. The urban

[i] FHWA uses the federal-aid standard of a census place with an urban population of 5,000 to 49,999 or a designated urbanized area with a population of 50,000 or more

system, however, is only 8,023 miles of the states 95,262 miles. Meaning 44.6 percent of annual VMT occurred on 8.4 percent of the network.[23] The degree of future urbanization will have consequences on where VMT is occurring. More travel concentrated in limited areas can create efficiencies but also congestion.

VMT, as reported by the Federal Highway Administration (FHWA), shows growth for the Urbanized Areas (UA) of Lincoln and Omaha.[ii] For both Lincoln and Omaha, daily VMT steadily increased between 2000 and 2018 (the latest data available) (**Figure 2-13**). In this period, the change reached a 41.1 percent increase in daily VMT for Lincoln and 33.5 percent for Omaha. [24]

**Figure 2-13: Average Daily VMT by UZA, 2000 to 2018**




Source: Federal Highway Administration (FHWA), Highway Statistics 2018

[ii] The FHWA reports VMT by Urbanized Areas (UAs). UAs are defined by the U.S. Census Bureau as an area with 50,000 or more people. Nebraska has three cities that meet the definition of UAs: Omaha in Douglas County, Lincoln in Lancaster County and Grand Island in Hall County. UAs in Nebraska represent areas that are geographically smaller than the county they preside in.

**Safety:** Urbanization and the resulting influx of more people and/or more modes of transportation raises safety concerns. More activity may be happening in places designed for different uses. As cities and technologies change transportation in the future, expectations of the urban right-of-way will change. **Section 3.1.3 Innovation in Transportation Choices: Transportation Consequences** covers more detail on the safety concerns with new modes. However, urban areas often have lower crash fatality rates than rural areas as vehicles are moving more slowly. Replacing rural VMT with urban VMT would likely result in fewer fatalities.

## 2.3 Information Society & Economy

Technology is significantly impacting the way individuals find service providers, receive goods, communicate and interact with one another, receive health care, learn, and work. As technology continues to increase access to societal and economic opportunities that once required in-person interactions, transportation mobility may look less like vehicles traveling on roads and more like video conference calls.

### 2.3.1 Trends

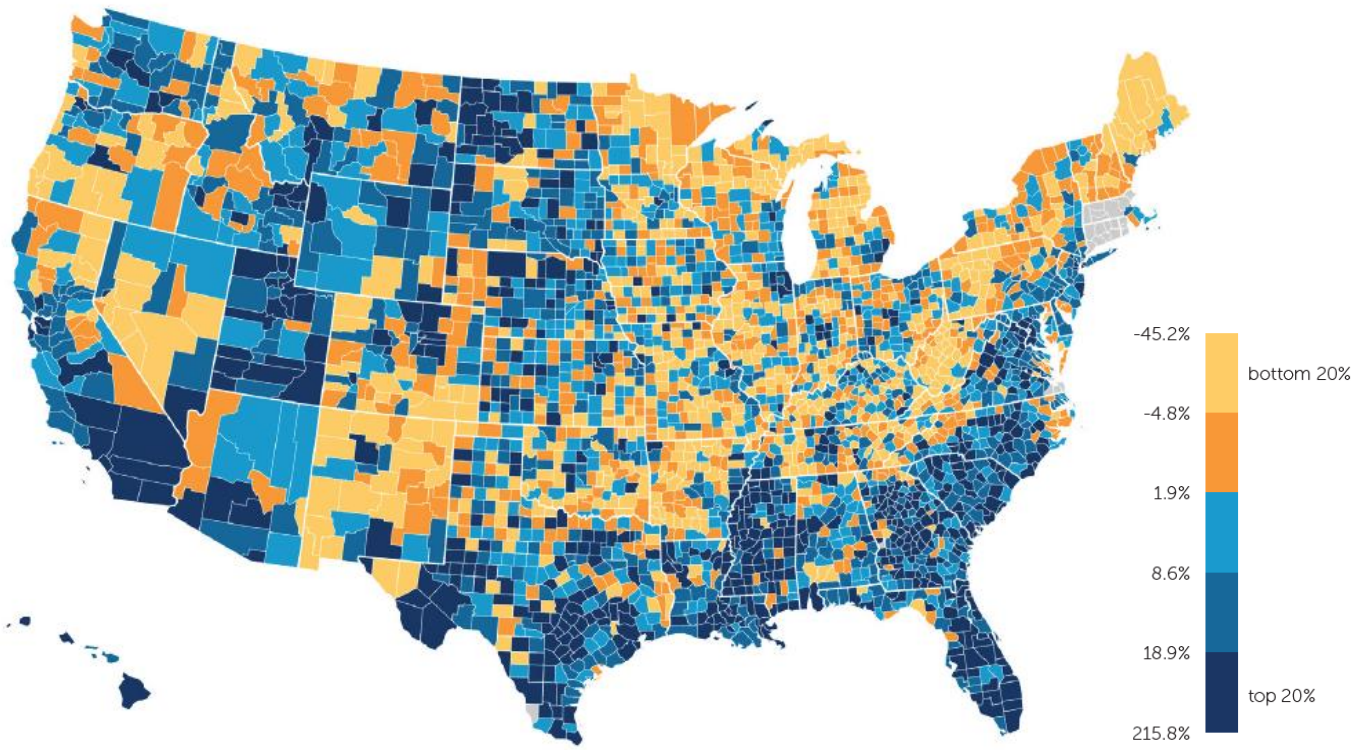
The major trends that have been identified as having the potential to impact the transportation system in Nebraska include the expansion of freelance labor opportunities through the "gig economy" powered by new technologies, the use of broadband networks to create economic development and support work from home opportunities, and the increased availability to telehealth. Each of these elements of the information society and economy has already been adopted to some extent in Nebraska.

**Gig Economy:** The "gig economy" refers to companies like Uber, Lyft, AirBnB, and GrubHub linking individual consumers to "gig workers" to address their needs – either commute, lodging, or food delivery. Gig work existed before the advent of smartphones and apps in the form of temporary agency work, freelancing, or contract work considered alternative arrangements. However, the growth in digital platforms has increased individuals seeking monetary gains as a service provider. One study shows that the share of the U.S. workforce between 2005 and 2015 engaged in alternative arrangements grew from 10.1 to 15.8 percent.[25] Additionally, self-employed workers during the same period grew more than 19 percent in the same period.[26]

The gig economy does not just include individuals classified as having alternative work arrangements. According to a 2016 survey of U.S. adults, approximately 24 percent of American adults earned money through the technology-supported gig economy. Some of these individuals have sold items on platforms while others used the technology for providing a professional service.[27]

As gig workers use digital platforms as a means of employment, growth in the gig economy is felt in both urban and rural areas. **Figure 2-14** shows the nationwide change in non-employer establishments by county.

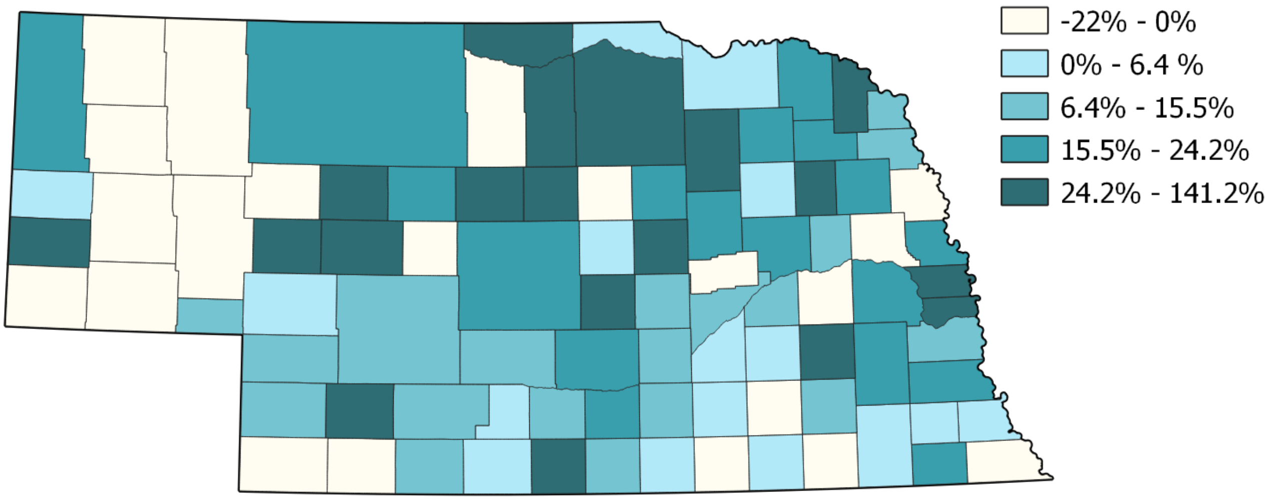
**Figure 2-14: Growth Rate for Non-Employer Establishments, 2005-2015**




Source: National Association of Counties, *Rise of the Gig Economy* (from U.S. Census Bureau Non-Employer Statistics, 2005-2015)

In Nebraska, several counties saw increases in their non-employer workforce between 2005 and 2015.[iii] The greatest changes in non-employer establishments in Nebraska during this timeframe were in Loup, Hayes, and McPherson counties (129.4%, 86.0%, 66.7%).[28] Conversely, 23 counties saw reductions in non-employer establishments. **Figure 2-15** shows Nebraska's non-employer workforce change by county.

**Figure 2-15: Nebraska Growth Rate for Non-Employer Establishments, 2005-2017**




Source: Map created with U.S. Census Bureau Non-Employer Statistics Data, 2005-2017

**Broadband and Remote Work:** Broadband access is seen as one of the most important indicators of connectedness for rural areas around the country. Broadband access is a critical piece of infrastructure for the information society and transition of the economy as virtual access to markets, services, and information are expected to make life in rural areas easier and encourage vibrant communities throughout Nebraska. Access to broadband is such a key influence for transportation and economic development in Nebraska that its expansion is included as one of 15 initiatives in *Blueprint Nebraska*, a statewide economic development plan.[29]

According to a recent study looking into broadband access across the country, 87.3 percent of all Nebraskans have access to fixed terrestrial broadband with

[iii] Non-employer businesses have no paid employees and are subject to federal income tax. Most of them are self-employed individuals operating a very small, unincorporated business with no paid employees. Many gig workers fit the Census definition of a non-employer.

a minimum speed of 25 Mbps/3 Mbps.[30] Fixed terrestrial broadband examined for the study included cable modems, fiber, and DSL connections. Satellite broadband was not included. Additionally, when examining rural and urban access to broadband the study found 58.0 percent of Nebraskans in rural areas could access fixed terrestrial broadband while 97.9 percent in urban areas had access.[31]

**Blueprint Nebraska Initiative**

**Increase rural broadband access and make Nebraska's large and small cities national models for rapid 5G network scale-up.**

High-quality broadband access creates opportunities for individuals to work remotely from the comfort of home. Remote work – traditionally called telework – has seen expanded popularity around the country in recent years due to the improvements in technology and the ability to work in coworking spaces. According to the 2013-2017 American Community Survey (ACS), approximately 4.3 percent of the workforce in Nebraska worked from home.[32]

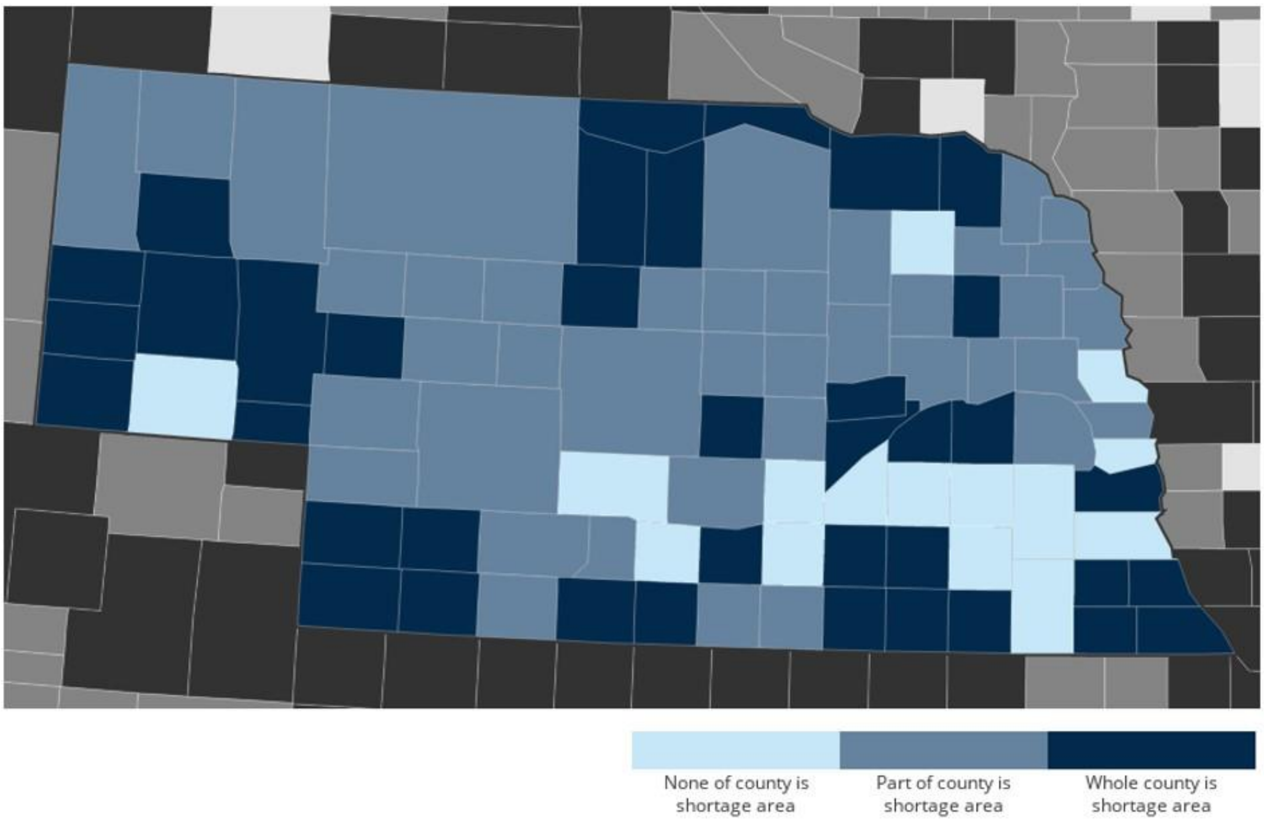
### *Coworking in Nebraska*

One of the major trends responding to the gig economy, the increasing number of freelancers, and the expansion of broadband in rural areas is the expanding market for coworking spaces. Coworking spaces are flexible workspaces that offer office amenities (internet, printing, coffee, conference rooms) for a monthly membership fee. In 2018 and 2019 it is estimated that more than 1,500 coworking spaces opened in the U.S.[33] The true benefits of coworking spaces are that they can be created nearly anywhere and can utilize available office space in rural downtowns. Rural coworking spaces are already being created in cities outside the Omaha or Lincoln metro areas. For example, the coworking space PERCH opened in 2016 in Petersburg and offers workstations and conference rooms in the town of 325 residents.[34]

**Health Care:** Technology is also changing how individuals receive healthcare. According to the American Hospital Association, 76 percent of hospitals in the U.S. use some degree of telehealth.[35] Telehealth – with some services considered telemedicine – covers a range of health care services that can include non-clinical training and education opportunities. There are various definitions of telehealth and various subsets (such as telemental health), but this memo we will consider telehealth to be the use of technology to provide health care services generally.[36]

Telehealth is seen as a potential solution to the challenges facing rural healthcare including shortages of physicians, closing of medical facilities, and the aging population. Nebraska is especially poised for these impacts as **Figure 2-16** shows.

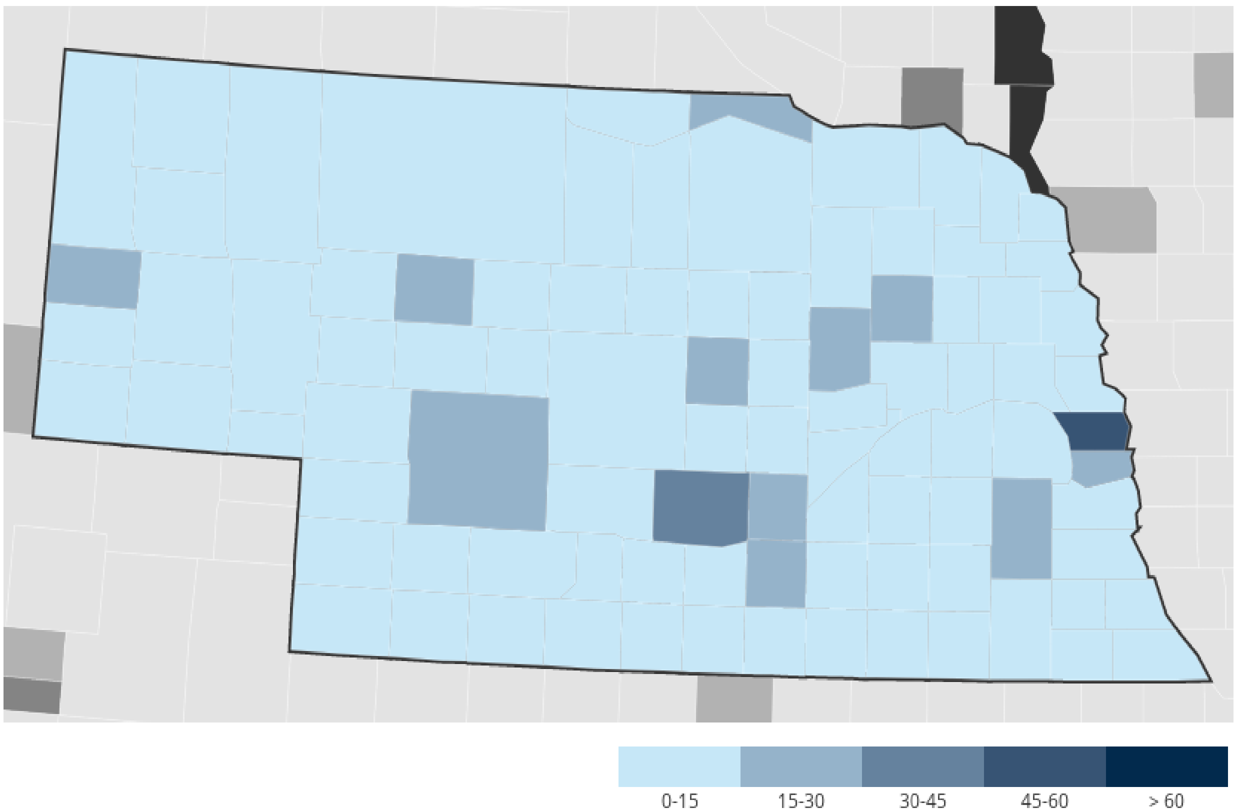
**Figure 2-16: Health Professional Shortage Areas: Primary Care by County, Nebraska 2019**




Source: Rural Health Information Hub, October 2019, data.HRSA.gov

In 2019, many of Nebraska's rural counties faced a shortage of health professionals in at least part of the county. When examining the number of physicians per 10,000 residents, **Figure 2-17** shows that most counties have 15 or fewer physicians per 10,000 residents.

**Figure 2-17: Total Physicians per 10,000 People, 2017**

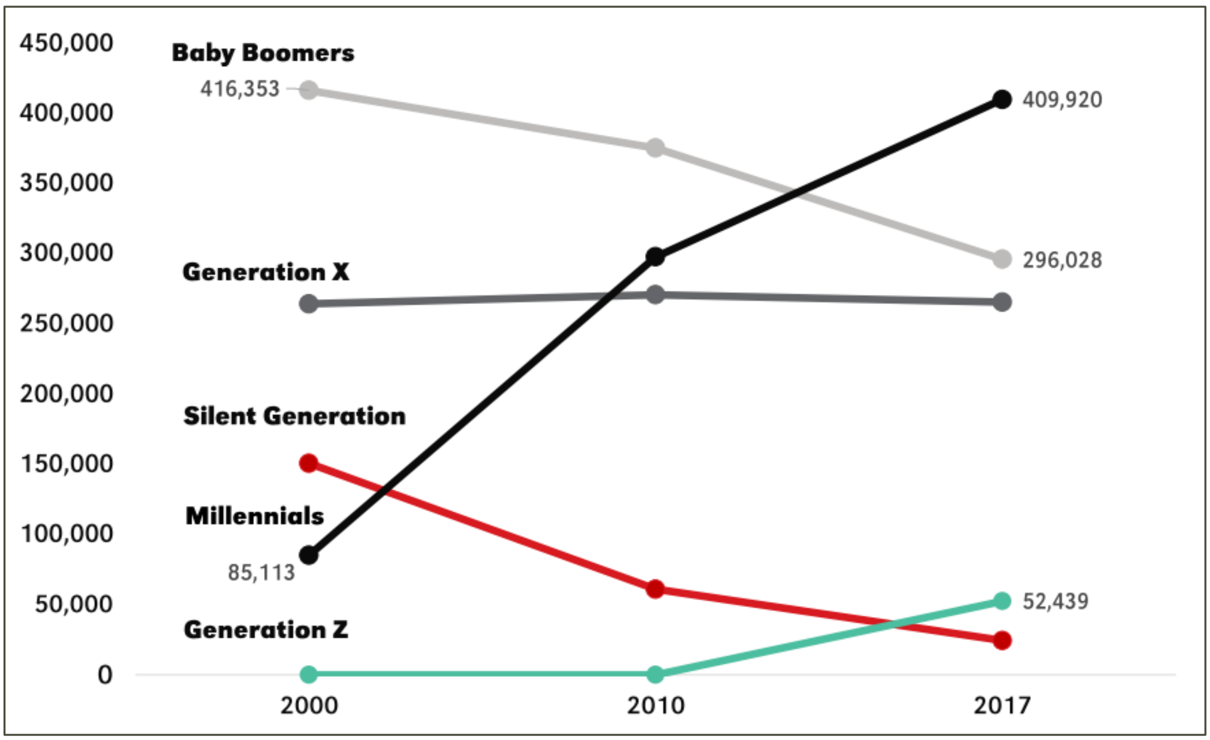



Source: Rural Health Information Hub, HRSA Area Health Resources Files, 2017 & 2018.

### 2.3.2 The Future

The expansion of the Millennial generation (born between 1981 and 1996) and Generation Z (born between 1997 and 2012) cohorts in the workforce is going to drive the information society and economic transition. According to a 2019 report on freelancing in the United States, 53 percent of Generation Z and 40 percent of Millennial workers freelance.[37] In 2017, Millennials became the largest proportion of the Nebraska workforce, while Generation Z's proportion also began to rise (**Figure 2-18**).[38] It is important to consider the future of the Nebraska workforce as we examine future projections for the gig economy, broadband and remote work, and the future of health care throughout the state.

**Figure 2-18: Population by Generation in Nebraska 2000-2017[iv]**




Source: UNO Center for Public Affairs Research - Nebraska's Workforce using Public Use Microdata Samples from 2000 Census, 2010 ACS, and 2017 ACS, U.S. Census Bureau.

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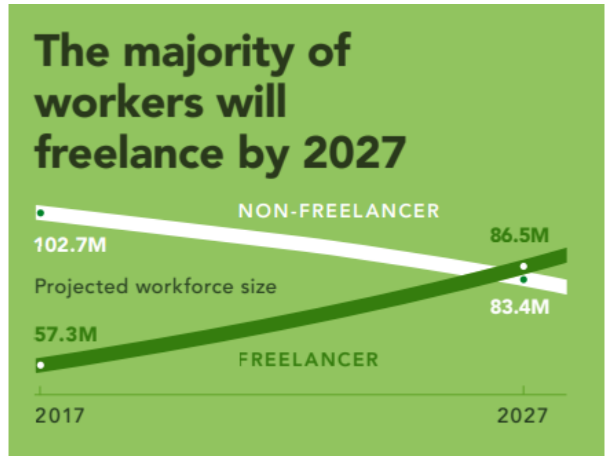
[iv] Generations as defined by the Pew Research Center: Silent generation born between 1928-45, Baby Boomers born between 1946-64, Generation X born between 1965-80, Millennials born between 1981-96, Generation Z born between 1997-2012. (https://www.pewresearch.org/fact-tank/2019/01/17/where-millennials-end-and-generation-z-begins/).

**Gig Economy:** By 2021 the gig economy in the United States is expected to increase to more than nine million workers in gig jobs.[39] Additionally, a 2017 survey estimated 50.9 percent of the U.S. population could be engaged in freelance work by 2027 (assuming continued growth equal to that of 2014 to 2017, year over year) (**Figure 2-19**).[40] While the estimated growth in the number of freelancers may be optimistic, technology has made it easier than ever to connect goods and service providers with consumers.

**Figure 2-19: Forecast of Freelance Labor**




Source: Upwork

**Broadband:** The future of broadband is heavily dependent on the expansion of fiber and other sources for transmitting information. However, individuals will likely continue to grow more connected through the expansion and improvement of internet access across the country. Based on a recent study, the average number of devices and connections per person in North America is expected to increase to 13.4 by 2022 (up from 8.0 in 2017).[41] Additionally, the expansion of broadband in rural areas may be driven by the potential for agricultural improvements. A U.S. Department of Agriculture (USDA) report estimates rural broadband could leverage an additional $47 to $65 billion annually toward the U.S. economy through efficiencies in precision agriculture. [42]

**Remote Work:** Remote work is anticipated to support the growth in the gig economy of freelancers. The full extent of remote working is unknown, but as companies realize potential cost savings and improved employee flexibility more individuals will likely continue to work remotely. The greatest impact for remote working will take place in the coworking sphere. It is estimated that by 2025 there will be nearly 26,000 coworking spaces worldwide, an increase of nearly 8,000 spaces from 2019 estimates.[43]

**Health Care:** Access to telehealth in rural areas is seen as an option to reduce the transportation challenges patients experience attempting to get healthcare services. For telehealth to expand throughout the state the necessary connectivity - likely through broadband expansion - would need to be in place and regulations may need to be updated to align with telehealth opportunities. As telehealth options are expanded, patients are likely to use the services. Based on a recent survey, telehealth visits in the U.S. are projected to increase to between 46 and 81 million in 2022.[44]

### 2.3.3 Transportation Consequences

While it is unclear as to the extent to which Nebraska will see broadband expand to rural areas, workers telecommuting regularly, freelancers growing the gig economy, or patients using technology to get healthcare services, we know that access to technology will continue to shape the information society and economic transition. As Nebraskans realize the full potential of this societal influence, the following transportation consequences have been identified as key indicators.

**Mode Choice:** With the expansion of broadband and remote working opportunities the typical commute modes could shift toward work from home and therefore reduce categories like drive alone, public transportation, walking, or biking. Coworking facilities – while supportive of remote workers – would likely minimize but not eliminate the traditional commute modes as there is still a commute to the coworking space. However, with sufficient coworking options, individuals will likely choose spaces closer and more convenient to home, potentially switching modes in the process.

**Reduced Trips:** Trip reductions will likely occur as technology improves access to needed services and improves the ability of an individual to work from home. As previously mentioned, telehealth can alleviate many of the transportation challenges related to seeking medical advice. These challenges include scheduling rides for those that cannot drive, paying for transportation to medical facilities, or traveling long distances to meet a specialist. The ability to use technology to receive physical and behavioral health services will reduce the need to meet with physicians or therapists in person – removing the trip to and from an office, hospital or clinic.

E-commerce and door-to-door deliver options such as grocery delivery will also reduce some retail trips but could increase trips for last-mile delivery. The impact of rising e-commerce sales has been studied extensively to identify the impact on travel demand through online retail. Online retail has typically been identified to potentially impact travel demand in one of three ways:[45]

- as a substitution to shopping trips,
- as a complementary function to shopping trips, or
- as a modification of shopping trips.

Additionally, as remote working becomes more prevalent, those individuals that choose to work from home are also reducing the number of commute trips they make during their day. With the removal of trips from the transportation system, traffic-related issues like peak-time congestion could see improvement.

**Shorter Commutes:** Coworking's impact on transportation is not yet fully known as it functions similarly to a standard office; however, industry experts believe larger companies will begin to see the value of coworking spaces to decrease the overhead of maintaining traditional offices. As office trends change, land use alterations may lead to individuals choosing coworking locations closer to their homes which in turn will lead to short commute trips and a reduction in VMT may result.

## 2.4 Structural Economic Shifts

The previous influence focuses on existing societal and economic opportunities brought about by the technological improvements to existing systems. As the expansion of broadband access will make it easier to access healthcare or allow individuals to complete their current work and shopping from home, technological advancements are pushing every sector of the economy toward a vast and structural economic shift. This section will examine the potential impacts of this structural economic shift on the sectors of manufacturing, agriculture, and retail.

### 2.4.1 Trends

Many of the trends identified for this influence are driven by private sector decisions that have the potential to impact transportation systems. While the Nebraska DOT may not be able to influence the decision making of business, the Nebraska transportation system will be impacted as these economic shifts occur.

**Fourth Industrial Revolution:** Historically speaking, there have been three industrial revolutions that have altered the process of producing goods. The first revolution deployed steam power and improved mechanized production, the second came with the introduction of electricity, and the third utilizes technology to optimize and automate systems.[46] We are still experiencing the societal and economic changes related to the third revolution as mentioned in the information society and economic influence above. However, the fourth industrial revolution builds upon the existing third revolution and expands the use of technology in systems of production.[47] Eight emerging technologies have been identified as the key drivers of the fourth industrial revolution:[48]

- Artificial Intelligence (AI)
- Internet of Things
- Augmented Reality
- Robotics
- Blockchain
- Virtual Reality
- Drones
- 3-D Printing

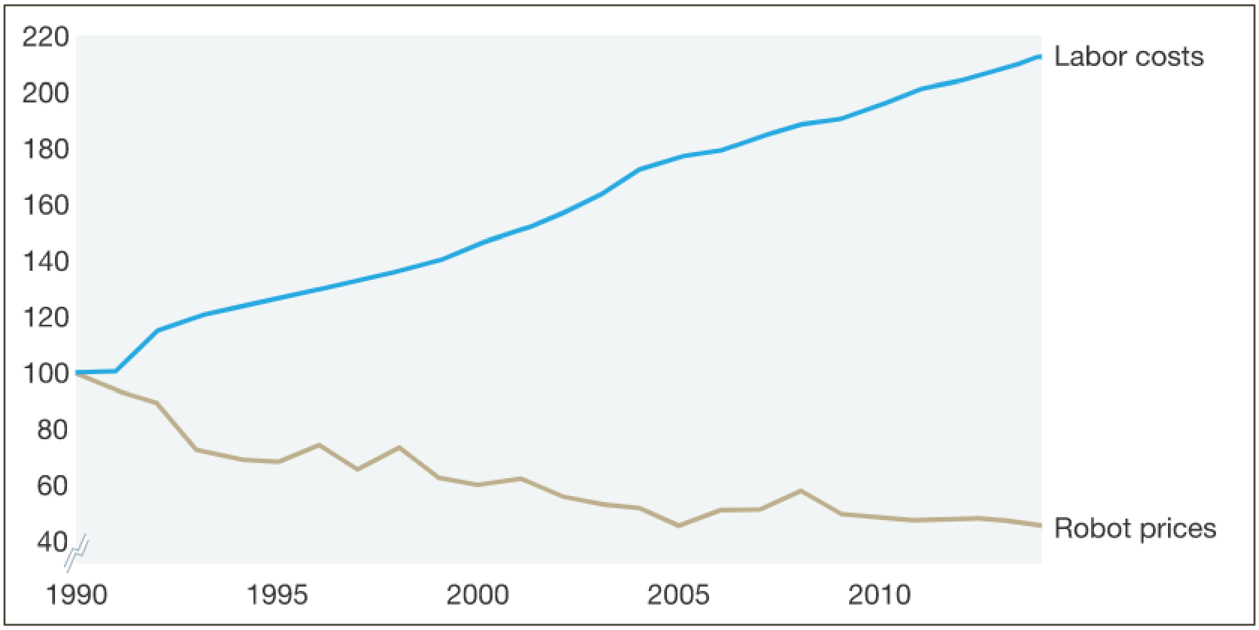
These technologies have the potential to dramatically change how goods are manufactured, agricultural products are produced, and how goods are purchased and delivered to customers.

**Manufacturing:** Manufacturing – especially auto manufacturing – has been a strong sector for the deployment of robotics to produce goods. In fact, between 2011 and 2017 robot acquisitions were predominately concentrated in automotive and automotive component production.[49] Robotics have typically taken the roles of high-volume production, repetitive movement, or heavy object placement.[50] In these roles, robots offer savings based on the increased speed of production and safety improvements compared to human labor.[51]

One of the key drivers leading to the increased use of robots in manufacturing – and other industries – is the continued decrease in the cost of robots compared to manual labor. A recent report highlighted the robot to human labor cost in manufacturing in the United States from 1990.[52] **Figure 2-20** shows how the cost of robots has decreased over time, while the cost of human labor has increased in the US.

**Figure 2-20: Cost of Automation Compared to Labor Costs**

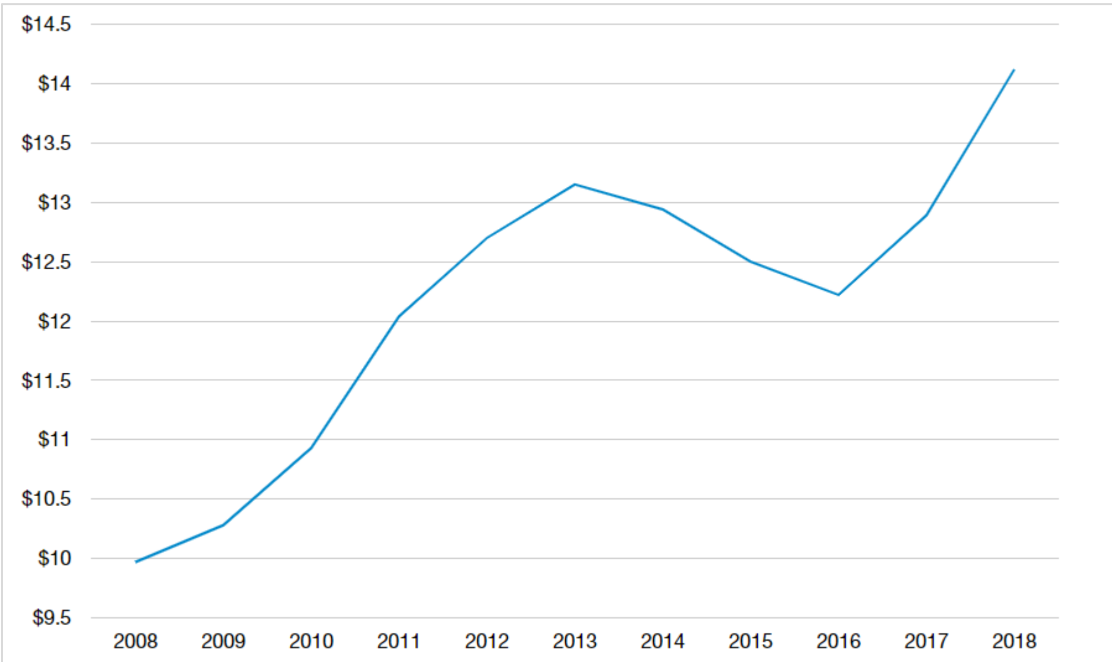
Index of average robot prices and labor compensation in manufacturing in the United States, 1990 = 100%




Source: Economist Intelligence Unit; IBM; Institut für Arbeitsmart- und Berufsforschung; International Robot Federation; U.S. Social Security data; McKinsey analysis[53]

In Nebraska, manufacturing is a major sector with approximately 11.5 percent of the state's total output and 9.7 percent of its workforce in 2018.[54] Since 2008, Nebraska has seen increasing manufacturing outputs – with a minor decline between 2013 and 2016,as shown in **Figure 2-21**.

**Figure 2-21: Manufacturing Output in Nebraska 2008-2018**



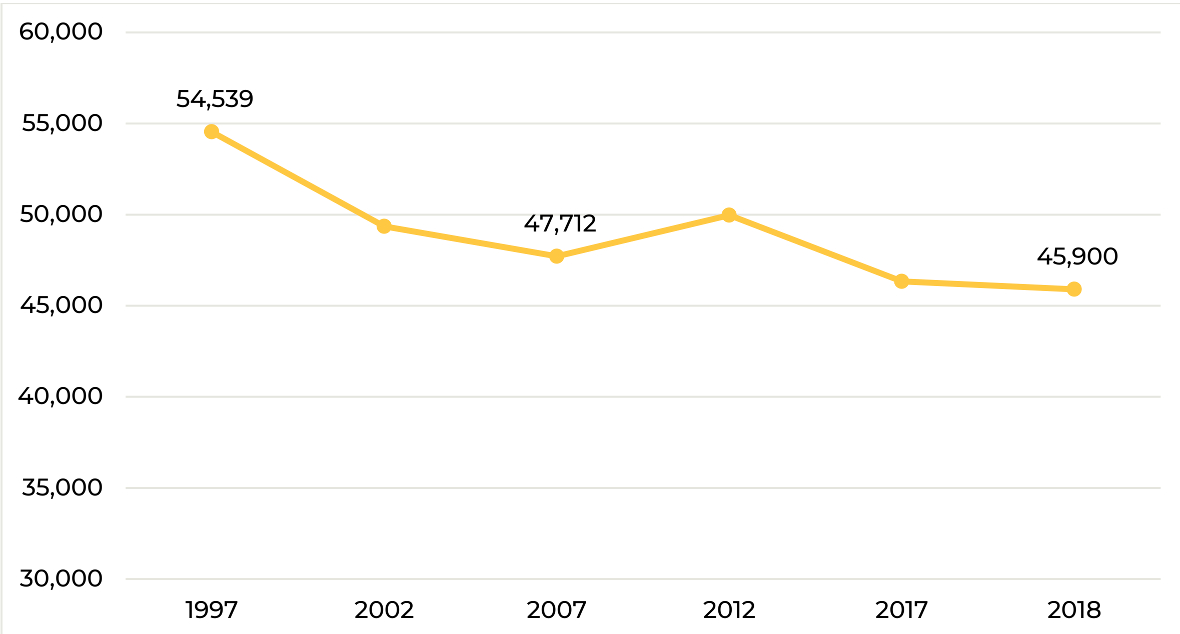

Source: National Association of Manufacturers, "2019 Nebraska Manufacturing Facts."

Robotics and automation are already being utilized in factories in Nebraska. The Kawasaki plant in Lincoln utilizes automated painters for several of the elements produced at the factory.[55] This type of automation is likely to continue to be widely used as prices for the robotic equipment continue to decline.

**Agriculture:** Precision agriculture utilizes several of the emerging technologies to improve the production of agricultural projects. For example, connected and automated equipment utilizing robotics and AI could make planting and harvesting more efficient. Additionally, drones could be used for monitoring crops for stressors like pests and moisture or monitor livestock in pastures. Blockchain – a secure record attached to data used for tracking the progression of the data or an item – is another technology that has been identified as an agriculture disruptor. Through blockchain-enabled records, the USDA estimates that it would take two seconds to trace the product's journey if issues occur in the supply chain or if health concerns are raised.[56] Many of these technologies are currently available and are being used on a small scale.

However, even with the new technology deployments to improve agricultural production, the number of farms in Nebraska has declined in the last several years. **Figure 2-22** shows the number of farms between 1997 and 2017. In 2018, Nebraska had 45,900 farm operations, down from just under 55,000 in 1997.[57]

**Figure 2-22: Farms in Nebraska 1997-2018**

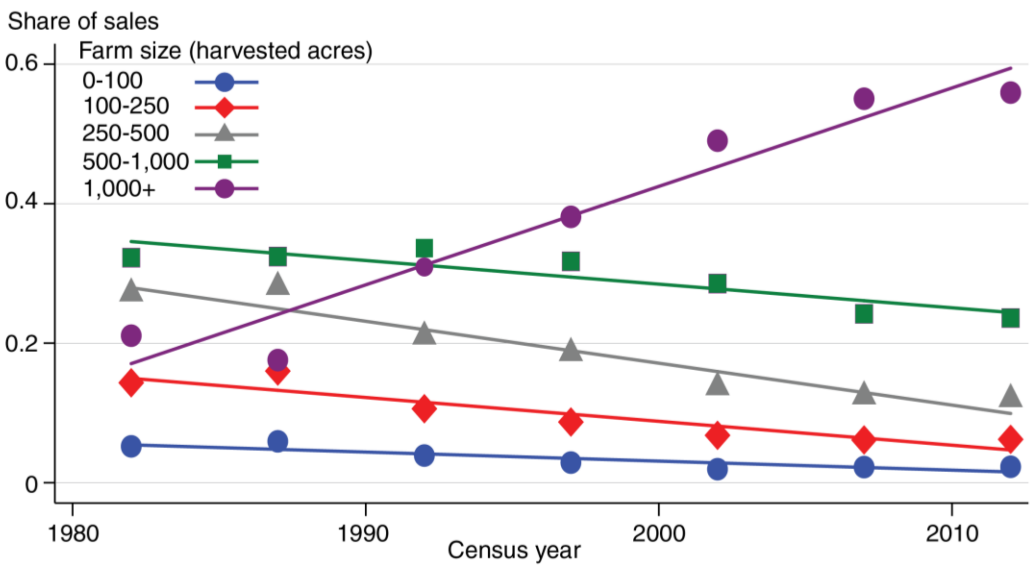



Source: USDA, Census of Agriculture data (1997-2018)

Additionally, farm consolidation is evidenced by the average size of farms in Nebraska. When looking at the 20-year timeframe between 1997 and 2017, the average farm size increased by 130 acres. The increase is largely driven by the productivity advantages (economies of scale).[58] Introducing new technologies will continue to be more financially feasible for larger operations and may widen the gap between large and small farm productivity.

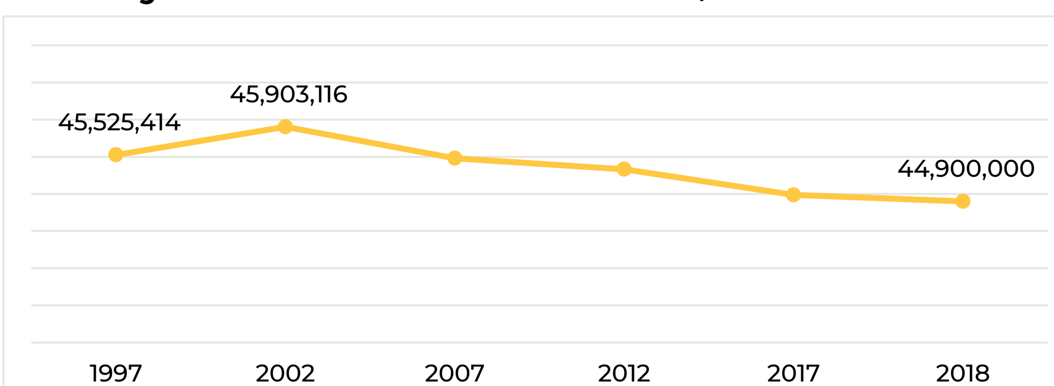
Moreover, shares of sales have primarily favored larger farm operations. **Figure 2-23** demonstrates how farms with more than 1,000 acres have increased their share of sales while smaller farms have declined. Between 1997 and 2018, Nebraska's total farmland acreage has slightly decreased by 1.4 percent (**Figure 2-24**).[59] While farms are consolidating, and larger farms are gaining market share, the total statewide acreage has experiences minor reductions.

**Figure 2-23: Production on Heartland Farms[v] 1982-2012**




Source: USDA, Economic Research Service calculations using data from USDA, National Agricultural Statistics Service, 1982-2012 Census of Agriculture[60]

**Figure 2-24: Total Nebraska Farm Acres, 1997-2018**

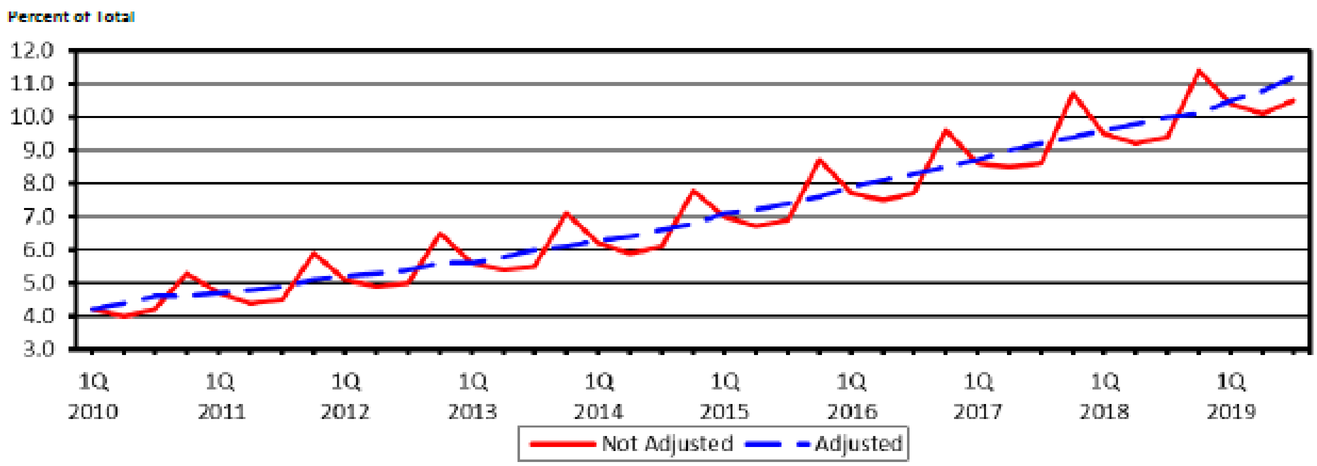



Source: USDA, Census of Agriculture data (1997-2018)

[v]The Heartland region is defined as all of Iowa, Illinois, Indiana and parts of Minnesota, South Dakota, Nebraska,, Missouri, Kentucky and Ohio

**Retail:** The retail sector is another sector where the fourth industrial revolution will greatly influence how individuals receive goods and retailers are already collecting a significant amount of data to support the shift.[61] Over the last decade, retail e-commerce sales have sustained continued growth. According to the U.S. Department of Commerce, in the third quarter of 2019 adjusted e-commerce sales were $154.5 billion.[62] **Figure 2-25** shows the growth in retail e-commerce sales as a percent of all retail sales. Based on this analysis, e-commerce sales were 11.2 percent of total retail sales.[63]

**Figure 2-25: Estimated Retail E-Commerce Sales 2010-2019**




Source: U.S. Census Bureau News, "Quarterly Retail E-Commerce Sales, 3rd Quarter 2019," November 2019.

Nebraska is home to an established e-commerce employment cluster. According to the analysis completed for the Nebraska Department of Economic Development, e-commerce and call centers were considered small clusters in the Nebraska economy even after seeing declines in employment between 2010 and 2015.[64] E-commerce remains to be a strong sector for the Nebraska economy with new firms being created and established retailers expanding in the state.[65]

### 2.4.2 The Future

**Manufacturing:** Manufacturing in the future will continue to be driven by automation to make work easier and more efficient for laborers and producers. Robotics are expected to continue to replace workers. One estimate states more than three million robots will be in use for manufacturing worldwide by 2020.[66] By 2030, robots could replace more than 20 million jobs around the world.[67]

Emerging technologies will also play a key role in the future of manufacturing. 3D printing, for example, is still in the early stages of adoption for production and offers an opportunity for customization of products.[68] Mass customization coupled with the existing e-commerce trend could allow consumers to identify the exact product they would like to own, modify it to their specific needs, send it to a 3D printing production center, and receive the product within a few days.

**Agriculture:** As mentioned, USDA estimates the expansion of broadband in rural areas of the U.S. could support precision agriculture for an additional $47 to $65 billion annual benefit.[69] Precision agriculture utilizes several of the emerging technologies identified as drivers of the fourth industrial revolution, but drones may be the most impactful. Agricultural drones provide an overhead view of crops that can reveal issues around irrigations, livestock health pests and growth. Paired with technological tools that deliver seeds, spray crops, conduct thermal imaging and mapping, drones can provide a wealth of knowledge and support regarding specific or large areas of land. The agricultural drone market in 2016 in the U.S. was estimated at $434 million. By 2025 the U.S. market for agricultural drones is estimated to increase by more than 38 percent.[70]

However, legislative work will need to be done to support drones in Nebraska. a March 2020 report by the Mercatus Center at George Mason University ranked Nebraska 44 of 50 states for drone-friendliness. The report cites concerns such as landowner air rights which are not expressly provided in Nebraska law today and raises litigation risk for drone operators.[71]

The other fourth industrial revolution drivers that will change the nature of agriculture are automation and blockchain. Agricultural implement producers and start-ups are designing automated field equipment.[72] Blockchain will play a key role in food safety as the agricultural sector looks to produce food for nine billion people worldwide by 2050.[73,]

**Retail:** Retail will see the continued growth of e-commerce. Purchasing goods will continue to be easier as AI recommends and orders goods for its users and online connections put shopping at our fingertips. Through new technology like smart fridges, grocery orders can be placed and – in some cases – delivered from the touch of a screen.[74] According to one study, online retail growth will continue to increase its share of overall retail sales and by 2023 reach nearly $970 billion.[75]

### 2.4.3 Transportation Consequences

The structural economic shifts on the horizon will shift the demand for transportation, impact land-use for economic sectors, increase last-mile delivery, and automated vehicles. The eight technologies driving the fourth industrial revolution are also key drivers for monitoring transportation infrastructure.

**Transportation Demand:** Beyond personal travel changes due to e-commerce, the fourth industrial revolution could create other transportation demand changes. 3D printing could reduce the need for transporting materials between factories as factories print materials as needed. The demand and supply of raw materials needed to 3D print, however, will still be ongoing. Additionally, AI could order your groceries and have them delivered without a trip to the store.

**Land Use:** One of the likely consequences of the fourth industrial revolution's impact on the various sectors mentioned above will be the changes in retail land uses due to e-commerce. The retail sector has already seen major store closings as the traditional approach to shopping has shifted to a greater share of e-commerce. In 2019, 9,300 brick and mortar stores closed, up from 8,000 in 2017.[76] The existing transportation system and future traffic projections were designed with these physical stores in mind. With the closure of retail stores, the transportation system around the closed store may no longer support the previous function and may need to be altered for new land uses.

Additionally, with the expansion of e-commerce more warehousing has been created to support the on-demand distribution of consumer goods.[77] The expansion of warehousing as a consequence of the fourth industrial revolution will likely be positive for Nebraska. Nearly anywhere in the country can be accessed within two days by truck, creating an economic development opportunity in the state.[78]

**Last-Mile Delivery:** Due to the significant rise in e-commerce sales, the number of delivery vehicles has grown to accommodate these purchases. By 2030 the World Economic Forum estimates that the number of delivery vehicles will increase by 36 percent in the top 100 cities globally.[79] Similar impacts will be experienced in all cities and towns. Cities in Nebraska will experience greater numbers of delivery vehicles as e-commerce continues to grow. Rural areas are also likely to see increasing numbers of deliveries. New technologies may be utilized to meet the demand, such as drones, cargo bikes, or automated delivery vehicles.[80]

**Vehicle Automation:** The fourth industrial revolution will be driven by automation, but automated vehicles have the potential to greatly impact the transportation system. More on automated vehicles can be found in the **3.3 Connected and Automated Vehicle**.

Vehicle automation will also greatly change how the agriculture sector functions. When combined with automated freight vehicles, there is the potential that many of the vehicles interacting with food production could be driverless. As precision agriculture continues to advance, automated vehicles will likely be seen in rural areas of Nebraska. Automated equipment and vehicles are often heavier or oversized and cause more wear on roads

**Technology Tools and Transportation Infrastructure:** Several of the technologies driving the fourth industrial revolution are being utilized to improve the operations and decision-making of transportation agencies around the country. For example, drones are being used to inspect bridges and other structures. AI is also being used to inventory roadside assets to catalog, monitor, and forecast agency needs.

# 3 Technology Influences

# 3 Technology Influences

Technology influences identified through the stakeholder engagement process for the 2040 Statewide Transportation Plan fit within four themes: innovations in transportation choice, electric vehicles, connected and automated vehicles, and smart infrastructure. Technology in the transportation sector is rapidly changing the way individuals move and many of the technologies in this section have the potential to dramatically change the operations of the transportation system.

## 3.1 Innovation in Transportation Choices

Since 2000, the transportation options available in the US, particularly in urban areas, have greatly changed. Car-sharing launched in 2000, bike-sharing launched in 2008, transportation network companies (TNCs) Lyft and Uber launched their modern-day service in 2012 and 2013. Electric scooters were introduced on the west coast in 2017 and were in 90 cities by 2019. Transportation options continue to grow as dockless bikes and electric bikes enter new cities and transportation-networking companies begin testing automated vehicle use in cities across the nation.

New options for travel are likely to emerge (particularly in urban areas) across the U.S., including:

- Shared use fleets (new car ownership models)
- TNCs
- Non-motorized options (particularly for shorter trips/ 'last mile' connections)
- Automated shuttles

### 3.1.1 Trends

In the last decade, transportation options in Nebraska have been constantly changing. TNCs are one the most wide-spread, recently developed transportation alternatives. In July 2015, Uber received approval to operate from the Nebraska Public Service Commission and Lyft followed in September 2015. Providers are reluctant to share exact coverage information, but Lyft's website lists five areas of service: Bellevue, Omaha Metro, Lincoln, North Platte, and Grand Island. Uber only lists Omaha and Lincoln as service areas. There is unofficially recorded coverage in some other urban and rural areas of Nebraska.

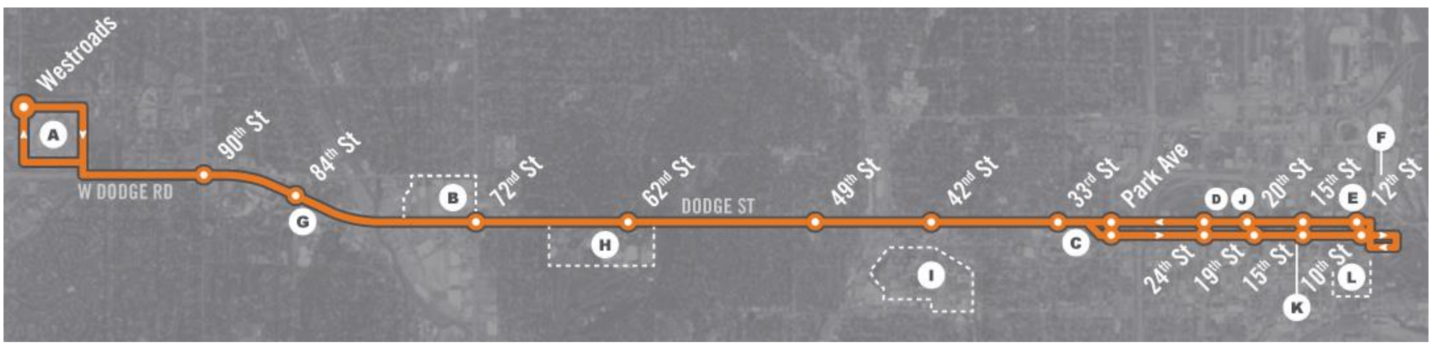
Additionally, zTrip began an expansion into Nebraska in early 2018. The company is a combination of a traditional cab company and a TNC with mobile ride-hailing abilities but with the regulations of a cab company.

Car-sharing, which allows multiple users (often paying members of a service) to rent and use a vehicle for short periods of time has been available in

Nebraska for years. Zipcar has offered car-sharing on the University of Nebraska-Lincoln campus since 2012[81] and is currently available on three other university campuses as well as the City of Omaha.[82]

**Public Transit:** While not a new form of transportation, public transit is also continuously evolving in Nebraska. In 2014, Omaha's transit agency, Metro began the development of bus rapid transit (BRT). The route (named Omaha Rapid Bus Transit or ORBT) will run from Westroads Mall to the Old Market District and connect key locations in the city such as UNO, hospitals, museums, and the downtown business district (**Figure 3-1**). Benefits highlighted through the addition of the ORBT line include increased mobility and access, reduced transportation costs, improved linkages to work, boosted health and wellness, and eased congestion. There are also economic benefits associated with the route such as improved connections and access to economic centers enhanced talent attraction and retention and accelerated economic development.

**Figure 3-1: Omaha Rapid Bus Transit (ORBT) Route**




Map Locations

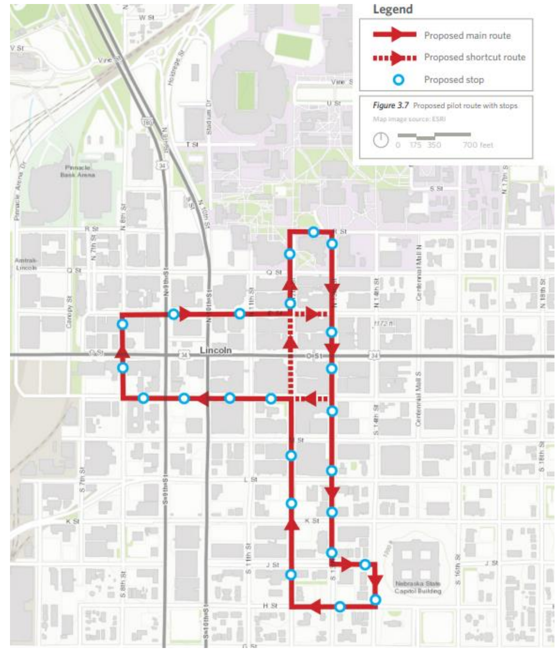
A: Westroads Mall & Transit Center
B: Crossroads Redevelopment Site
C: Midtown Crossing
D: Joslyn Art Museum
E: The Capital District
F: CHI Health Center
G: Methodist & Children's Hospitals
H: University of Nebraska – Omaha
I: Nebraska Medicine
J: Omaha Central High School
K: Downtown Omaha
L: Old Market District

Source: ORBT[83]

One transit trend emerging in urban areas is pilot applications of automated transit shuttles. A recent example is the automated shuttle study completed in Lincoln during 2018. These shuttles, which operate using on-board technology (Light Detection and Ranging (LiDAR), cameras, radar), are a solution to address first/last mile connection issues through on-demand transit service.

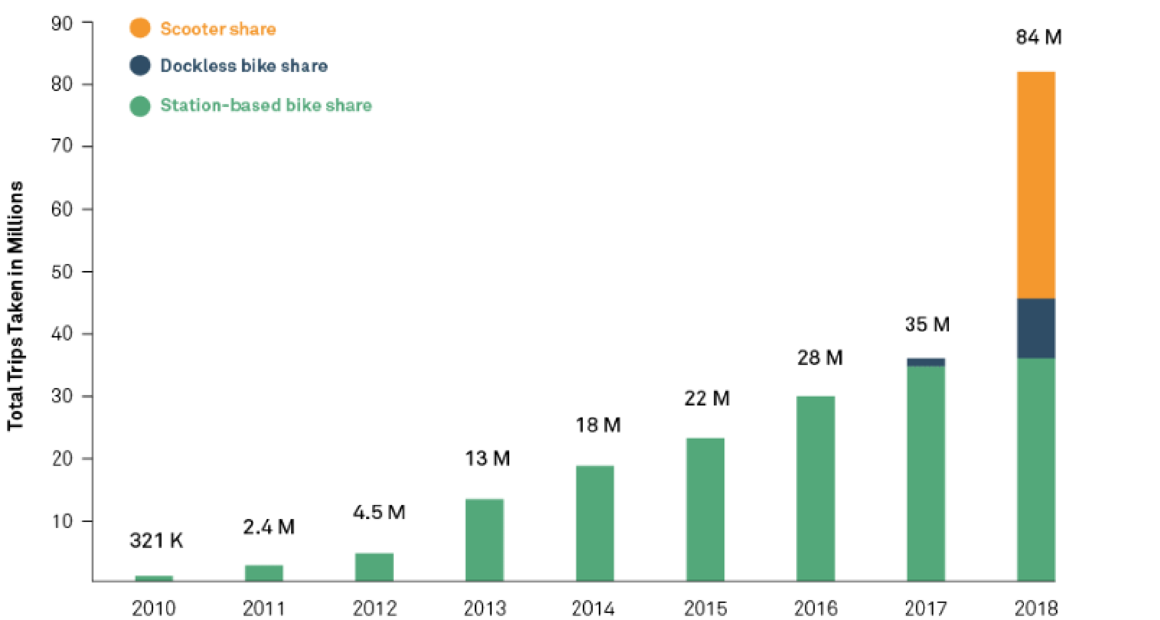
The Lincoln shuttle route is identified to connect the University of Nebraska campus, the State Capitol Building, and the Haymarket District (**Figure 3-2**). The use of automated transit shuttles is expected to reduce labor costs compared to operating a traditional transit vehicle and provided added flexibility through the use of on-demand service via app-based ridership requests. [84]

**Figure 3-2: Potential Automated Shuttle Pilot Route, Lincoln, NE**




**Micromobility:** Shared micromobility is an emerging, and sometimes controversial, transportation option around the country. Developed originally as station-based bicycle shares, shared micromobility now Includes "all shared-use fleets of small, fully or partially human-powered vehicles such as bikes, e-bikes, and e-scooters."[85] In 2018, e-scooters were placed in cities around the country for individuals to rent via phone-based apps. The expansion of available micromobility options resulted in a dramatic increase in trips on shared micromobility. According to a National Association of City Transportation Officials (NACTO) report, over 200 million trips have been taken on shared micromobility since 2010 and 84 million trips in 2018 (**Figure 3-3**).[86]

**Figure 3-3: U.S. Shared Mobility Trips, 2010-2019**




Source: NACTO Shared Mobility Webpage[87]

Shared micromobility has already entered the mix of options for Nebraskans in Omaha and Lincoln. Car-sharing is available at unviersities in both cities and both Omaha and Lincoln currently have station-based bicycle share systems. More recently Omaha has launched an electric scooter pilot program through a partnership with the companies Lime and Spin.[88] The six-month project (from May 2019 – November 2019) logged over 200,000 rides during the initial test period. The City of Omaha is currently evaluating the program and may extend the pilot during 2020. Lincoln is also moving toward a scooter pilot, anticipated for the spring/summer of 2020.

The addition of micromobility options to the transportation system produces user data that can benefit cities as they look to plan a complete transportation system. The City of Omaha announced that along with the pilot of e-scooters in the city, the program would use a new micromobility management platform to provide data on scooter distribution and usage to determine if the scooters are achieving the desired outcomes set by the city.[89]

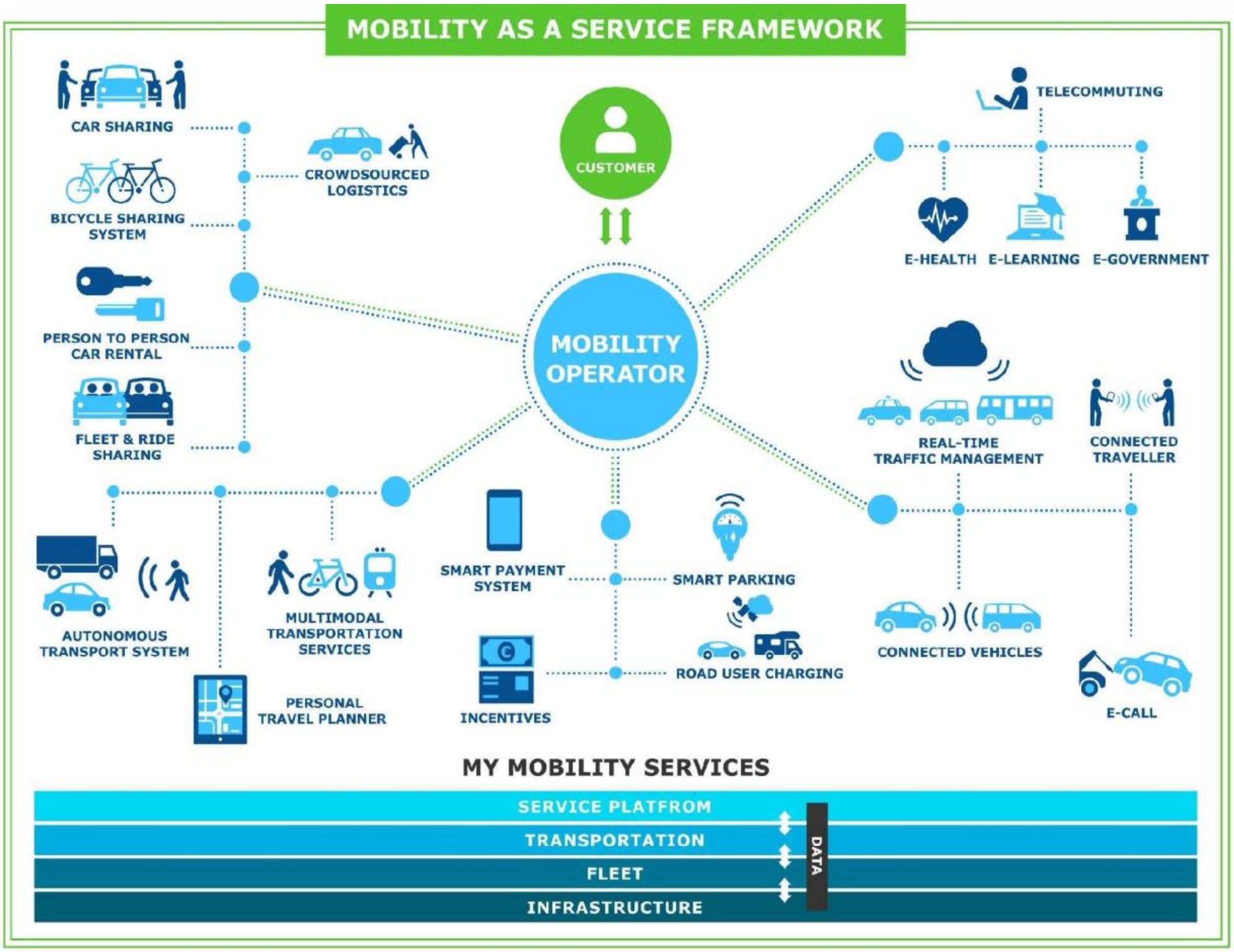
Many of the emerging transportation options have started or have a stronger presence in urban areas but rural communities have also witnessed new transportation options. Liberty Mobility, a start-up with a mission to provide TNC service in rural areas, announced service in Nebraska in 2017 but filed for bankruptcy in 2018.[90]

**Mobility as a Service:** The combined use of these technologies is sometimes used in Mobility as a Service (MaaS). MaaS entails providing transportation options as an alternative to owning a private vehicle. It typically involves the following:

- a single mobility operator manages payment and planning for transportation services, typically in the form of a mobile application available through a smartphone;
- combining services from both public (e.g., transit) and private (e.g., TNCs, such as Uber) transportation providers; and
- offers multimodal options specifically catered to the user (e.g., cars with drivers, bicycles, transit).

The framework to deliver MaaS is shown in **Figure 3-4.**

**Figure 3-4: Mobility as a Service Framework**




Source: World Electric Vehicle Journal[91]

MaaS attempts to provide a comprehensive transportation offering for any individual to travel essentially anywhere. To do so, MaaS providers look to leverage multiple forms of technology, including mobile apps that allow users to plan and pay for transportation services, Global Positioning Systems (GPS) to track both users and vehicles, and ultimately automated vehicles, to offer travel through vehicles without having to pay drivers.

MaaS could be a potential solution for those with limited access to transportation whether it be because of cost, location, physicality or anything in between. However, while it can work for a variety of populations some baseline practices may exclude vulnerable populations. For example, reliance on mobile apps and internet access can limit the viability of MaaS in rural areas and can be a barrier for certain vulnerable communities to travel. Additionally, MaaS usually requires an electronic payment method that may not be comfortable or available for the unbanked.

**Equity:** The lack of and failure of TNC service in rural areas represents an equity concern for emerging transportation options. A 2018 national Pew Research Center report found that 19 percent of Americans living in rural areas have used ride-hailing apps compared to 45 percent of urban and 40 percent of suburban dwellers.[92] A different 2018 study investigated the rural-urban ride-hailing divide in Pennsylvania found that spotty cellular service and limited broadband technology have the most significant impact when it comes to reaching small towns. Additionally, some of the market appeal of emerging technology may not exist in rural areas. Many of the services discussed above, offer alternatives to driving and are most attractive when the distance is short and parking fees are high.[93] Emerging transportation options have used technology and mobile applications to reach customers and the costs of driving have drawn economies of scale. If these are not reliable in rural areas, some populations may be left behind.

According to the FHWA's Travel Behavior report on shared mobility and transportation equity, the shared mobility users tend to be younger, have higher levels of educational attainment, higher incomes, and less diverse than the general population. Bike sharing, for example, has historically documented gaps in income and race/ethnicity between users and non-users. The difference can relate to the lack of stations in low-income neighborhoods. Car-sharing vehicles are also often located in higher-income neighborhoods.[94]

The technological interface of shared and micro-mobility services also presents a barrier for the unbanked – those without a debit or credit card. The services often ask for card payment to pay for trips and/or as collateral for equipment.[95] According to a 2017 survey by the Federal Deposit Insurance Corporation (FDIC), approximately 6.5 percent of U.S. households are unbanked and an additional 18.7 percent are underbanked (they have a checking or savings account by obtaining financial products and services outside of the banking system). A disproportionate share of minorities is under or unbanked.[96]

Social barriers also impact low-income and minority households from using emerging mobility options. The FHWA cites marketing and system design as a significant barrier. Non-English speaking or limited-English proficiency users, for example, often lack appropriate language outreach.[97]

The divide that prevents rural users from taking full advantage of emerging transportation options also presents itself within older populations. As of the Pew Research Center 2016 study, those over the age of 65 are most likely to not use the internet (41%) and not own a smartphone (42%).[98]

Lastly, the design of emerging transportation has had limitations for those with different physical abilities. TNC vehicles, usually owned by the independent driver, are often not accessible to those in a wheelchair. The most common equipment available in bike-shares and electric scooter sharing, require physical abilities that may not be safe or available for all. Some systems are responding; Uber and Lyft have been testing adaptive fleets (vans with lifts or ramps to accommodate wheelchairs) in several U.S. cities.[99] Portland, Oregon became the first U.S. city to introduce an adaptive bike share pilot in 2017 and other cities like San Francisco and Detroit have followed suit.[100] Yet, physically inclusive options are not widely available in most markets and present a concern for equitable transportation in the future.

**Infrastructure:** New transportation modes create unexpected or unique demands on existing infrastructure. In recent years, for example, the growth and attention to cycling have led to the installation of bike infrastructure and the designation of bike routes around the state. Omaha has one of the larger networks comprised of shared streets, bicycle boulevards, bike lanes, and pathways; the bike network covers 38 miles as of April 2019.[101] However, the state has continuously ranked low in "bicycle friendliness" as defined by The League of Bicycle Friendly America's 100+ data-point analysis. The Bike Friendly State Report Card ranks Nebraska 49 of 50 states overall and last on infrastructure and funding.[102]

Sidewalks facilitate the interaction of many new transportation options. The supply of electric scooters, for example, relies on freely available drop-off and pick-up of scooters and sidewalks have become a common solution creating congestion and blockage issues. Currently in Nebraska, pedestrian sidewalk construction and maintenance are generally the responsibility of adjacent property owners (with some exceptions such as the City of Lincoln). Sidewalks often present a code enforcement challenge for local communities. Enhanced planning and construction of more robust bicycle and pedestrian systems is ongoing in many Nebraska communities.

Additionally, growth in TNCs and shuttle services have increased the demand for access to the curb. In most urban neighborhoods, the curb is already in high demand for transit, paratransit, parking, amenities such as benches and bike racks, and loading zones. As a result, cities such as San Francisco have begun mapping and managing the curb space with demand-based parking rates. [103]

### 3.1.2 The Future

The growth in shared and micro-mobility is expected to continue in the future as technology spurs new modes and enhances existing modes. The commercial development of AV technology will likely make TNCs more profitable; Uber and Lyft are both developing AV technology and partnering with automakers to realize advances. The long-term TNC business model is reliant on AVs as existing operations continue to be unprofitable. Lyft and Uber lost $3.8 billion in 2019. However new research from MIT indicates, the cost of running AVs with single occupants will still be more expensive than the traditional private-vehicle ownership and driving model.[104]

The same AV scenario can be applied to transit. Public transportation agencies and private entities across the country are piloting automated transit vehicles. Jacksonville, FL, Corpus Christi, TX, Columbus, OH and Lincoln, NE are just a few cities testing AVs for transit.[105] With limited or eliminated operator costs, public transit could potentially reach more communities or provide more service. However, technology costs will be a factor and competition from shared or personal automated vehicles could threaten public transportation demand.

Future transportation options may also include unmanned aircraft systems (drones). Already seeing use for goods movement, a market study recently commissioned by the National Aeronautics and Space Administration (NASA) examined three uses for drones: last-mile package delivery, air metro (public transportation like buses), and air taxis. The study found air taxis may be very expensive and have limited market appeal, both air metro and last-mile parcel delivery are projected to be profitable by 2030.[106]

**Equity:** While there is a list of inequalities in new transportation options to date, future transportation provides the opportunity to lessen long-standing mobility challenges for many communities. Reducing transportation costs and connecting more people to more options can alleviate location or financial barriers. TNCs, bike share, or e-scooters could fill the first and last-mile gaps to/from public transit. The growth in active and electric transportation options (including electric scooters) holds the potential to improve air quality in the communities adjacent to highways, busways, delivery centers, and other trip generators.

However, the potential for continued inequities remains where future modes are available, how they are accessed, who can use them and who can afford them. As new transportation options emerge; policy solutions should be considered to leverage mobility options for all and prevent ongoing inequity from subverting future transportation. **Table 3-1** highlights current and future equity concerns.

**Infrastructure:** As new modes arise, they will continue to challenge the way we use our infrastructure. Smart infrastructure may be needed to manage new smart transportation options. Funding mechanisms will need to be considered if transportation options change. Property owners, cities, and airports have designated TNC pick-up and drop off space and electric scooter storage. Bus and rail vehicles are now designed to accommodate bicycles and bike lanes are supporting the needs of scooters, rollerbladers, and more. As new transportation options emerge, planning, design, and allocation of transportation infrastructure may need to be altered.

**Table 3-1: FHWA STEPS to Transportation Equity[107]**

| Transportation Barriers | Definitions | Share Mobility Opportunities | Shared Mobility Challenges |
|---|---|---|---|
| **Spatial** | Spatial factors that compromise daily travel needs (e.g., excessively long distances between destinations, lack of public transit within walking distance) | • Public transit operators and ride-sourcing first and last-mile partnerships<br>• Microtransit for lower-density areas | • Higher operating costs in lower density exurban and rural settings<br>• Limited curb space for an increasing variety of mobility services |
| **Temporal** | Travel time barriers that inhibit a user from completing time-sensitive trips, such as arriving to work (e.g. public transit reliability issues, limited operating hours, traffic congestion) | • Dynamic microtransit<br>• Late-night ride-sourcing and shuttle services<br>• Commuter carpooling services | • Wait-time and travel-time volatility on congested roadways<br>• Unpredictable wait times due to supply fluctuations |
| **Economic** | Direct costs (e.g., fares, tolls, vehicle ownership costs) and indirect costs (e.g., smartphone, internet, credit card access) that create an economic hardship or preclude users from completing basic travel | • Shared mobility subsidies for low-income users<br>• Multiple payment options for shared mobility services<br>• Multi-modal hubs with Wi-Fi access | • Credit/Debit Card payment<br>• High cost for longer distance and peak-demand trips<br>• Maintaining affordability, while providing livable wages |
| **Physiological** | Physical and cognitive limitations that make using standard transportation modes difficult or impossible (e.g., infants, older adults, and disabled) | • Older adult-focused mobility services<br>• Voice-activated mobility app features | • Maintaining legacy technology access<br>• Ensuring adequate driver training |
| **Social** | Social, cultural, safety, and language barriers that inhibit a user's comfort with using transportation (e.g. neighborhood crime, poorly targeted marketing, lack of multi-language information) | • Ridesourcing app interface that minimizes sociodemographic profiling<br>• Targeted outreach to low-income and minorities<br>• App information in the user's native language | • Attracting marginalized groups<br>• Driver prejudice against riders<br>• Providing security at un-manned vehicle stations |

### 3.1.3 Transportation Consequences

**Car Ownership and VMT:** The direct impact on car ownership and VMT is difficult to measure or predict. Between 2012 (when transportation network companies like Uber and Lyft entered the market) and 2017, household vehicle ownership has increased in the eight biggest U.S. cities where Uber, Lyft and other transportation options are most heavily used. Census data indicates an increase in multiple-car households outweighed the growth in car-free and car-light household. Seattle, San Francisco, Philadelphia and Chicago saw car-free and car-light households grow faster than population but households overall vehicle growth exceeding population growth in Boston, Chicago, Los Angeles, New York, and Philadelphia.[108]

Individuals make their transportation choices based on what is available, what is affordable, and convenient. However, growth in multiple transportation options is expected to lead to car-free or car-light households.

While transit, bicycle, walking, and scooter trips might decrease VMT or move people away from their cars, TNCs may increase VMT. A joint analysis conducted by Lyft and Uber in September 2018 found their ride-hailing vehicles are responsible for significant portions of VMT in six major urban areas. The analysis found that Uber and Lyft make up as much as 13.4 percent of all VMT in San Francisco County. In Boston, it's eight percent and just over seven percent in Washington, D.C. with lower contributions in other cities. In the six studied cities, 54 to 62 percent of TNC VMT was driven with a passenger present. The remaining miles represent the travel time or waiting time for TNC drivers alone.[109]

The data from these six cities is an important consideration for the growth of TNCs in the future, especially as automated technology comes online. The shared vehicle model may only reduce VMT and congestion if trips are also shared.

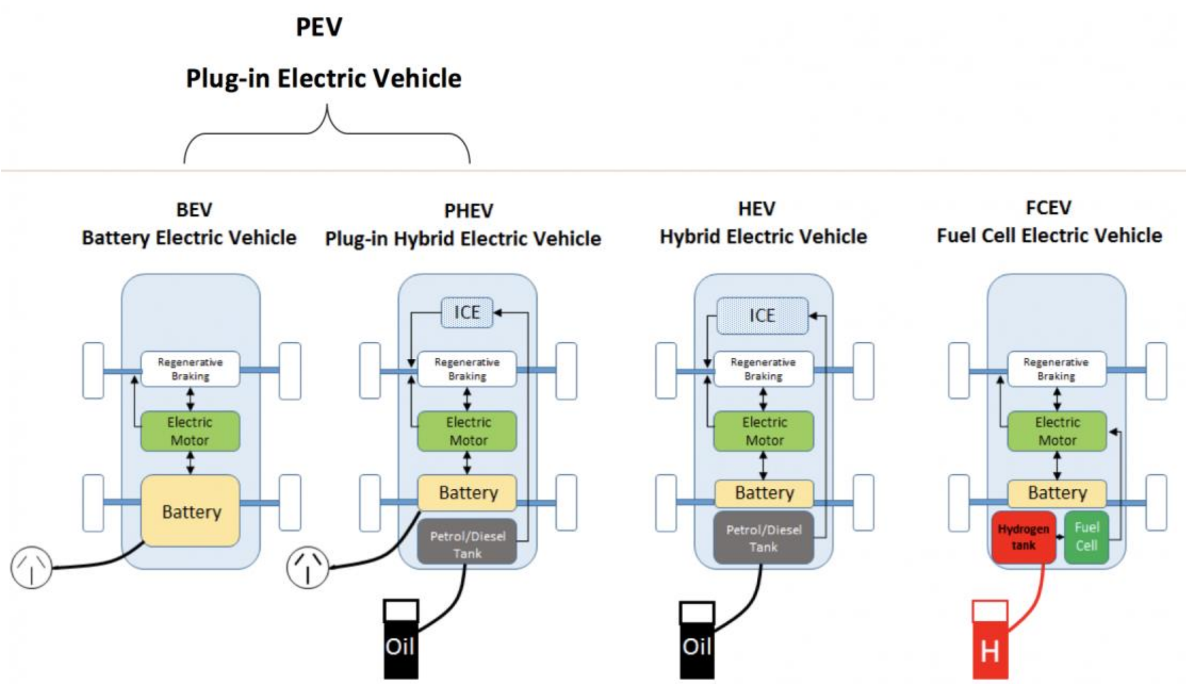
**Safety:** New modes operating on infrastructure designed for other purposes creates a safety risk. According to data from the National Highway Traffic Safety Administration (NHTSA), 2018 saw the most pedestrians and cyclists' fatalities since 1990. The number of pedestrians killed grew by 3.4 percent and cyclist deaths rose by 6.3 percent even as total traffic deaths decreased. While larger vehicles and distracted driving are contributing causes, growth in the use of these alternative modes is also a factor.[110] Additionally, the introduction of electric scooters which are typically operated in the right-of-way, led to fatalities and injuries in cities across the country. Just as cyclists and pedestrians, these new users are vulnerable to the much larger vehicles on the road. Alternatively, the rise of TNCs was met with scrutiny over passenger safety. Both Lyft and Uber faced lawsuits in 2019 regarding the handling of sexual assault claims.[111]

Emerging and new transportation modes require special consideration in how they interact with the transportation network and how individuals relate to the new modes.

## 3.2 Electric Vehicles

Electric vehicles are a much-discussed technology of today and the future. When discussing electric vehicles (EVs) and charging locations, it is important to start by clarifying the technology. **Figure 3-5** shows the four types of vehicles that could be referred to as "EV." Most of this section will refer to Plug-in Electric Vehicles (PEVs), but the terminology from this figure will be used throughout.

**Figure 3-5: Types of Electric Vehicles**




Source: The Driven [112]

Three types of chargers are used to charge PEVs:

- **Level 1 chargers** are powered by 120V outlets and can be plugged into power outlets commonly found in homes. Level 1 chargers will add about three to five miles of range per hour.
- **Level 2 chargers** are powered by 208V or 240V outlets that are rated 2.5kW to 19.2kW, like the outlets that power a washer and dryer in a home. Level 2 chargers are typically 7.2kW and will add 10 to 20 miles of range per hour.
- **Level 3 Direct-Current Fast Chargers (DCFC or DC Fast Charging) stations** are powered by 208V or 480V three-phase lines and can be

rated from 50kW to 350kW, but they are typically at the lower end of that range. These chargers can provide around 80 percent of a charge to a vehicle in 20 to 30 minutes, but the battery is not able to handle that much power for the remaining 20 percent of capacity.

### 3.2.1 Trends

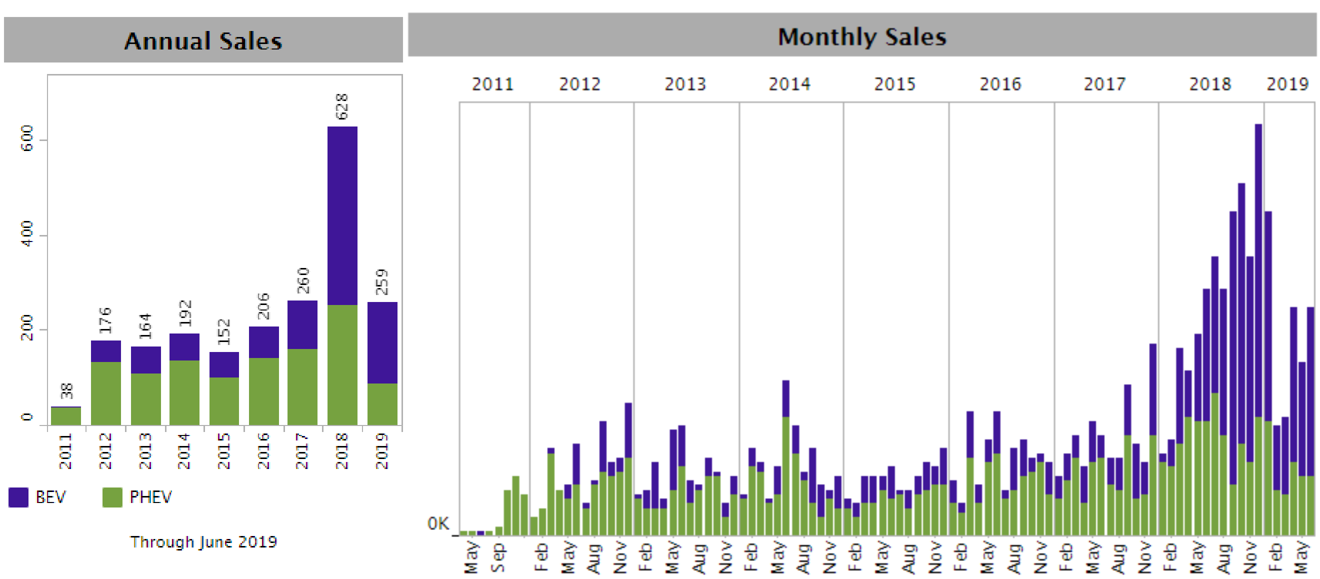
Electric vehicle ownership in Nebraska is relatively low and new EV sales suggest limited growth in recent years. **Table 3-2** shows that in 2018, less than one percent of all new vehicles sold in Nebraska were PEVs. Nebraska ranks 41st in total EVs by state, with 2,075 PEVs sold since Jan 2011. **Figure 3-6** contains a summary of BEV and PHEV sales data from 2011 to 2019.

**Table 3-2: Sale of EVs in 2018**

| Location / Vehicle Type | Nebraska | | United States | | Global | |
|---|---|---|---|---|---|---|
| | Sales | Percent of Sales | Sales | Percent of Sales | Sales (mil) | Percent of Sales |
| BEV | 375 | 0.44% | 203,625 | 1.21% | 1.45 | 1.5% |
| PHEV | 253 | 0.29% | 124,493 | 0.74% | 0.65 | 0.7% |
| **Total** | **628** | **0.73%** | **328,118** | **1.95%** | **2.1** | **2.2%** |

Source: Auto Alliance 2019, EV-volumes.com 2019[113]

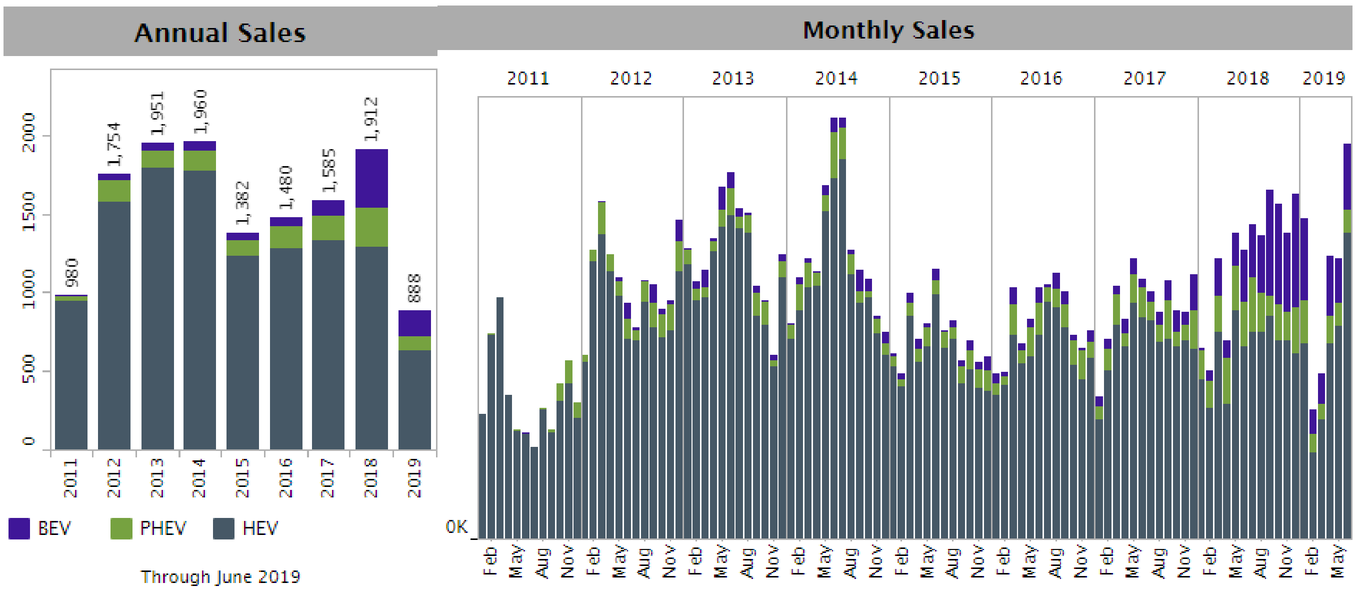
**Figure 3-6: Nebraska PEV Sales by year and month**




Source: Auto Alliance 2019

While the shift for EVs has been increasing, there has been a noticeable trade-off effect. Sales of PHEV replace the sale of non-plug-in hybrids (HEVs) and sales of fully electric BEVs growing at the expense of HEVs and PHEVs. **Figure 3-7** illustrates this sales activity. These figures support another trend where hybrid adoption is a strong indicator of PEV adoption.

**Figure 3-7: Nebraska all EV sales by Year and Month**




Source: Auto Alliance 2019

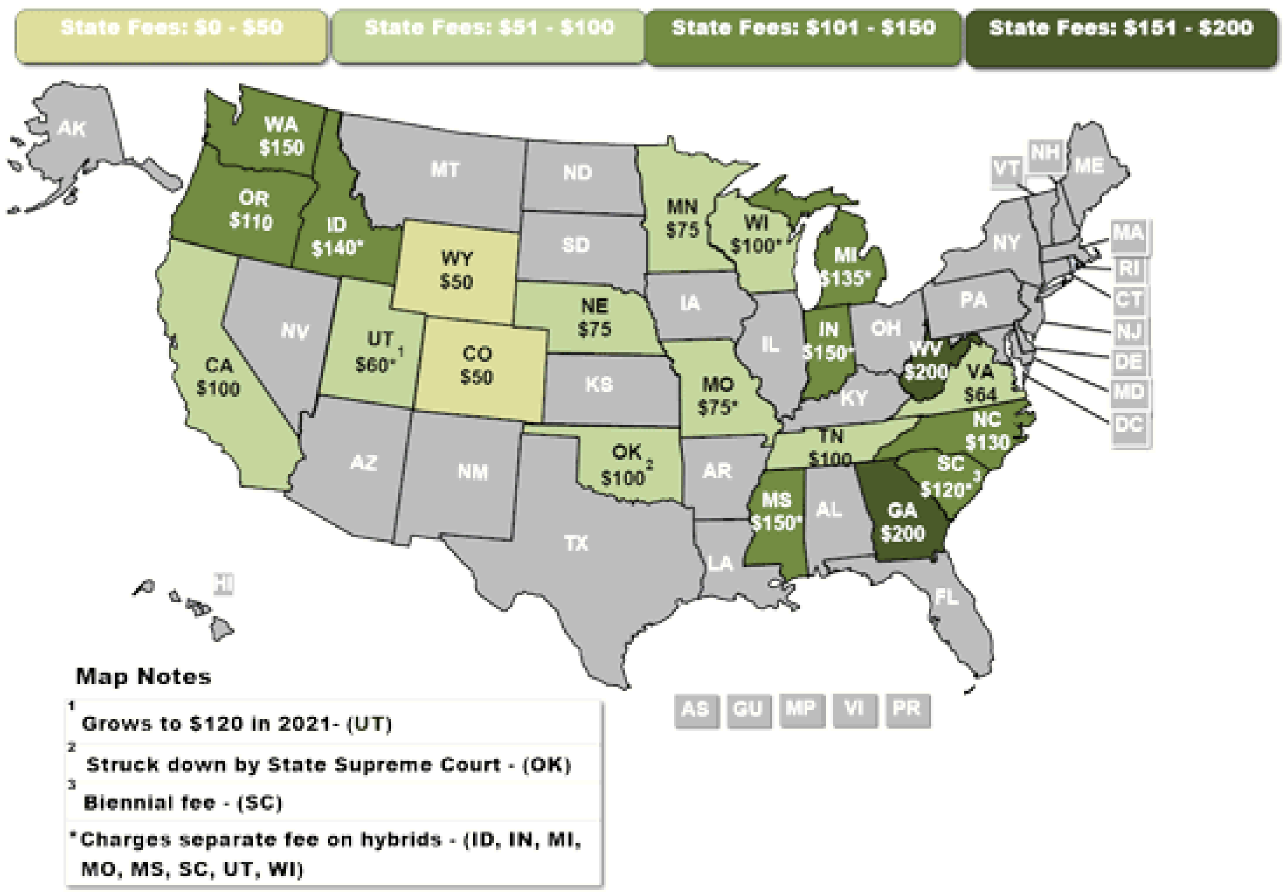
The two most discussed factors affecting PEV adoption are cost and convenience.

**Cost of PEVs:** The cost-benefit balance is an important consideration for potential PEV buyers. PEVs are often more expensive than an internal combustion engine (ICE) vehicle. The customer must consider the benefits to justify the higher price but, the two main benefits - reduced operation and maintenance cost through savings on fuel and lower environmental impact - are hard to quantify for an individual. The lower the price difference between PEVs and ICE vehicles, the more likely people will be willing to purchase PEVs.

### *Operation and Maintenance Costs*

In addition to the higher price of PEVs, many times they have additional registration fees that can act as a barrier to adoption. While these fees are the primary way for states to make up lost revenue from the motor fuel tax, these fees can discourage the adoption of PEVs by adding cost to the already more-expensive option. Nebraska – and several neighboring states –use an EV registration fee as shown in **Figure 3-8.**

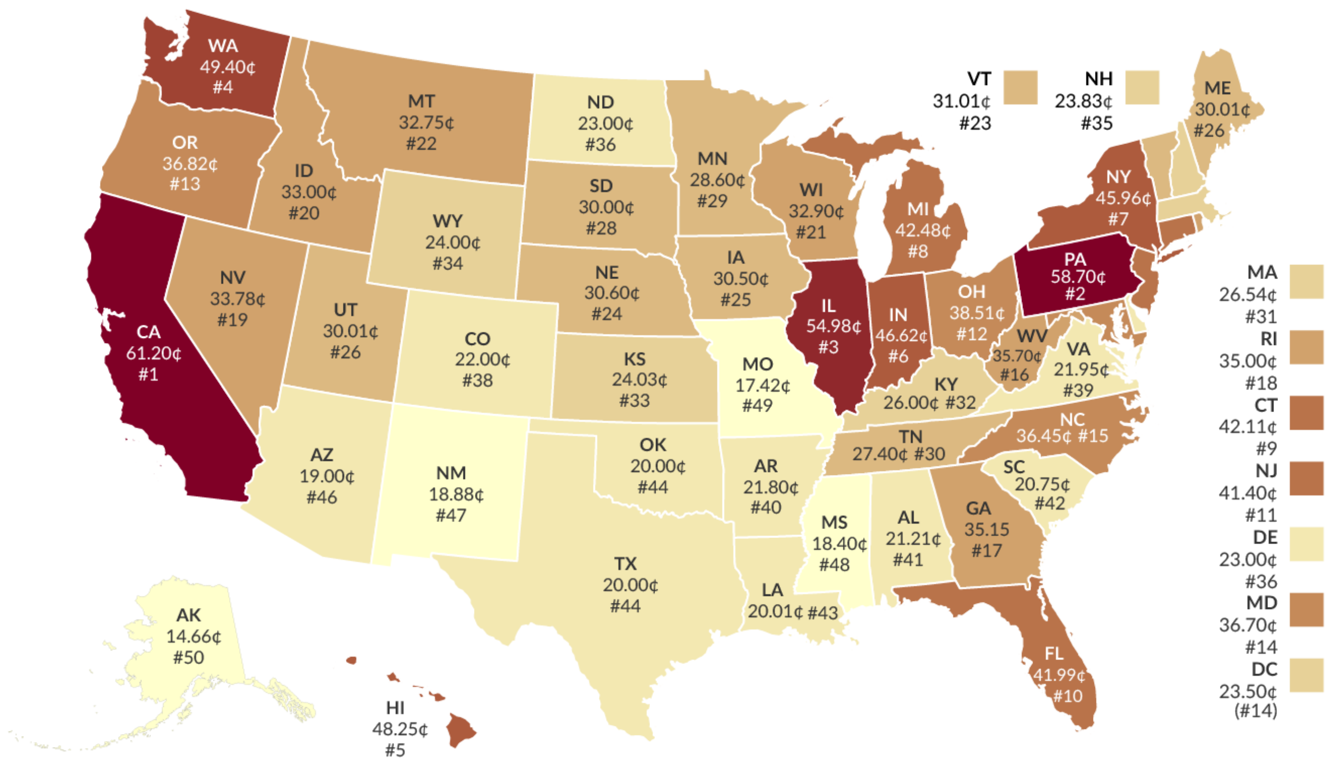
**Figure 3-8: EV Registration Fees by State**




Source: National Conference of State Legislators[114]

**Figure 3-9** provides additional context by showing the fuel tax by state. When considering the average driver purchases around 500 gallons of gasoline a year (15,000 miles at 30 mpg), the fees on EV are generally less than the gas tax paid by the average driver. However, the EV registration fee is charged as a lump sum rather than distributed throughout the year, which may be considered less appealing to vehicle owners.

**Figure 3-9: Motor Fuel Tax by State (cents per gallon, federal tax excluded)**




Note: These rates do not include the 18.40 cent/gallon federal excise tax rate on gas. The American Petroleum Institute has developed a methodology for determining the average tax rate on a gallon of fuel. Rates may include any of the following: excise taxes, environmental fees, storage tank taxes, other fees or taxes, and general sales taxes. In states where gasoline is subject to the general sales tax, or where the fuel tax is based on average sale price, the average rate determined by API is sensitive to changes in the price of gasoline. States that fully or partially apply general sales taxes to gasoline are California, Connecticut, Georgia, Illinois, Indiana, Michigan, and New York.D.C.'s rank does not affect states' ranks, but the figure in parentheses indicates where it would rank if included.

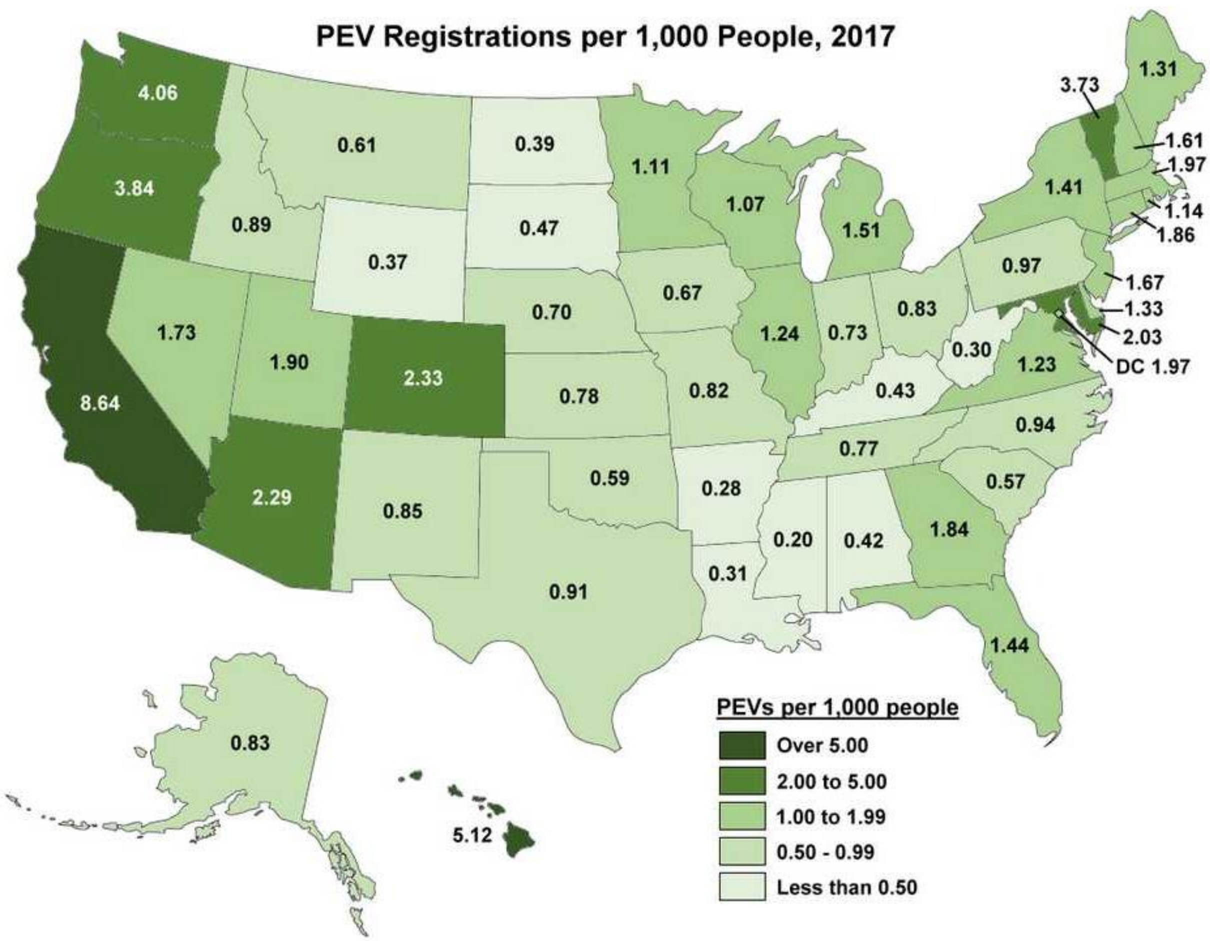
Source: American Petroleum Institute, "State Motor Fuel Taxes by State (July 2019)"

Total State Taxes and Fees on Gasoline


Source: Tax Foundation[115]

While the PEV registration fee may be an upfront deterrent for prospective PEV owners, PEV owners are saving on the cost of fuel compared to the cost of electricity. The overall estimated savings from fuel costs in Nebraska is 69 percent.[116] However, the average fuel savings may not be encouraging EV adoption as experts anticipate. Based on the number of PEV registrations per 1,000 people, the rate of adoption in many states is less than one vehicle. Nebraska's PEVs per 1,000 people in 2017 was 0.70 (**Figure 3-10**).

**Figure 3-10: PEV Registrations (2017)**

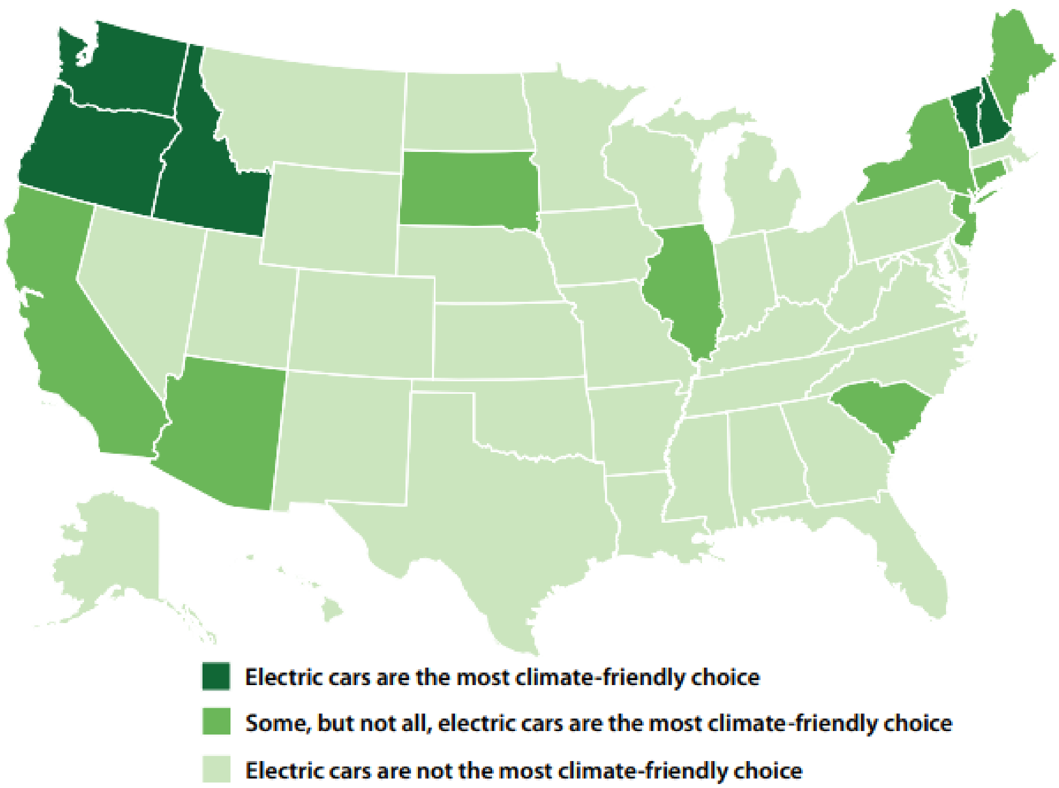



Source: Inside EVs[117]

### *Lower Environmental Impact*

One characteristic that correlates most closely to EV registration rates is the carbon footprint of electricity generation by state. States where PEVs produce the largest benefit to the environment (**Figure 3-11**) have a close alignment with the highest PEV registration. PEVs are most environmentally friendly where electricity is produced with a lower carbon footprint. While the climate impact of EVs is highly correlated it may not be causative, these states also generally have a very environmentally conscious culture and many of them offer additional incentives for PEV adoption that further increase the convenience or decrease the upfront cost for PEVs and their supporting infrastructure.

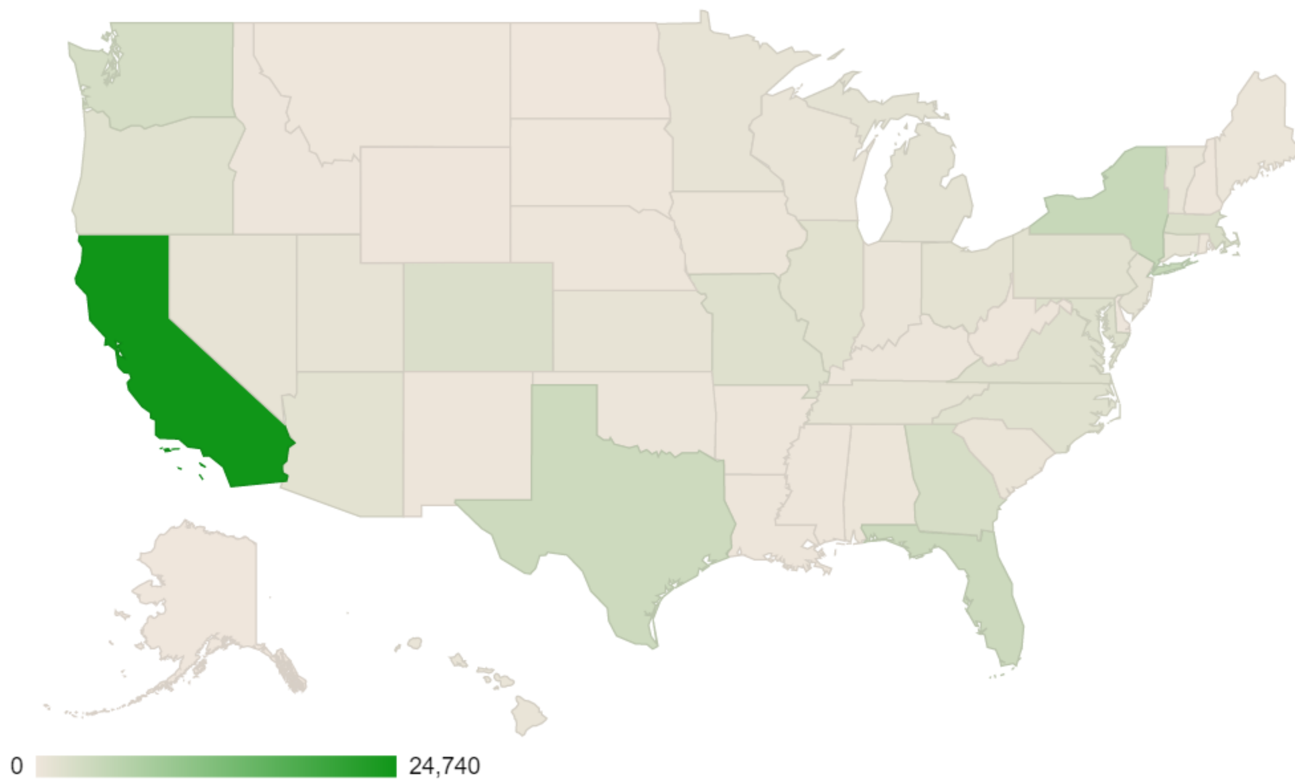
**Figure 3-11: Climate Benefit of EVs by State**




Source: Climate Central[118]

**Convenient Access to Charging Stations:** The second factor in considering PEV adoption is convenience. This is related to 'range anxiety' and vehicle charging, with the overall lack of fast and accessible charging options seen as an issue for consumers. Nebraska currently has a limited charging network. There are 92 non-residential charging stations with 239 total charging outlets, where on average each location can charge two to three vehicles at a time. This places Nebraska 40$^{th}$ and 42$^{nd}$ in the country for the number of EV charging stations and outlets respectively. A countrywide snapshot of the number of charging outlets by state can be seen in **Figure 3-12**.

**Figure 3-12: Charging Outlets by State**

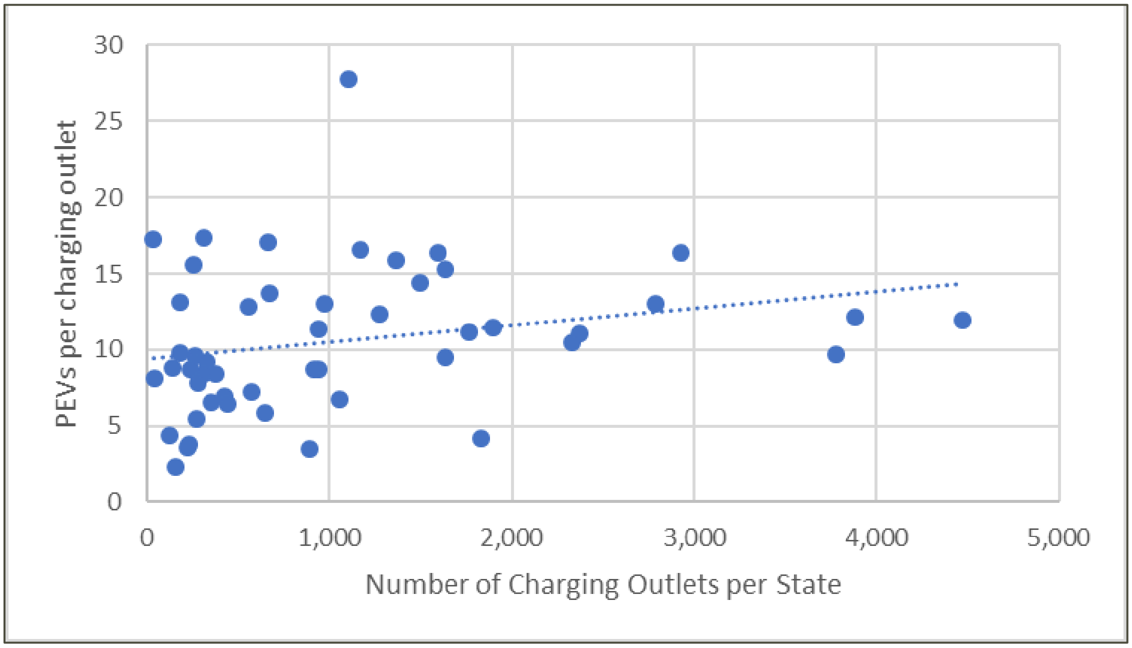



Source: USDOT Alternative Fuels Data Center[119]

As previously noted, Nebraska is currently ranked 41$^{st}$ in total PEV sales. This means there are nine PEVs for every charging outlet in the state. This is just below the median of 10 PEVs per charging station countrywide.

Charging stations do show a “build it and they will come” relationship. Nationwide there is a positive correlation - the more charging outlets a state has the more PEVs they have per outlet as shown in **Figure 3-13.** This is consistent with the understanding that reducing range anxiety and increasing charging convenience is a significant factor in PEV adoption.

**Figure 3-13: EV Charging Outlets per State by Vehicles Sold per Charging Outlets**
(Excludes California)

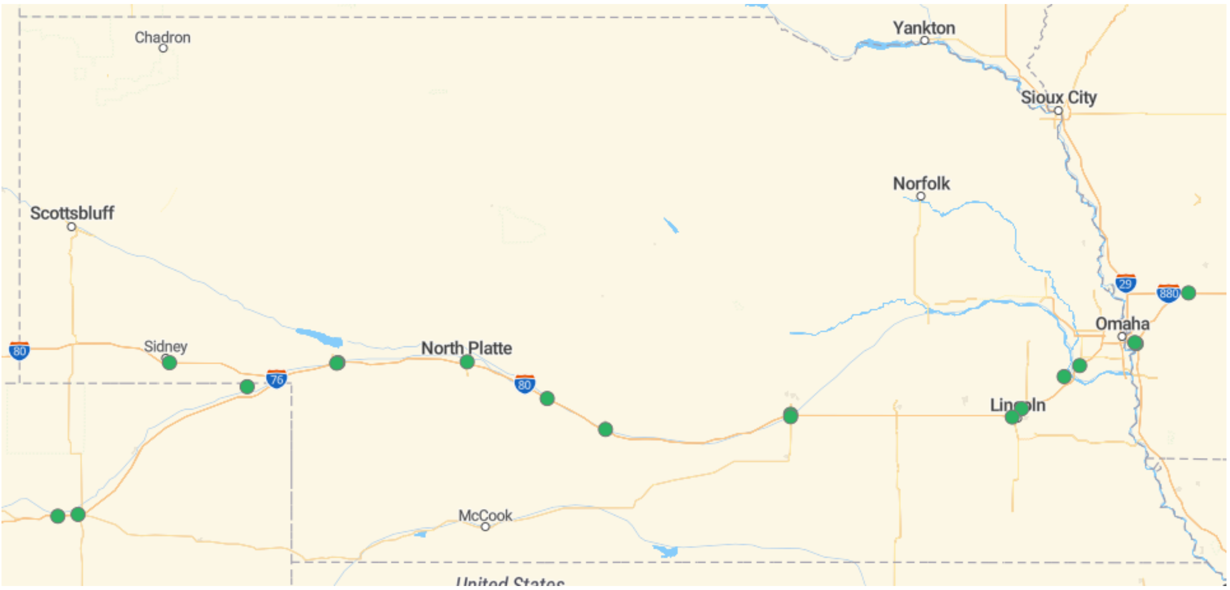



Source: Data based on EV sales by state from Auto Alliance[120] and charging station per state data from the US DOT Alternative Fuel Data Center[121]

This trend indicates that the continued growth in EV charging infrastructure in Nebraska will lead to increased EV adoption.

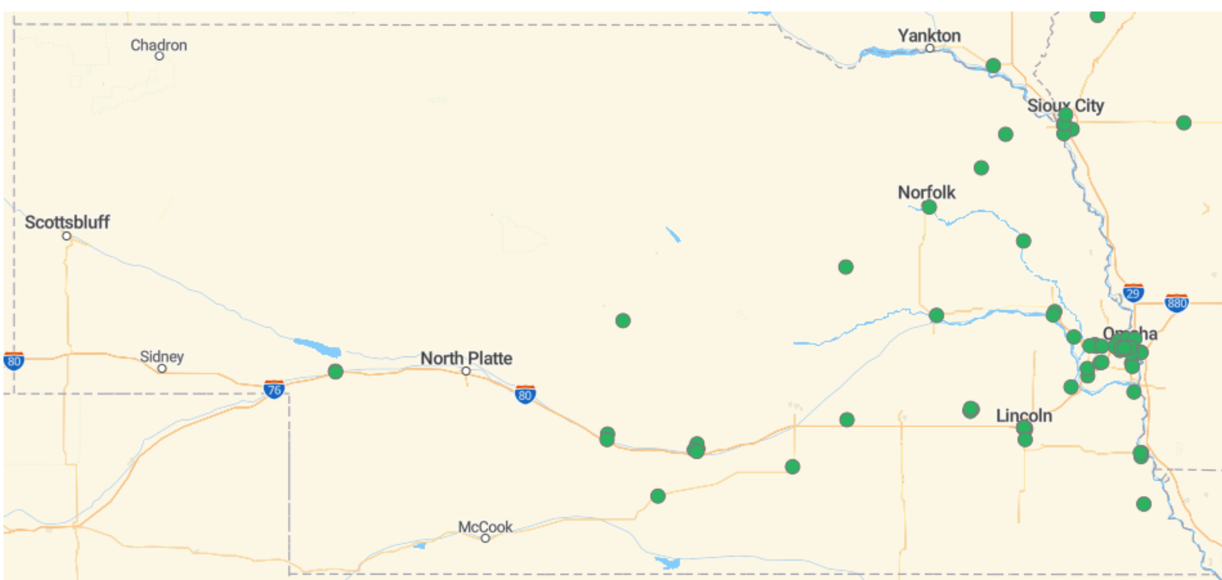
**Figure 3-14** and **Figure 3-15** on the following page show the location of EV chargers in Nebraska. The available chargers are located primarily along I-80 as well as in Omaha and Lincoln. Additional buildout should further support the state highway network and continue to build on intracity charging locations across the state.

**Figure 3-14: DC Fast Charging Locations in Nebraska**




Source: USDOT Alternative Fuels Data Center, February 2020[122]

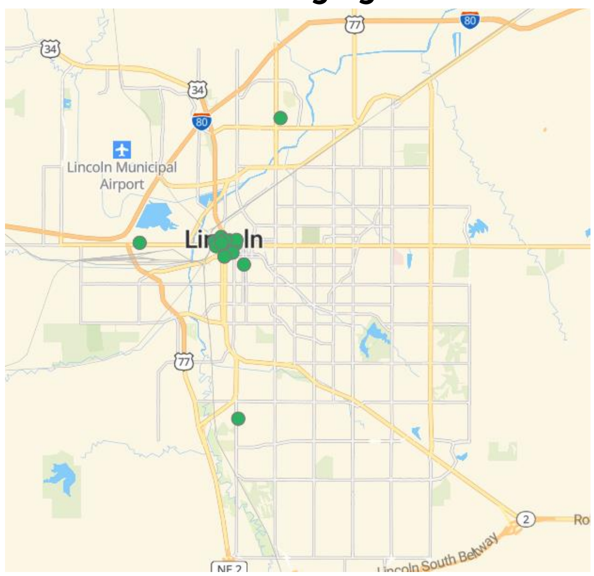
**Figure 3-15: Level 2 Charging Locations in Nebraska**




Source: USDOT Alternative Fuels Data Center, February 2020

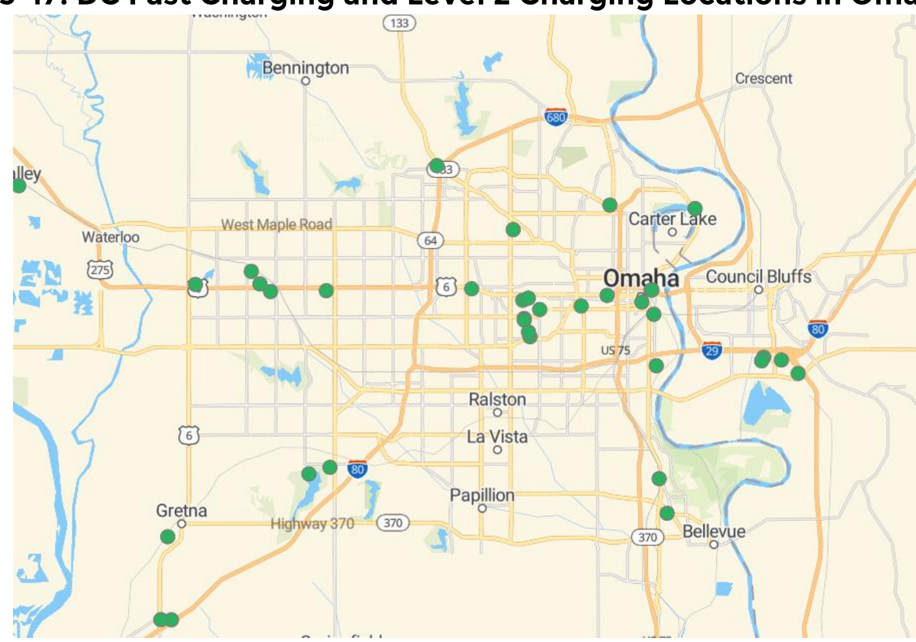
**Figure 3-16** and **Figure 3-17** provide the EV charging station location in Omaha and Lincoln while **Figure 3-18** offers a comparison of a very robust charging infrastructure network in Santa Clara, CA. While Nebraska may not have the EV density to need as many locations as the Santa Clara, geographic and route coverage is important to provide enough outlets so vehicles do not have to wait when they need a charge.

**Figure 3-16: DC and Level 2 Charging Locations in Lincoln, NE**



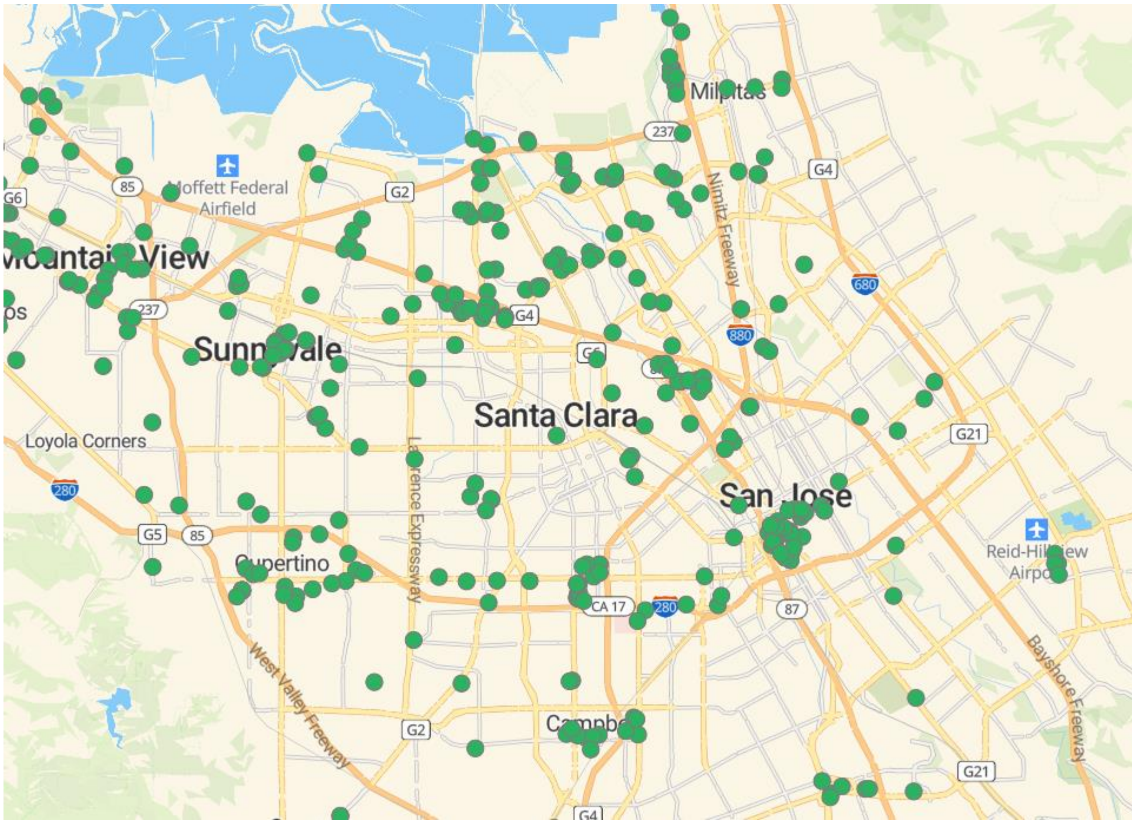

Source: USDOT Alternative Fuels Data Center, February 2020

**Figure 3-17: DC Fast Charging and Level 2 Charging Locations in Omaha, NE**




Source: USDOT Alternative Fuels Data Center, February 2020

**Figure 3-18: DC Fast Charging and Level 2 Charging Locations in Santa Clara, CA**



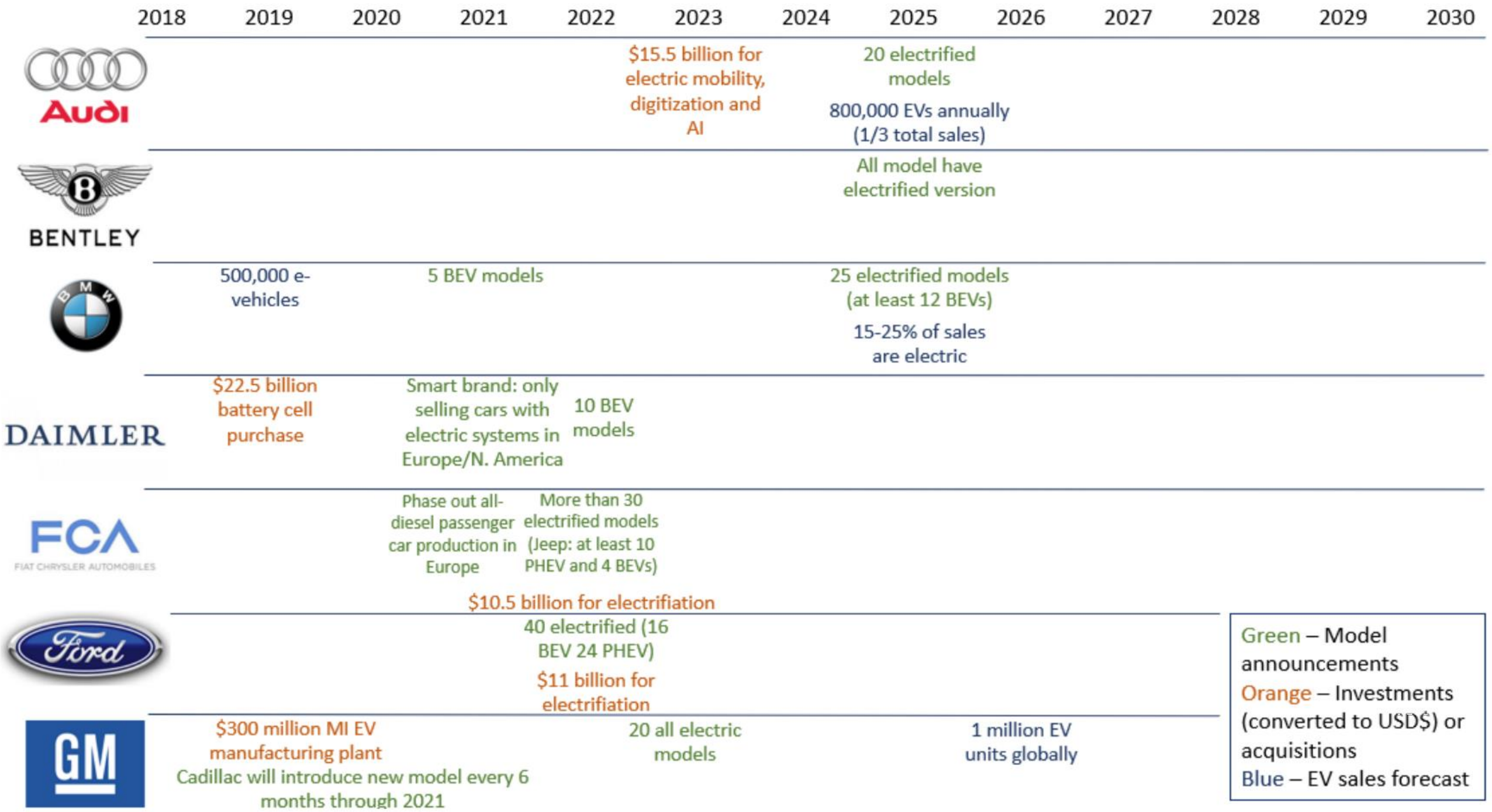

Source: USDOT Alternative Fuels Data Center, February 2020

Nebraska is positioned to continue to grow its EV infrastructure. There are three programs currently in place to support this development. There are low-cost loans through the Dollar and Energy Savings Loan Program as well as two rebates on EV charging infrastructure. One rebate is offered through the Nebraska Department of Environment and Energy as part of the Volkswagen Environmental Mitigation Trust for level 2 and DC fast chargers and one is provided by Omaha Public Power District for level 2 residential charging equipment.

### 3.2.2 The Future

A key factor in the future of EV use is the investment in electric and hybrid vehicle technology by vehicle manufacturers. **Figure 3-19** shows the electrification claims and announcements that have been made by the various vehicle manufacturers. While the manufacturers generally consider 2025 as the critical year for EV production, these projections could change based on regulations and consumer preferences.

**Figure 3-19: Vehicle Manufacturers Actions on EVs**




Source: Electric Vehicle Market Status, MJB & A[123]

Several factors are likely to have a substantial impact on future EV adoption related to the cost and convenience:

**Electric Vehicle Cost:** Three factors have been identified that will play into the future of electric vehicle costs. These factors include battery availability, price parity, and vehicle options.

*Battery availability:* While many manufacturers are committing to large numbers of full EVs, some are discussing the limitations of their battery supplies. For example, Toyota has elected to use its available resources to produce 1.5 million PHEV rather than 28,000 BEVs. Auto manufacturers will need battery suppliers to dramatically increase production to meet the sales targets that have been announced and highlighted in Figure 3-19.

*Price parity:* Price parity between EVs and ICE vehicles will make the biggest difference in the decision to purchase a car. PEVs still cost more than standard ICE vehicles. Federal tax rebate programs currently offset some of this price difference, but there is no guarantee that these incentives will continue. Increases in both battery and vehicle production are likely to bring down the costs; the mid-2020s is often identified as the estimates point price parity.

*Vehicle options:* Currently, only certain models have a PEV option, which can force consumers to choose a PEV at the expense of other features they may also want. As more models and trim levels have electric options, this trade-off will become less impactful.

**Convenience:** Two factors have been identified that will play into the future of electric vehicle convenience: vehicle charging network and fuel cell electric vehicles.

*Vehicle charging network:* PEVs are well suited as a second or third vehicle for homeowners. Most local trips will not require charging during the day because a single nightly charge from an in-home level 1 charger will be sufficient. But without a built-out charging network, intracity trips will be inconvenient or impossible. Similarly, individuals without garages where they can park and charge their PEVs will be reliant on public charging facilities, which may be too slow or too dispersed to meet their needs. Once charging convenience improves there will likely be an increase in the adoption rate.

*Fuel Cell Electric Vehicles:* It is also possible that Fuel Cell Electric Vehicles (FCEVs) that use hydrogen will become more prominent instead of or in addition to other types of EVs. Hydrogen could provide a better option for long-distance travel and trucking. PEVs currently have a limited range and increasing the size of the battery would add a great deal of weight. While a bigger battery can support a longer range, the additional weight also creates more demand for the battery, neutralizing the size benefits. The refueling network for hydrogen would parallel that of current gas stations because in-home refueling would not be an option. The use of FCEVs could be more likely widespread if there are more stringent fuel efficiency or emissions standards placed on the trucking industry and there are no major to the energy density of batteries. Toyota specifically sees PHEVs, rather than BEVs, as the transition while FCEVs develop.

### 3.2.3 Transportation Consequences

EVs will have two primary effects on the transportation system:

**Funding:** As EV adoption increases, gasoline consumption along with the revenue collected from the gas tax are likely to decrease. This trend could be doubly impactful if reduced travel cost per mile for EVs results in an increase to VMT. Similar to the rise in travel seen when gas prices drop, more travel will mean a need for more roadway maintenance and a greater need to increase capacity. The impact will be less prominent if gas prices remain low but could be more impactful if gas prices rise.

New mechanisms will be needed to recoup or even exceed the lost revenue from the gas tax. The anticipated reduction in gas tax revenues has led to pilot programs and research by states for new mechanisms to develop funding opportunities for a future with greater EV adoption.

**Development of Electric Grid:** The use of EVs will increase the need to expand and upgrade the electric grid, and these costs will likely be passed on to consumers. The rise of shared mobility will impact the way the grid expands and develops. If charging is taking place in homes, a more distributed set of needs may be required. But if more vehicles move out of the home and into shared mobility fleets with concentrated facilities for parking and charging, the network will need to be prepared for a different type of load more concentrated at few locations. While many of these decisions will be made by electric companies rather than transportation agencies, communication between the two will be vitally important. There must be sufficient capacity and resiliency of routing options to allow reliable access to large charging facilities. Redundancy and resilience in the transportation network will become even more important considerations, as discussed in more detail in the next section.

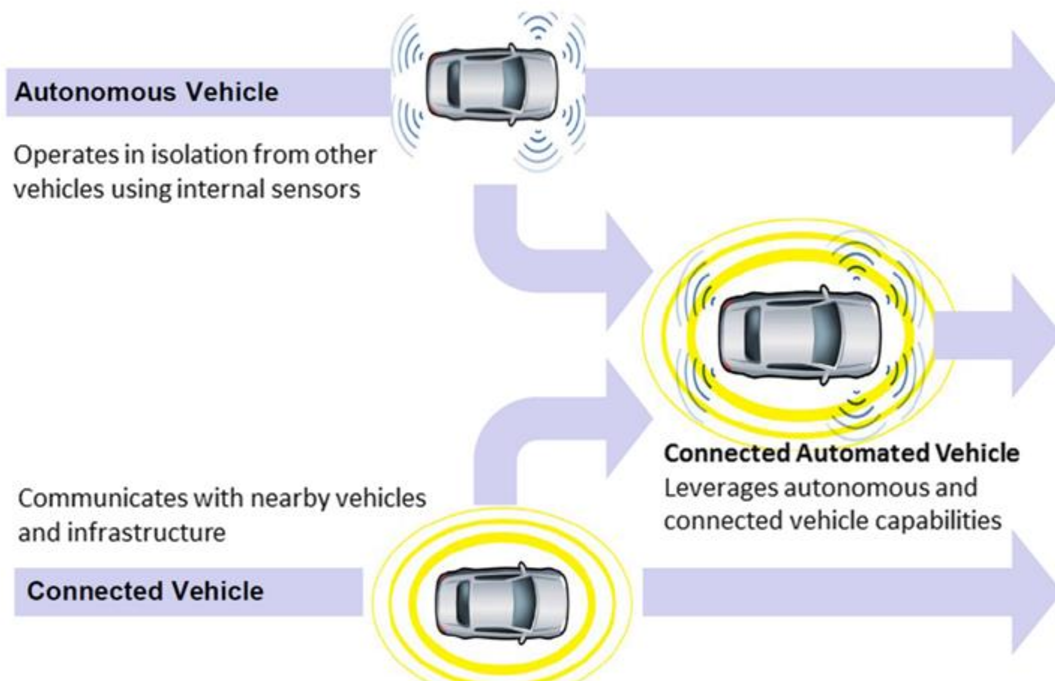
**Land Use:** EVs themselves are unlikely to significantly impact traffic operations but could impact land uses supporting transportation. EVs will have minimal impacts on the operation of traffic as they do not disrupt the ownership model or traffic characteristics. With the increasing adoption of EVs, less dedicated land will be required for charging stations as compared to gas stations, which could open space at intersections for additional development or roadway expansion.

## 3.3 Connected and Automated Vehicles

Connected vehicles (CVs) and automated vehicles (AVs) (sometimes referred to as autonomous vehicles) are two independent technologies that can work with one another (**Figure 3-20**). CVs can communicate directly with other vehicles or components of the transportation system. They can be human-driven or autonomously driven. AVs are vehicles that operate without a human driver. AVs can be connected or unconnected. Unconnected AVs rely on onboard sensors to sense the world around them, be it video, radar or LiDAR.

A combination of the two vehicle types, known as connected automated vehicle (CAVs), can identify, collect, process, and transmit information to/from other vehicles, coordinate movements, use sensors to learn about the environment, and communicate information about themselves and their surroundings to other connected equipment. In addition to physical information, they can provide intentions to enable better coordination, such as, "This vehicle will begin slowing in five seconds to make a right turn."

**Figure 3-20: Connected and Automated (Autonomous) Vehicles**




Source: U.S. Department of Transportation (USDOT), ITS Joint Program Office

### 3.3.1 Trends

**CVs:** CV technologies have received less attention in recent years due to the increase in AV testing and the excitement around this emerging transportation technology. However, CV connections to infrastructure systems have progressed rapidly and have been proven effective in deployments around the country.

Tolling passes are one small example of CV technology that is readily available today. These systems communicate vehicle movement with tolling infrastructure via an in-vehicle device. The passes allow for more efficient tolling, as compared to pay stations and license plate detection.

Signal Phasing and Timing (SPaT) technologies is another connected technology that is already utilized. The SPaT Challenge, a National Operations Center of Excellence program, has been going on nationwide with many applications and integration. The goal is to broadcast signal timings to surrounding vehicles, allowing them to know when a light is going to turn red or green so that drivers or vehicles can plan accordingly. **Figure 3-21** shows the locations that are currently working toward the SPaT Challenge, including Sarpy County which identified 26 intersections along State Highway 370.

Some vehicle manufacturers, such as Audi, are utilizing this information where available by deploying traffic light information systems on their vehicles, with several other manufacturers considering similar systems. These systems will provide information about signal timing directly into vehicles. Third-party phone apps could also be used to integrate these features into vehicles.

**Figure 3-21: SPaT Implementation Locations**


Sources: National Operations Center of Excellence, SPaT Challengem Retrieved February 2020[124]

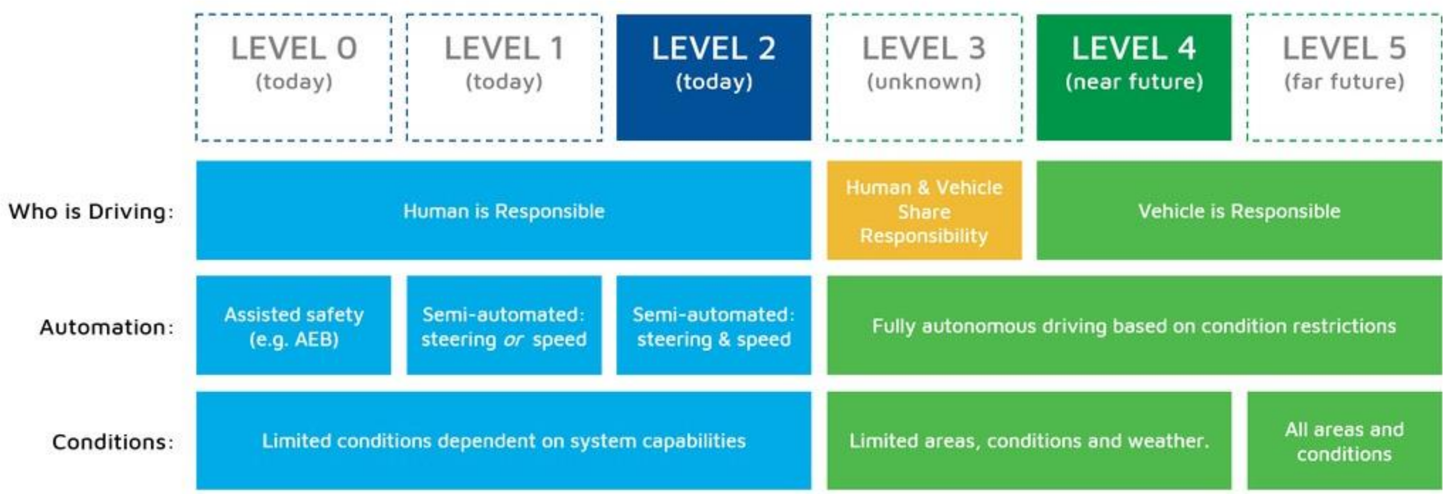
**CV Infrastructure – dedicated short-range communication (*DSRC) or fifth generation wireless technology (5G):*** There is an ongoing debate about whether future communication for CVs will be based on DSRC or 5G. Existing deployments have focused on DSRC because it is a more mature technology and has been ready for commercial deployment for several years. Some manufacturers are installing both communication technologies so they can reap immediate enefits while remaining flexible to future developments.

**AVs:** AV developments are making steady progress, however, at a slower pace than many manufacturers had claimed in previous years. While these vehicles still hold great promise for enhancing safety and mobility for those unable to drive, significant capacity improvements are looking less likely without some type of policy or design action by the government.

Today, original equipment manufacturers (OEMs) are focused on individual users' needs, designing for their safety and comfort. While it may be possible for AVs to follow each other at shortened headways due to their faster reaction times and better awareness of their environment, there are currently no incentives for manufacturers to program vehicles to drive in such a way that optimizes traffic flow. One exception to this rule could be the trucking industry, where platooning and increased efficiency theoretically is economically valuable, and many vehicles are owned by a single operator. However, in January 2019, automated truck technology producer Daimler Trucks said their pilot platooning projects were providing less benefit than expected and concluded there was no business case for platoons long-distance U.S. applications.[125]

The Society of Automotive Engineers (SAE) has conceptualized five levels of vehicle automation, as depicted in **Figure 3-22**.

**Figure 3-22: SAE levels of Autonomy**




Source: Auto Pilot Review[126]

Level 1 and Level 2 vehicles have specific driver-assist features that can improve safe driving, but still require drivers to fully operate the vehicle. Level 3 autonomy is widely considered to be too dangerous for the general public but represents the current level for vehicles being tested by private companies. Level 3 vehicles would require drivers to be attentive to take control back from a vehicle in time to intervene in an emergency. For this reason, these types of systems are not likely to be released to the public.

At Level 4, a vehicle can perform all driving functions with no human intervention, but only in certain operational domains. These domains can be as broad or specific as the manufacturer's desires and can include external factors or locations, such as limits on use during certain weather events. The operational domain is solely based on the vehicle manufacturer and allows manufacturers to bring the vehicle to market by focusing on the most profitable and useful domains first. At Level 4, vehicles will realize every benefit that has been discussed as part of AVs. Level 5 is the fullest realization of Level 4 where the vehicle can operate under all conditions.

For the purposes of planning future transportation systems for AVs, the two levels that are most important to consider are Level 2 and Level 4.

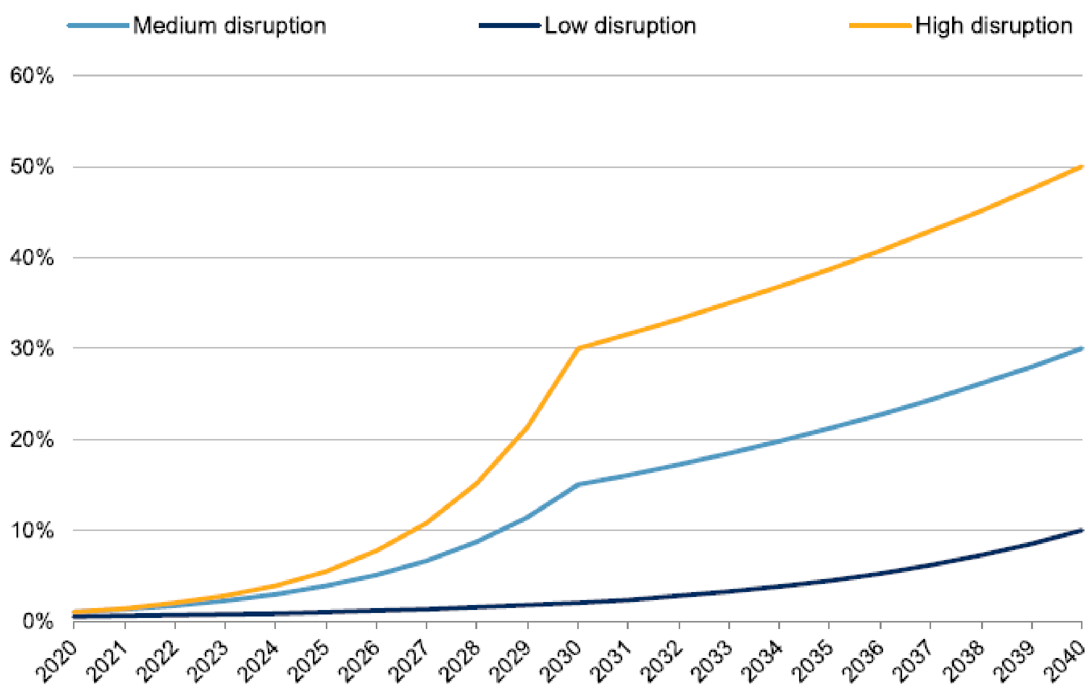
**CAVs:** The prominent topic that is starting to appear in vehicle technology is that communication between vehicles may be difficult across different brands. Even with current low-level automation features, such as emergency braking and adaptive cruise control, nearly every company has its unique name and systems in place for very similar features. If this isolated development continues with higher levels of automation, direct vehicle-to-vehicle communication may be difficult. To address this issue, research is being conducted for infrastructure systems that can coordinate between vehicles. While this would add an extra step to the process, it would give transportation agencies more control in how vehicles would interact, as these communication devices would likely be under transportation agency control and allow them to determine how vehicles coordinate their movements, much like they do with signals or ramp metering devices today.

### 3.3.2 The Future

**CVs:** CV technology will likely continue to see incremental improvements, with more advanced warnings and more integrated vehicles. In general, CV technology will assist travelers by providing them with information about features and activities. For example, CVs may provide additional information about road conditions or crashes. All of this information will still require humans to gather or provide data. What humans do with that information and whether they act on this information or  abide by the suggestions is beyond the system's control. Without the addition of AVs into the equation, CVs will probably not create a fundamental shift in our transportation networks. Instead, they will increase the safety and efficiency of our existing systems.

**AVs:** The impact that AVs will have on roads is much harder to predict. They may radically alter transportation, but how they do this remains unclear and can be impacted greatly by policy and planning. The first question to answer is how fast the vehicles will come to market. Once the technology becomes commercially available, it will not be offered on every car, and even when it is offered, it will carry a premium price tag. For example, automatic braking saw its first modern commercial deployment in Mercedes-Benz in 2003, and today it is offered as standard on approximately 30 percent of all vehicles. Most major vehicle features have taken nearly 20 years from the time they were first introduced to the time they were standard on all new vehicles. **Figure 3-23** shows a wide range of possible adoption curves for AVs.

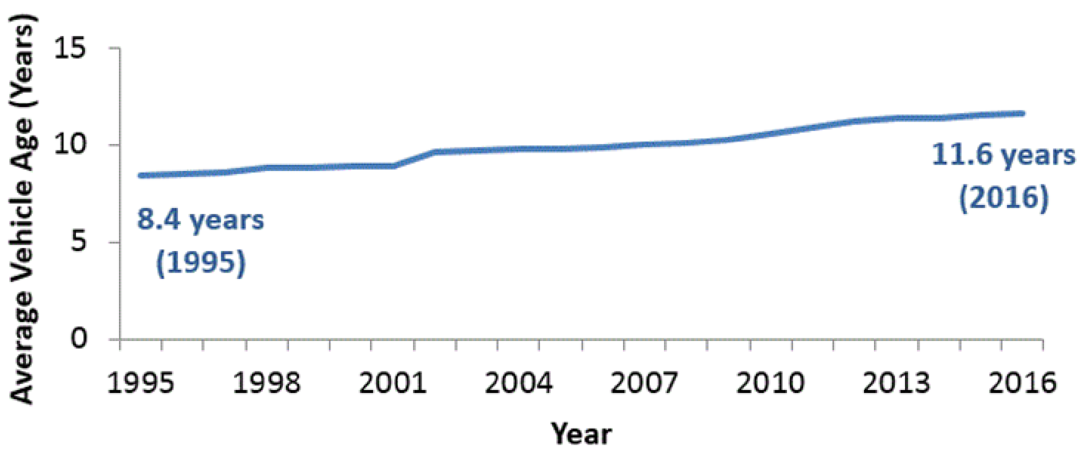
**Figure 3-23: Automated Vehicle Adoption Rate Forecast (2020-2040)**




Source: S&P Global Ratings, The Road Ahead for Autonomous Vehicles[127]

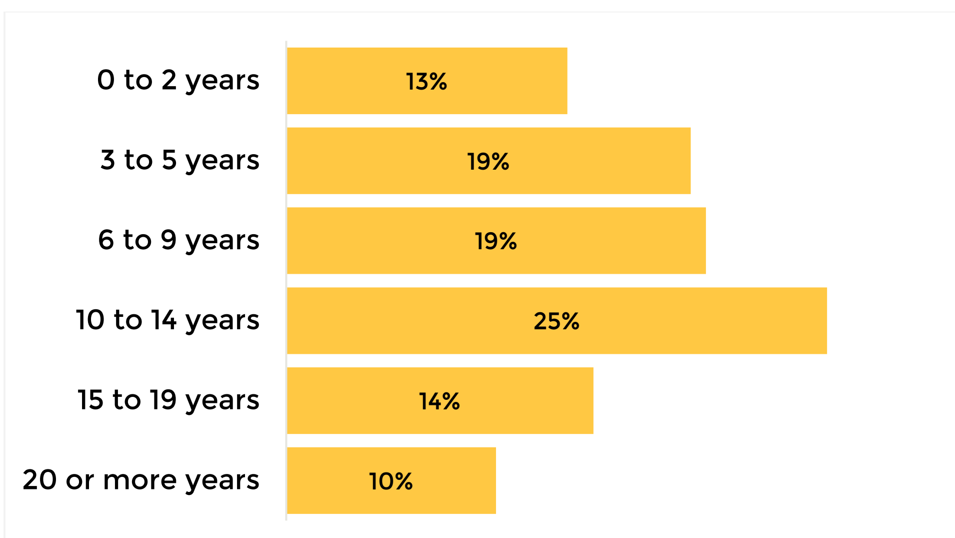
Based on a 20-year timeframe for a technology to become standard, it will take many years for these features to be widely adopted. The average age of vehicles has steadily been increasing (**Figure 3-24**) which means fleet turnover takes more time. The percentage of vehicles with the new features on the road will lag significantly behind those in the showroom. The average vehicle is over 10 years old, and many vehicles on the road are quite a bit older than that (**Figure 3-25**).

**Figure 3-24: Increasing Age of U.S. Light-Duty Vehicles**




Source: The Fuse. (2018). America's Aging Vehicles Delay Rate of Fleet Turnover.[128]

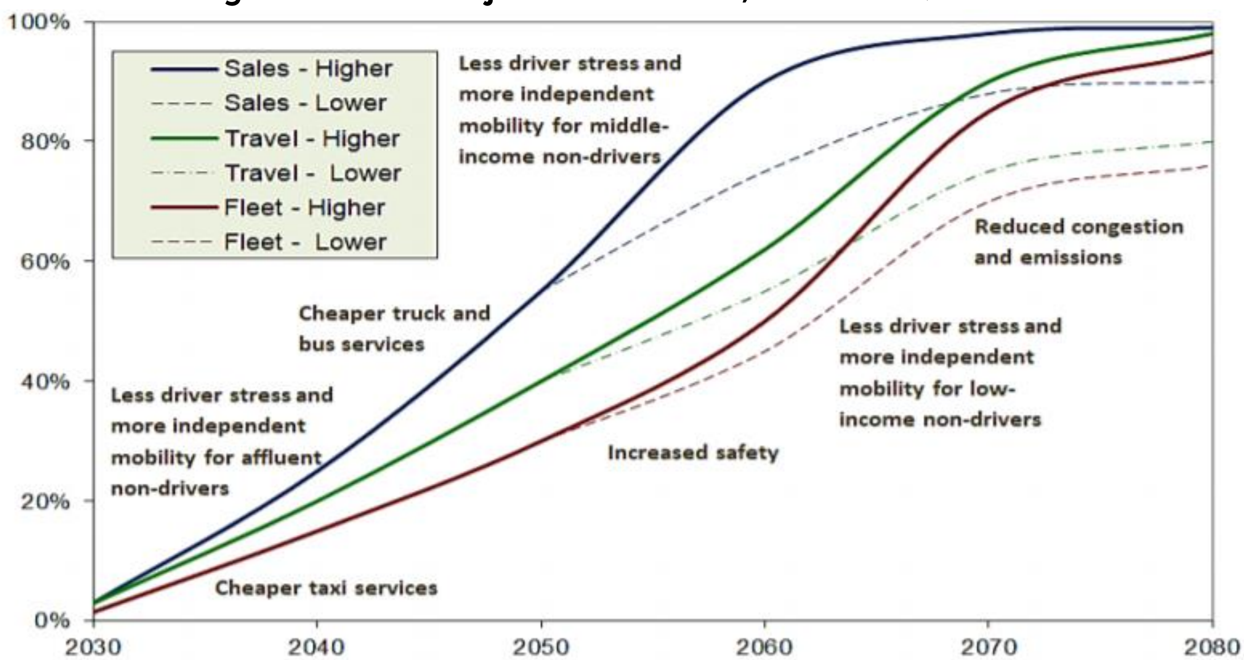
**Figure 3-25: U.S. Household Vehicle Age Distribution (Percent of Household Vehicles), 2017**




Source: USDOT, FHWA, National Household Travel Survey[129]

The uncertainty in the adoption of AVs is shown in **Figure 3-26** with some of the potential benefits. As sales of AVs increase, so will the percentage of the vehicle fleet and vehicle miles traveled by AVs. Benefits related to the adoption of AVs include improved safety, reduced congestion, and potentially less cost to the traveler.

**Figure 3-26: AV Projections for Sales, Fleet Size & Travel**




Source: The Victoria Transport Policy Institutue, Autonomous Vehicle Implementation Predictions, March 2020[130]

A variety of driver-assistance systems are getting close to autonomy in isolated situations. The features that generally fall into Level 1 and Level 2 autonomy are helpful to drivers and will possibly increase the public's acceptance of higher levels of autonomy. When the first fully automated (Level 4) vehicle is released with enough confidence and testing that it does not need a safety driver, as well as an operational domain large enough to provide useful services throughout a city, the U.S. will start to see the impacts of AVs.

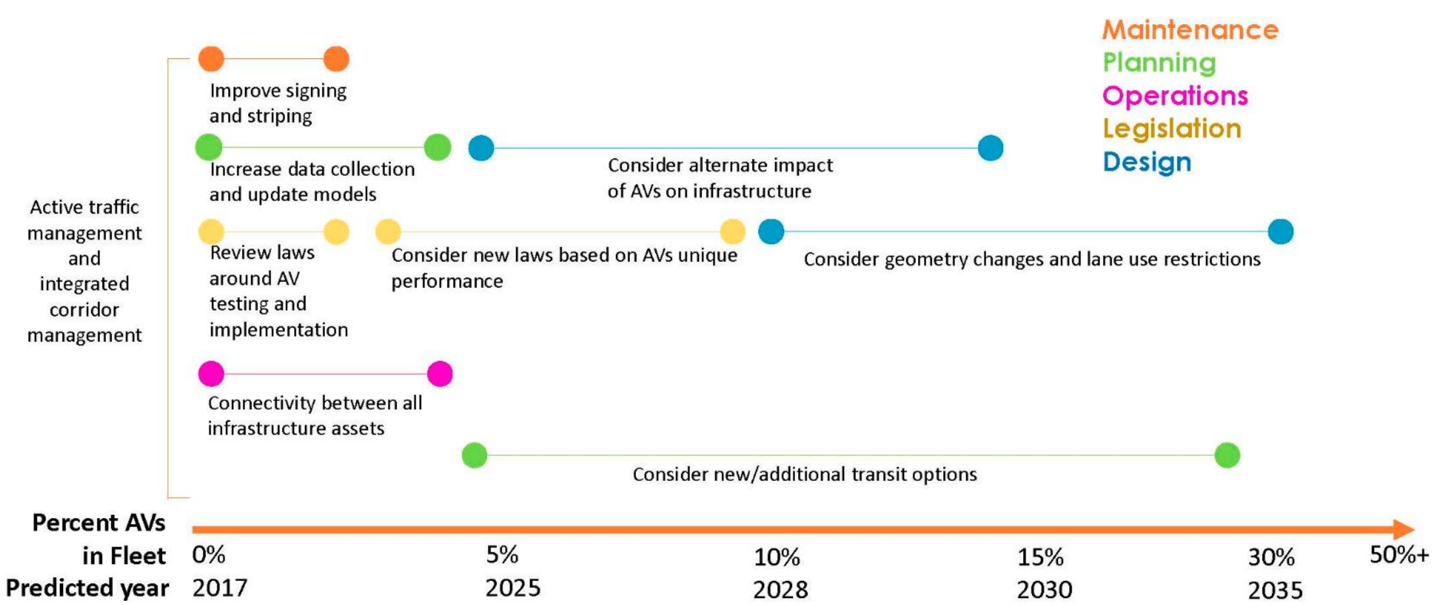
With the first fully automated vehicle (which estimates say could be available as soon as sometime in next one to five years), the deployment of AVs will likely occur rapidly among transportation network providers, such as ride-hailing services and trucking companies. These organizations have the capital for large-scale investments and would see a high return on investment by eliminating driver labor costs. These vehicles will quickly expand to cover more areas as they steadily increase their operational domain. The large initial investment by these industries will likely spur significant savings. Policies can also dramatically increase the trend. Going back to the example of automated braking, automated breaking was only in 30 percent of vehicles in 2018, however, auto manufacturers have agreed to make this a standard feature by 2022. This external policy will disrupt the standard adoption curve.

**CAVs:** The movement to CAVs would be the most dramatic future shift. When AVs receive additional information, they can use that information to coordinate movements and improve traffic flow. In a fully CAV future, vehicles would be able to seamlessly communicate with one another as well as the infrastructure around them. This interaction would include communicating with streetlights; identifying and reserving parking spots to avoid wasted driving and increase parking efficiency; and including pedestrians, cyclists and other road users in the transportation landscape safely and effectively. This scenario is still in the distant future, as many of these benefits would require 100 percent CAVs to operate. But, some of these interactions could begin to occur if there is a high percentage of CAVs in a localized area. This concentration could result from policy or design changes where only AVs can operate on certain facilities, such as central business districts (CBDs) or a portion of the highway in a separate lane.

### 3.3.3 Transportation Consequences

While it is unclear as to the extent to which Nebraska will see AVs, CVs, or CAVs adopted throughout the state, adoption of these technologies in the vehicle fleet will likely produce impacts for capacity, safety, travel demand, mode choice, and infrastructure. A possible deployment timeline for the impacts on the transportation system is shown in**Figure 3-27** for AVs based on the expected market penetration.

**Figure 3-27: Transportation Agency Deployment Timeline based on AV percentage**




Source: Burns & McDonnel TEAMs conference for MODOT LRTP

**Capacity:**
*AVs –* Minimal to significant effect on capacity, with slight improvements from smoother driving but potential for zero-passenger trips to challenge capacity. Safer driving will lead to fewer accidents that impede the roadway. More conservative driving behavior and larger following distances could reduce throughput on travel lanes. Increase in travel demand could challenge capacity.
*CVs -* Minimal impact from improved safety improvements, with slight improvements in progression and capacity on arterials.
*CAVs -* Large potential capacity improvements from safety measures but will require partnerships at the vehicle manufacturer level. Exclusive facilities could help realize greater benefits from these technologies. Large potentical decrease if travel demand increase from zero-passenger trips or more single-occupancy trips.

**Safety:**
*AVs -* Dramatic safety increases from better decision making; better awareness and no distractions.
*CVs -* Slight safety improvements through the advanced warning of certain hazards, such as icy roads or a vehicle running a red light.
*CAVs -* The largest benefit to safety, with all the benefits of AVs and better. More consistent utilization of the information provided from CVs.

**Travel Demand:**
*AVs -* Increase due to additional travelers including zero-passenger trips. Lower cost of travel time because other tasks can be performed.
*CVs -* Minimal impact; can reduce travel times by better route choice and assist in finding open parking.
*CAVs -* If able to travel at higher speeds, could increase miles traveled as the travel time budget of commuters would not be impacted.

**Mode Choice:**
*AVs -* AVs have the potential to improve transit and ride-hailing services, while also making private travel more convenient. This will be heavily shaped by how the market, policy, and programs develop.
*CVs -* Will allow better functionality for any system.
*CAVs -* Similar to AVs.

**Infrastructure:**
*AVs -* Less variability in driving location and behavior could lead to increased wear on portions of the pavement, reduced lane widths could be possible, increased marking/signing needs, and additional mapping or location-verification infrastructure such as GPS corrections stations.
*CVs -* Communication devices on infrastructure, 5G or DSRC in the field and roadside units, and ways to handle, transfer and process that data.
*CAVs -* Increased data generation and communication potential; possible exclusive facilities to maximize benefits.

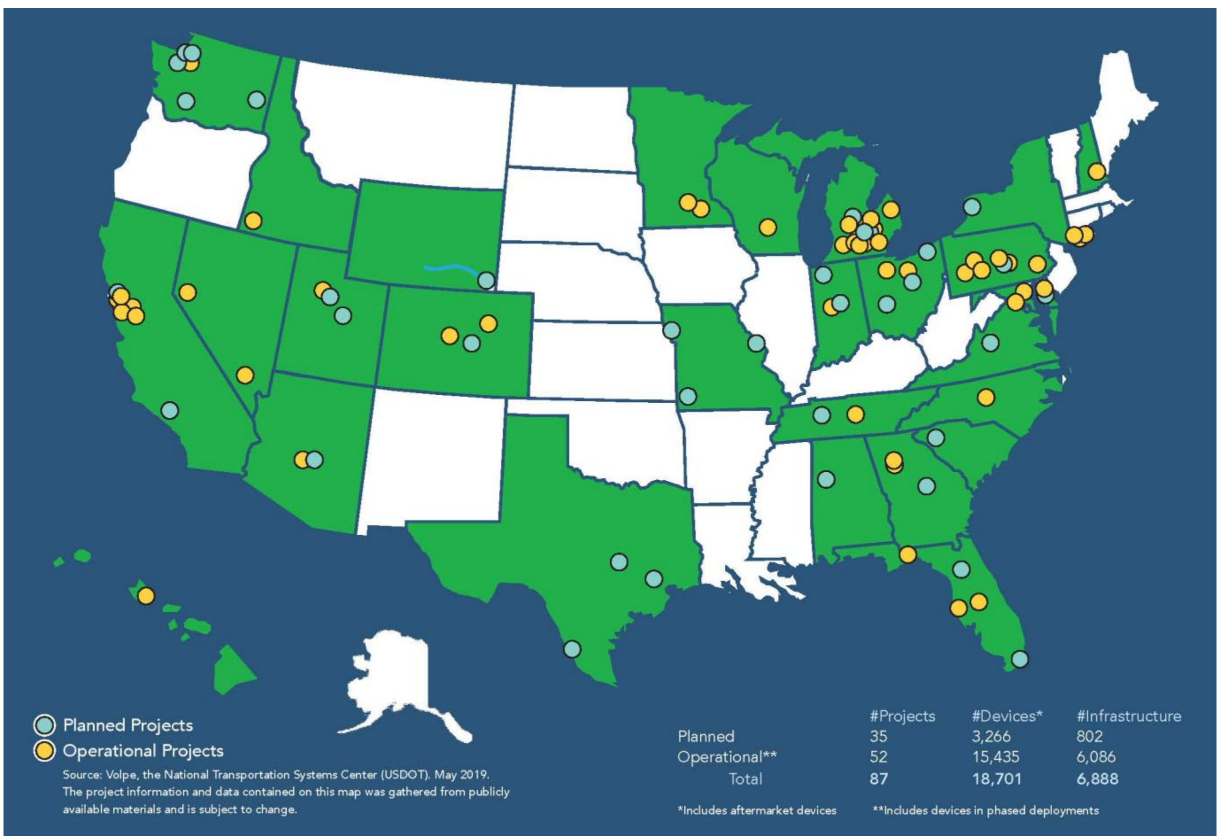
## 3.4 Smart Infrastructure

In the 1990s the Intelligent Transportation Systems Joint Program Office was created and began supporting the planning and deployment of intelligent transportation systems (ITS) and vehicle to infrastructure (V2I) systems.[131] Advancements in transportation technology, including CVs, AVs, and MaaS, have altered the design of transportation systems across the country that incorporate AI and the internet of things.[132] These advancements have been supported by the growth of ITS and connected infrastructure devices to allow real-time communication of travel conditions to vehicles.

### 3.4.1 Trends

Improvements in ITS and vehicle to everything (V2X) technology have been deployed and tested around the country. While V2X technology is being tested, a national debate is occurring between DSRC and 5G technologies to determine the best approach for V2X communications. Additionally, the USDOT is debating the dedication of the 5.9 Gigahertz (GHz) safety spectrum for connected transportation technology. In 2019, ITS America identified 87 projects using 18,701 devices either planned or operational for CVs across the country, as shown in **Figure 3-28**.

**Figure 3-28 CV Deployment Locations – Planned and Operational**




Source: USDOT[133]

Existing technologies that are being implemented across the country include:

*Adaptive Traffic Signals/Traffic Control Devices:* Adaptive traffic control is a technology that modifies signal timing based on real-time traffic conditions that has been widely used since the 1970s. However, modern systems rely more heavily on data to enable communications between corridors and employ more sophisticated control. As a result, they are beginning to incorporate detailed vehicle data through V2I connections.

*CV Test Deployments and Simulations:* CV systems can take many forms. The simplest is a data connection to the vehicle that can provide information about the location of a vehicle to other vehicles, or roadside devices. An example of these applications is using the vehicle as a data collection "probe" to gather information about traffic speed and congestion.

*CV Traffic Control Interaction:* Passenger vehicles can also benefit from V2I integration with traffic signal systems. Advisory speed limit systems as a speed harmonization approach, for example, can reduce delay caused by stop-and-go traffic by 15 percent. SPaT data combined with vehicle trajectory information can provide speed and movement advice to CVs, which models show can reduce urban fuel consumption by 58 percent.

*Integrated Corridor Management (ICM) Approaches:* ICM leverages technology deployment and management plans across adjacent roadways where traffic may interact during recurring or incident-related congestion. The use of CV technologies in combination with traditional ITS deployments can provide a greater benefit. The active management (lane guidance on freeway, signal timing on arterials, etc.) techniques can be enhanced by leveraging the applications described above.

### 3.4.2 The Future

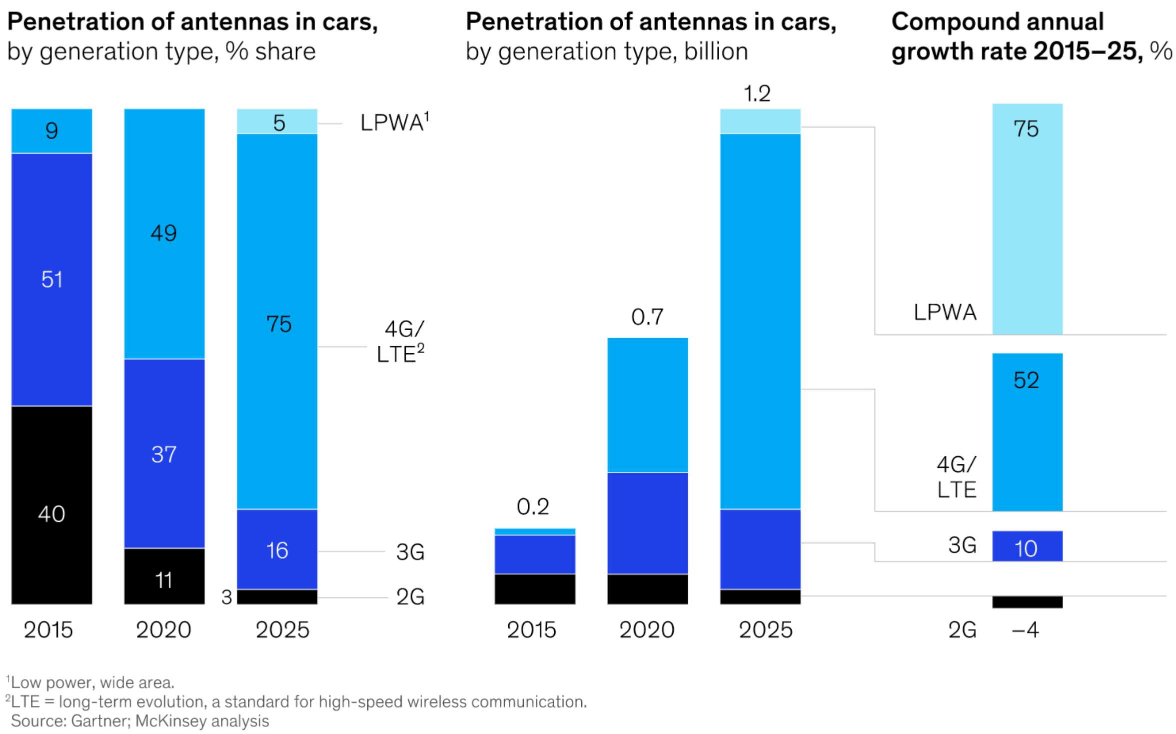
It has been estimated that there will be hundreds of millions of vehicles with CV technologies by 2025.[134] Other reports estimate that nearly six million V2X-equipped vehicles will be on roads worldwide by 2022 with a potential estimated market of $1.2 billion.[135] Regardless of the number of V2X ready vehicles on the road in the next few years, it is likely that new vehicles will include advanced technologies that can improve driver safety or provide data related to driving conditions.

A key driver of the adoption and expansion of V2X infrastructure will be the implementation of devices in vehicles. Auto manufactures will likely push the need for connected infrastructure in cities and rural areas. For example, Ford has announced its vehicles will be equipped with wireless technology by 2022 and expect to launch self-driving vehicle sales by 2021.[136] Transportation agencies will likely be responsible for deploying technology to communicate with connected devices in vehicles within the transportation right-of-way.

Additionally, there are opportunities for public-private partnerships to deploy smart technology.

With connected infrastructure in place, CVs and V2X technologies will be collecting and processing copious amounts of data. By one estimate, more than four terabytes of data will be generated per day by these new vehicles.[137] The data transmission will likely rely on antennas in the vehicle with data being submitted to roadside devices. **Figure 3-29** shows the increase in antenna penetration by type, showing the changes in technology through 2025. [138]

**Figure 3-29: Vehicle Antennas in Cars by Type**




Source: McKinsey & Company

### 3.4.3 Transportation Consequences

Transportation consequences related to the implementation of connected infrastructure technologies are like those that will be accomplished by the adoption of the complementary technologies of CVs and AVs. The three most cited benefits of CVs and associated technologies are safety, traffic mobility, and emissions.

**Safety:** Enhancements to vehicle technology are expected to improve safety through real-time data analysis and warning systems. The vehicle-to-vehicle, pedestrian, or roadside unit will provide 360-degrees of data on conditions around the vehicle to enhance driver awareness of immediate situations and advanced warning for events further down the road.[139] According to NHTSA, V2X technologies are estimated to prevent up to 413,000 to 592,000 crashes, save 777 to 1,083 lives, and reduce 191,000 to 270,000 injury crashes.[vi][140] Additionally, safety applications are expected to reduce left-turn crashes by 36 to 62 percent.[141] These numbers reflect only vehicle-to-vehicle crashes but pedestrian identification, warning notifications and features such as automatic braking could help prevent pedestrian and bicycle crashes as well.

**Traffic Mobility:** Traffic mobility effects are typically estimated based on reductions in travel times. The USDOT has estimated that V2I applications will have impacts to travel time through improved traffic signal timing. According to field testing for V2I applications, travel time could be reduced by up to 27 percent. Emergency responders and transit vehicles would also benefit from the implementation of V2I technologies at intersections. USDOT estimates that emergency responder travel time could be reduced by 23 percent. Lastly, V2V technology and adaptive cruise control could reduce travel time on freeways by up to 42 percent through speed harmonization.[142]

**Emission Reductions:** Approximately 28 percent of the nation's greenhouse gas emissions are produced by the transportation sector.[143] With the implementation of V2I technologies, greenhouse gas emissions are expected to be reduced. Based on traffic simulations, signal and freeway operation improvements could improve fuel savings by up to 22 percent. Through "eco-signal" operations carbon dioxide emissions could be reduced by 11 percent.[144]

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[vi] This NHTSA estimate is based on a relatively aggressive technology installation, including aftermarket installation starting in 2020. Sales are projected through 2050.

# 4 External Influences

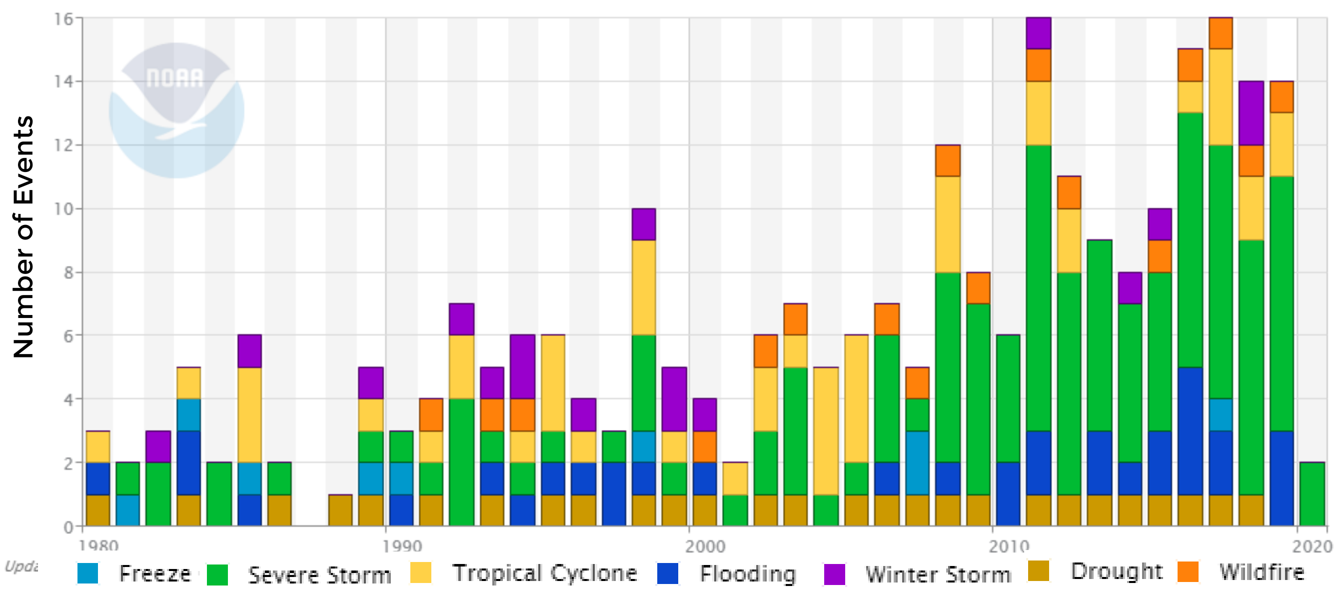
# 4 External Influences

External influences identified through the stakeholder engagement process for the 2040 Statewide Transportation Plan fit within two themes: weather extremes and federal funding. Recent impacts of weather events, primarily flooding, are fresh in stakeholders' minds and levels of and shifts in funding can significantly stress or challenge maintenance of the transportation system.

## 4.1 Weather Extremes

Globally, the climate is changing at a pace faster than natural variations throughout Earth's history. Between 1901 and 2016 global average temperature has increased by about 1.8 degrees Fahrenheit and has contributed to a growing number of extreme weather events. Since 1980, the number of one-billion-dollar extreme weather events has increased significantly (**Figure 4-1**). The Fourth National Climate Assessment from the U.S. Global Change Research Program (USGCRP) and the Environmental Protection Agency (EPA) states "the last few years have also seen record-breaking, climate-related weather extremes, the three warmest years on record for the globe, and continued decline in arctic sea ice. These types of records are expected to continue to be broken in the future". Future average temperatures over the contiguous United States are expected to increase by 2.2 degrees Fahrenheit regardless of future model scenarios. Nebraska and the world need to be prepared for extreme weather consequences. [145]

**Figure 4-1: U.S. Billion-Dollar Events, 1980-2020 (cost adjusted for inflation)**



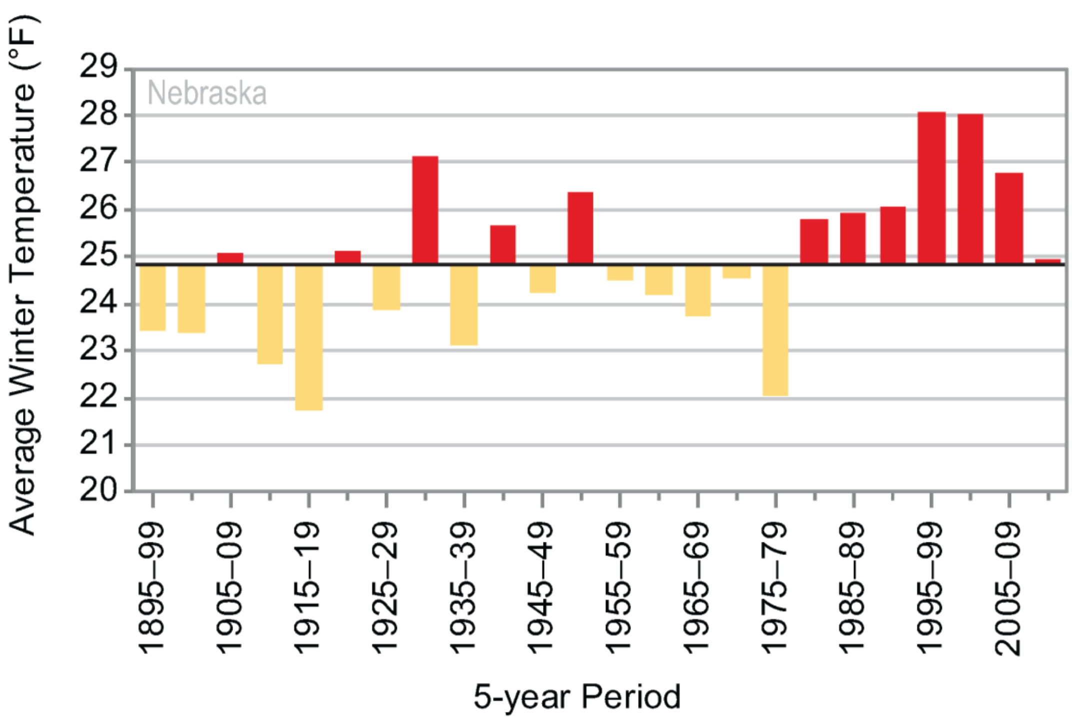

Source: NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2020).[146]

Nebraska's diverse environment puts it at risk of numerous weather events. Thousands of miles of rivers and the eastern Missouri River border means flooding can and has caused serious catastrophes including the March 2019 floods that totaled more than $1.3 billion in damage.[147] During winter months, snow and ice storms can cause travel and infrastructure hazards. Western Nebraska has a history of winter blizzards and along with North and South Dakota has the highest probability of blizzards in the nation (greater than 50% probability a blizzard occurs in any given year). Southwestern Nebraska also sits in the most hail-prone area of the nation (also known as "Hail Alley") and the whole state experiences the fifth-highest number of tornadoes with 57 per year. [148]

### 4.1.1 Trends

Nebraska has a history with climate changes and extreme weather events. Since the 1900s, Nebraska's average temperature has increased by approximately one-degree Fahrenheit spurred by a concentration of warmer winters and springs.[149] **Figure 4-2** displays five-year average winter temperatures in Nebraska compared to the long-term average (the horizontal base line).

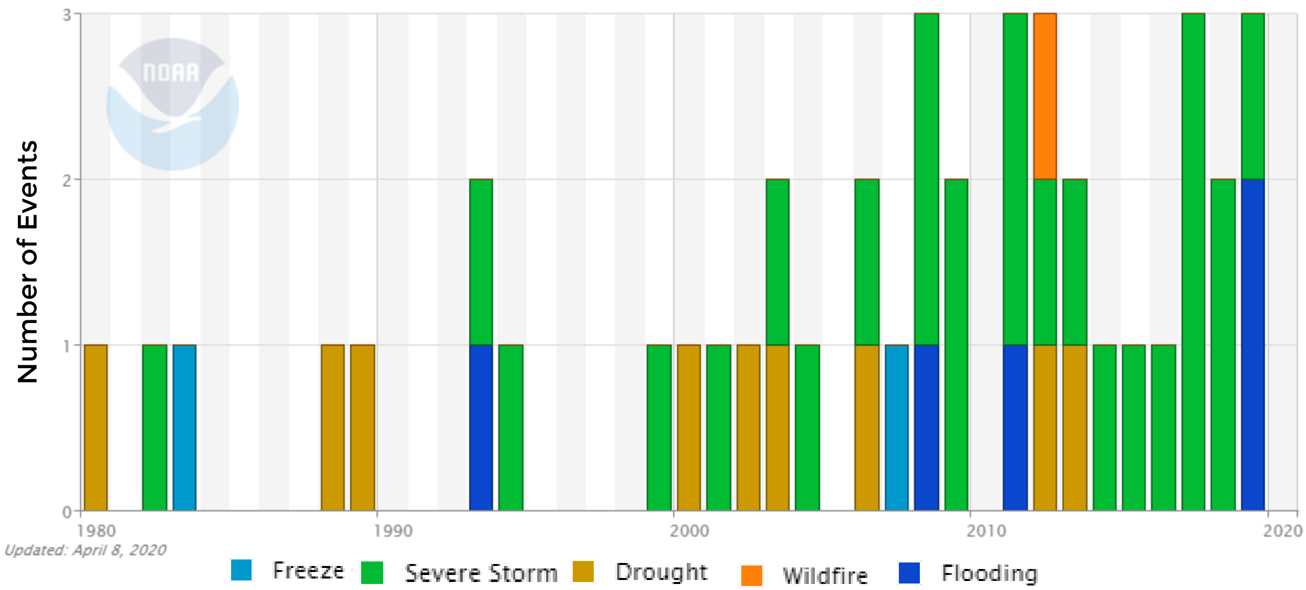
**Figure 4-2: Observed Winter Temperature**




Source: NOAA National Centers for Environmental Information[150]

Nebraska's precipitation has historically been very variable; the statewide annual precipation average ranges from 13.36 inches of precipitation (2012) to 35.50 inches (1915). This variability paired with warm summer months creates a vulnerability for severe drought. Most famously, the 1930s Dust Bowl era saw dry conditions exacerbated by extreme heat.[151] More recently, 2012 was Nebraska's driest year on record 2012 with only 3.74 inches of summer rain that led to over 75 percent of the state experiencing severe drought conditions that significantly and negatively impacted non-irrigated crop yields and pasture conditions. That drought became the state's costliest weather disaster, costing an estimated $4 billion in losses.[152] Like the nation, Nebraska has also experienced in increase in the number of billion-dollar weather events (**Figure 4-3**).

**Figure 4-3: Nebraska Billion-Dollar Disaster Events, 1980-2020 (costs adjusted for inflation)**




Source: NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2020).[153]

While the amount of rain has been variable, the frequency of heavy rain events has increased in recent years. The heavy rain events and winter weather patterns in Nebraska and nearby states define the potential for floods for the thousands of miles of rivers throughout the state. For example, in June 2011, runoff from record winter snowpack in the Rocky Mountains paired with heavy rains to cause major flooding of the Missouri River; in Omaha, the river crested at 36.29 feet[154] (normal height is around 19 feet and the action stage is 25 feet).[155]

**Infrastructure:** The infrastructure costs of extreme weather events is no stranger to Nebraska. In March 2019, severe winter storms carried freezing rains, ice and heavy snow to the Great Plains. The rain and snowmelt runoff lead to widespread historic flooding as shown in the NDOT images in **Figure 4-4** and **Figure 4-5**. The estimated damage on both state and local federal routes is near $200 million. At the peak of flooding over 3,300 miles of roads were closed and the aftermath left approximately 200 miles of pavement in need of repair in addition to 27 damaged state bridges.[156] Repairs to federal-aid highways are being supported by a $68 million Emergency Relief reimbursement from FHWA and $25 million in FHWA Quick Release funds for local government reimbursement.[157]

**Figure 4-4: Highway 91 Flood Damage**

**Figure 4-5: Highway 12 Mormon Canal Bridge Washout**

In total, Nebraska suffered more than $3.4 billion in losses from disastrous weather in 2019.[158] This total only covers one year and the costs of weather response, but daily operations and the long-term health of infrastructure are also impacted by Nebraska's climate.

**Distribution of Travel:** Weather events have the potential to impact the number of people traveling and the places they travel. The eastern Nebraska Town of Winslow, for example, has started researching and planning for the option to relocate. Relocation was raised after repeat flooding cumulated in the 2019 flood which left many structures damaged. Due to the town's location on the flood-plain, repairs would be expensive to meet strong building code and flood planning regulations.[159] Voluntary relocation of individuals and towns is just one form of change that may redistribute population and travel. As water tables and flood plains change, community or transportation infrastructure can become financially infeasible or unsafe to maintain and use.

**Planning:** Maintaining a system of sustainable and resilient transportation infrastructure in addition to the use of water, land and energy resources requires participation from numerous landowners and stakeholders. Infrastructure construction and planning occur over a long-time frame and as a result, climate changes must be considered early on. Infrastructure planning to-date meets national requirements like the National Environmental Policy Act (NEPA) but is limited in its understanding and consideration of resiliency impacts of the future. In 2014, Nebraska completed a statewide climate change assessment report which led to facilitated roundtable discussions of eight sectors in 2015.[160] The resulting report identified a suite of key issues and next steps that failed to gain legislative approval. [161]

Locally, some communities are moving ahead with resiliency planning. The Mayor of Lincoln launched a sustainability and resiliency initiative to lead a Climate Action Plan in July 2019.[162] Nationally, legislation that funds the federal-aid highway program was proposed in the reauthorization under America's Transportation Infrastructure Act of 2019. The Senate bill called for funding for resiliency planning and response but has not advanced as of February 2020. [163]

NDOT is deploying some advanced weather planning systems. The Maintenance Decision Support System (MDSS) is a computer application for managing and improving highway maintenance practices during winter weather events. Combined with Automatic Vehicle Location (AVL) and Mobile Data Collectors (MDCs), NDOT maintenance managers can view sophisticated weather and pavement models, plow truck locations, camera views of roads ahead, material usage, and more. Snowplow operators receive current and predicted weather information, location of other plow trucks, and recommended material application rates and time to apply.

### 4.1.2 The Future

The U.S. Global Change Research Program produces the National Climate Assessment (NCA) to assess the impact of climate change on the United States using various projections and a team of experts. The fourth NCA, released in 2018, outlines a series of climate changes that will impact Nebraska in the years to come:

- Higher probability of very hot days (days with maximum temperatures above 90°F),
- Many fewer cool days (days with a minimum temperature less than 28°F),
- Continued average precipitation variability, and
- An increasing number of heavy precipitation events (events with greater than one inch per day).

The combination of these changes will have a particularly large impact on water management throughout the Northern Great Plains. Small changes in annual precipitation or snowmelt have large effects downstream.

**Infrastructure:** The future of infrastructure starts with planning today. The impacts of climate change and extreme weather events compound to increase the cost of maintaining infrastructure. Infrastructure that is approaching or beyond its design life is particularly at risk. The American Society of Civil Engineers (ASCE) estimates that there is already a $1.2 trillion gap in transportation infrastructure needs.

Warming winters will change the timing and location of freeze and thaw events, potentially increasing pavement cracking and pothole conditions. Meanwhile, bridge failure is the most common side effect during unprecedented floods. Even during less extreme floods, bridge scour (sediment around piers and abutments is washed away) occurs with heavy precipitation and flooding, compromising a bridge's structural integrity. Warming temperatures can also stress bridge integrity in addition to weakening rail tracks and disrupting air travel. As stated in the Fourth National Climate Assessment:

> *"Elevated temperature, combined with increased salinity and humidity, accelerates deterioration in bridges and roads constructed with concrete. Higher ambient temperatures and extreme heat events can negatively impact pavement performance and, in turn, increase costs due to material upgrades to accommodate higher temperatures; these costs are only modestly reduced by less frequent maintenance. For example, fixing pavement distress caused by a 2011 heatwave and drought cost the Texas Department of Transportation (DOT) $26 million (dollar year unspecified)."*[164]

The infrastructure impacts of climate change and weather events are vast and will continue as national transportation infrastructure ages.

**Distribution of Travel:** As weather changes throughout the state, the need for and reliability of the transportation network may change. Changes in floodplains and water tables may reduce the need for or practicality of maintaining certain routes. The exact allocation and distribution of travel are unknown, the potential for change is very real.

Travel changes and disruptions in urban environments have the potential to be amplified by infrastructure (including non-transportation infrastructures such as energy and telecommunications systems) experiencing greater demand. However, urban settings have a greater chance of transportation network redundancy that can be used in extreme weather events. During Superstorm Sandy, for example, bus service in New York City was able to compensate for flooded subway tunnels and walking served as a source for others.[165] Rural and suburban transportation systems, however, are often less redundant and increase dependence on each road and bridge. A washout or a floodplain change in a rural area could cut off access that is costly or impossible to address.

**Planning:** The future of resiliency planning is being formed today. The risks to transportation have drawn increased attention to identifying and addressing vulnerability and reactions across the transportation network. Resiliency and vulnerability planning will continue to be important for transportation practitioners.

### 4.1.3 Transportation Consequences

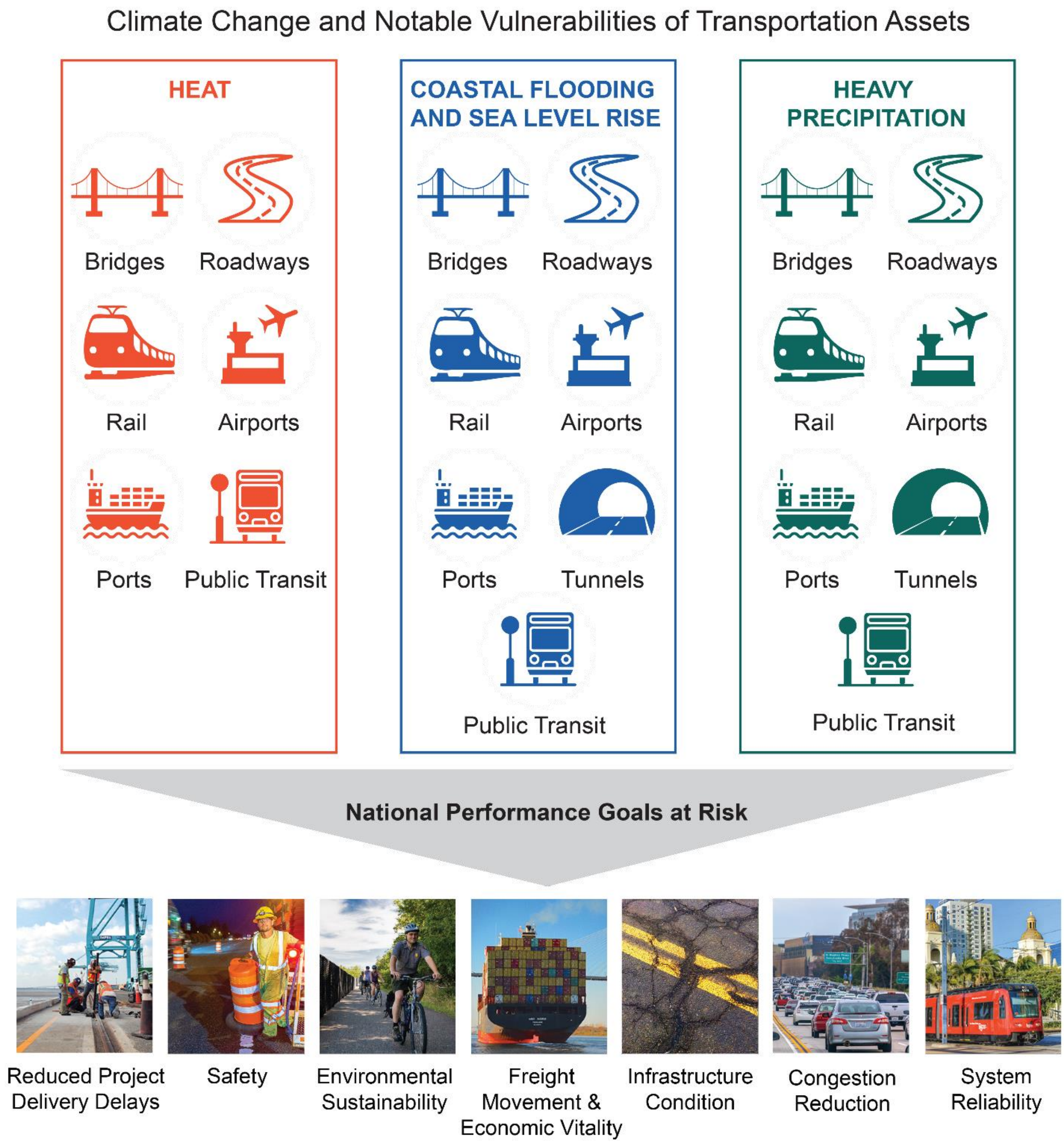
The changing weather extremes of Nebraska's future come with numerous transportation consequences. **Figure 4-6** from the U.S. Global Change Research Program displays some of the potential consequences. Two of the most pressing concerns are:

**Funding:** Infrastructure preparation, emergency response, and post-event repair come at a cost. Federal support may be available to help, as is the case with the March 2019 flooding's $68 million Emergency Relief reimbursement from FHWA. As the nation experiences more extreme weather events, federal agency funding will be in high demand across the country. Ongoing maintenance costs and reserve financing will be funding needs for both current and future transportation systems.

**Safety:** From bridge wash outs to winter road conditions, weather can present shocks to the system that create unsafe situations for travel. Additionally, frequent weather events or extreme weather conditions (such as very hot or cold days) add stress to transportation infrastructure, leading to asset deteriation that can cause infrastructure failure.

**Reliability and Delay:** Weather of all kinds can slow travel and create delays on the road, tracks, and air. For example, a Transport Policy report found climate change is anticipated to increase railway delay costs by $25-$60 billion (in 2015 dollars).[166] In Nebraska, from 2014 through 2018, the 5-year rolling average of minutes per closure due to weather was 434.8 minutes, a 6.4 percent increase from the previous 5-year rolling average.[167]

**Figure 4-6: Transportation Assets and Goals at Risk[168]**




Source: U.S. Global Change Research Program

## 4.2 Federal Funding

Transportation planning, infrastructure, and construction are largely dependent on federal funding. When discussing influences with NDOT staff, it was recognized that the uncertainty related to funding is an influence that will continue to impact the Nebraska transportation system and well as NDOT. Throughout discussions it was also clear that potential changes in priorities for the transportation system will also influence how funding is provided.

### 4.2.1 Trends

#### Federal Authorizations and Extensions

The Fixing America's Surface Transportation (FAST) Act (Pub. L. No. 114-94) is the current federal legislation authorizing the federal surface transportation program. The FAST Act funds six formula programs for federal-aid highways:

- National Highway Performance Program (NHPP);
- Surface Transportation Block Grant Program (STBG);
- Highway Safety Improvement Program (HSIP);
- Congestion Mitigation and Air Quality Improvement Program (CMAQ);
- Metropolitan Planning; and
- The National Highway Freight Program (NHFP).

The FAST Act authorized $207.4 billion in contract authority to the states over five federal fiscal years to maintain their highway systems ($39.7 billion in FY 2016, $40.5 billion in FY 2017, $41.4 billion in FY 2018, $42.4 billion in FY 2019, and $43.4 billion in FY 2020).[169]

The FAST Act is scheduled to expire on October 1, 2020. Ideally, by this time Congress will have passed, and the president will have signed, a new multi-year authorization act. However, this may not happen, as has occurred at the expiration of the two previous authorization acts. Congress may instead pass continuing resolutions, which short-term extensions are of otherwise expired authorization acts.

For example, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) expired on September 30, 2009, and was temporarily extended through June 30, 2012, with nine separate pieces of legislation. The Moving Ahead for Progress in the 21st Century Act (MAP-21) expired on September 30, 2014, and was temporarily extended through December 4, 2015, with five separate pieces of legislation.

Continuing resolutions pose challenges to state departments of transportation from planning and cash flow perspectives. If recipients of federal-aid highway, transit, and/or passenger rail funding face short-term uncertainty over whether their eligible expenditures will be reimbursed, it affects their ability to deliver projects and to plan their work programs. Also, it requires them to be more conservative with their cash planning, jeopardizing their ability to deploy the full measure of federal funding that they have been apportioned under law.

### *Nebraska's Share*

Under SAFETEA-LU, the FHWA was required to apportion Federal-Aid Highway Program (FAHP) funding to the various states through formulas calculated on annual measures of factors such as:

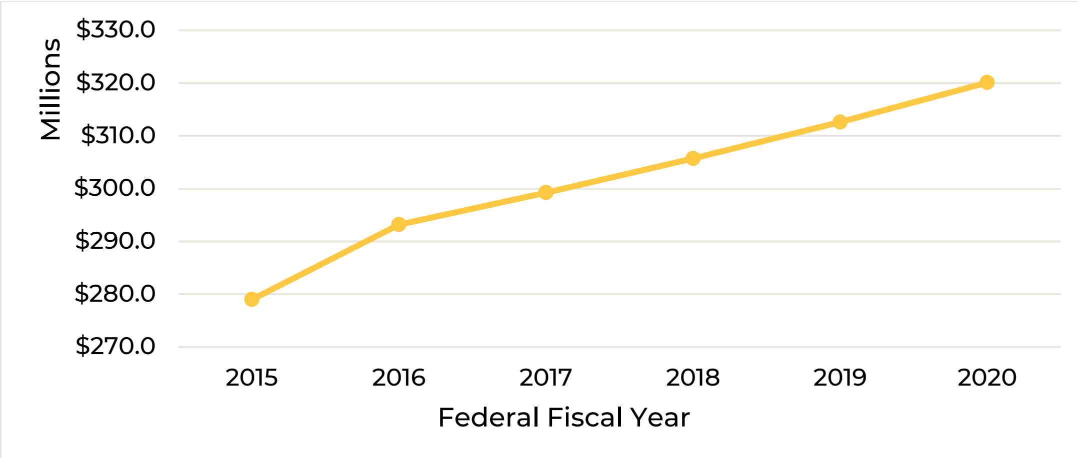
- Interstate System lane miles
- VMT on interstates
- Annual Highway Trust Fund (HTF) contributions attributable to commercial vehicles
- Lane miles on principal arterial routes excluding interstates
- VMT on principal arterial routes excluding interstates
- Diesel fuel used on highways
- Lane miles on principal arterial highways divided by population
- Lane miles of Federal-aid highways
- VMT on Federal-aid highways
- Tax payments into the HTF attributable to highway users
- The relative share of the total cost to repair or replace deficient highway bridges
- Weighted Clean Air Act non-attainment and maintenance area populations
- Number of fatalities on the Federal-aid system

Rather than updating the annual data underlying these formulas, or devising new formulas, subsequent FAHP authorizations have calculated all states' apportionments based on their proportions of total funding received in the final 2012 SAFETEA-LU extension, including earmarks.[170]

Nebraska is presently apportioned 0.74 percent of the entirety of all formula funding in the FAHP.

**Figure 4-7** shows the trajectory of funding apportioned to Nebraska under the FAST Act on the following page.

**Figure 4-7: FAST Act Highway Program Apportionments to Nebraska (includes 2015 actuals)**




Source: FHWA (2015).[171]

### 4.2.2 The Future

Motor fuel taxes and additional truck-related taxes that support the Highway Trust Fund are eroding due to technological advancements in fuel economy and the adoption of vehicles whose fuel is not subject to federal motor fuel taxation under current law. The basis of motor fuel taxation – that it is an effective and efficient approximation of a user fee for the highway system – has been undermined.

In addition, Congress's decision to not adjust the fuel tax rates to account for inflation since 1993 has eroded the purchasing power of the states' apportionments of federal funding. The 18.4 cent-per-gallon federal tax on gasoline has about one-third less purchasing power than it did when the tax was last raised in 1993.[172]

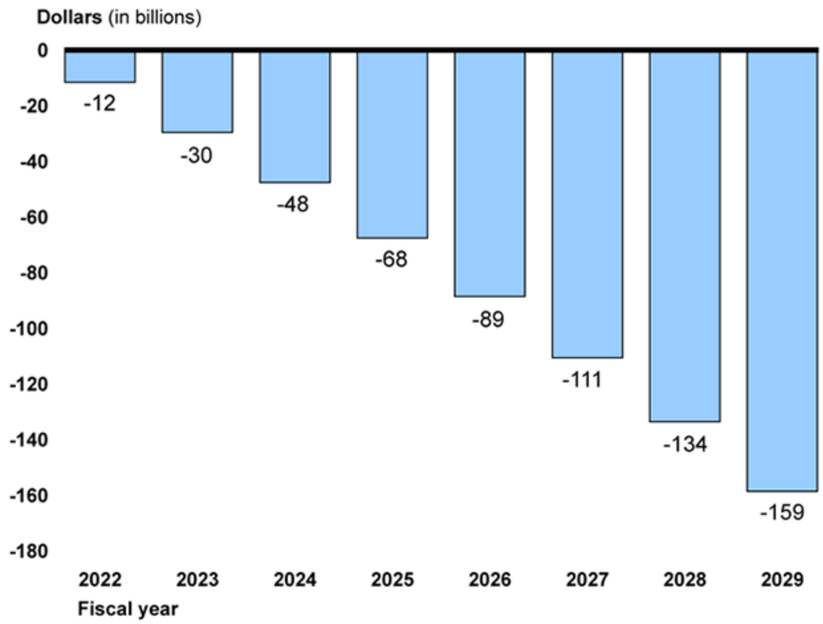
While tax receipts into the HTF have stagnated, outlays from the HTF have not. The inadequacy of current federal motor fuel taxes to sustain outlays has created a structural imbalance in the finances of the highway and mass transit accounts of the HTF.

Highway user-generated revenue was sufficient to cover outlays until 2008, but since 2008 Congress has sustained the HTF's level of outlays by transferring $140 billion of federal general funds to the HTF, including $70 billion in 2016 alone.

Assuming that current obligation limitations enacted in the Consolidated Appropriations Act grow by inflation through 2029, the Congressional Budget Office (CBO) projects cumulative shortfalls of $124 billion in the Highway Account, and $47 billion in the Mass Transit Account, by 2029.[173]

Another non-partisan congressional information service, the Government Accountability Office (GAO), has published similar projections. In **Figure 4-8**, the GAO projects a combined cumulative shortfall of $159 billion by 2029.

**Figure 4-8: Projected Cumulative Highway Trust Fund Highway Account Balance**




Source: Government Accountability Office (2019).[174]

Without a ready-made replacement for federal motor-fuel taxation, the two options to maintain current levels of federal financial support for highways, transit, and passenger rail are a substantial motor fuel tax increase or ongoing subsidies from the federal general fund. According to the Eno Center for Transportation, an immediate 11 cents-per-gallon increase in federal fuel taxes split 71 percent to highways and 29 percent to transit would maintain the Highway Account's and Mass Transit Account's solvency through 2030.[175]

In the future, it appears likely that there will be a transition away from fuel taxation as the principal federal funding source for the federal highway, transit, and passenger rail programs. While timing and specifics remain unclear, successive federal authorization acts have given states options for funding improvements and maintenance of federal-aid highways through direct charges for the use of the highway facility. The following programs are already available to transportation agencies under current law:

1. The 1998 Transportation Equity Act for the 21st Century (TEA-21) created the Interstate System Reconstruction and Rehabilitation Pilot Program (ISRRPP)[176]. ISRRPP allows a State to collect tolls on a facility on the Interstate System to reconstruct or rehabilitate an interstate highway

corridor that could not otherwise be adequately maintained or functionally improved without the collection of tolls.

2. The 1991 Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) Value Pricing Pilot Program (VPPP)[177] allows for implementation and evaluation pricing to manage congestion on highways through tolling and other mechanisms under certain circumstances.

3. MAP-21 expanded on the types of federal-aid facilities and projects eligible for tolling under 23 U.S.C. § 129.[178] Transportation agencies may impose new tolls on federal-aid highways in the following circumstances:

   - Initial construction of a new highway, bridge, or tunnel
   - Initial construction of new lanes on highways, bridges, and tunnels (including interstates), if the number of toll-free lanes is not reduced
   - Reconstruction or replacement of a bridge or tunnel
   - Reconstruction of a highway (other than an interstate)
   - Reconstruction, restoration, or rehabilitation of an interstate highway, if the number of toll-free lanes is not reduced

4. A provision in SAFETEA-LU known as Section 166 (23 U.S.C. §166) created the HOT/HOV Lane Program[179], which allows High Occupancy Vehicle (HOV) lanes to be converted to High Occupancy Toll (HOT) lanes with variable pricing and electronic toll collection with approval from the local Metropolitan Planning Organization (MPO).

### 4.2.3 Transportation Consequences

Potential consequences from the stark imbalance between HTF revenues and outlays and from political challenges related to the timely multi-year reauthorization of the federal surface transportation program include:

**Shift to System Preservation:** Faced with stagnant federal financial support and uncertainty around the magnitude and timing of federal reimbursements, transportation agencies may be less inclined to invest in major projects to expand their transportation systems. Instead, they could focus more on system preservation projects whose magnitude is small enough as to not pose cash flow issues in the event of the temporary unavailability of federal reimbursements.

**Capacity:** As major external demographic forces cause the United States to become more urban, the combination of more motorists attempting to use facilities at peak hours and a lack of dynamic pricing that reflects the external costs imposed by congestion will lead to gridlock on urban highway facilities. Localized population growth will tend to increase land values, which in turn increases the cost of acquiring right of way. This will restrict transportation agencies' ability to expand urban facilities or to address congestion hot spots through geometric reconfiguration or interchange modernization.

**Tiering of the Highway System:** If today's level of federal financial support for surface transportation cannot be sustained through motor fuel tax increases and/or federal general fund transfers to the HTF, transportation agencies may need to concentrate a larger share of their reduced federal funding towards maintaining strategic assets such as interstates and non-interstate segments of the NHFN. This could create a triage-like effect where state resources that maintain more marginal elements of the state highway system are reallocated to state highways with greater passenger traffic and/or freight volume. An extreme outcome would be that lesser state highways are left to go to gravel or are abandoned altogether. Major reallocation of state resources in the event of a significant reduction in federal funding would likely cause political tension between urban and rural parts of states, with transportation agencies caught in the middle.

**Increased Pressure on Local Governments:** If marginal highways see drastic reductions in funding or are abandoned due to the cascading effects of sharply reduced federal funding, local governments may face added pressure to fund the highway system. Especially in rural areas, local governments may not have the tax base to meet such a challenge.

**Reduced Mobility:** A significant reduction in federal funding could significantly reduce mobility, to the detriment of the economy and quality of life. Whether due to increasing congestion in urban areas or diminished rural highway facilities, a contraction in the geographic area that constitutes a feasible commute would raise structural unemployment. Combined with reduced support for transit through the HTF Mass Transit Account, vulnerable populations would experience the greatest impact from reduced mobility.

**Increase in Telecommuting:** Reduced mobility resulting from a major reduction in federal support for surface transportation could shift the balance of many employers' cost/benefit calculations in offering telecommuting solutions to their employees. Over time, this could cause significant impacts on productivity, communication, and the markets for residential and commercial real estate.

# 5 Conclusion

# 5 Conclusion

The future impacts of these influences on the Nebraska transportation system are often uncertain, but through the process of identifying the trends and possible futures for each influence Nebraska will be able to identify their likely transportation consequences. The likely consequences for each of the influences is provided on the follow page in **Table 5-1**. These consequences will inform future tasks related to the development of the 2040 Statewide Transportation Plan. The influences will be utilized in future scenario planning, the identification of goals and objectives, and strategies for addressing long-term impacts on the system.

**Table 5-1: Transportation Consequences by Influence**

| Influence | Transportation Consequence |
|---|---|
| **Social and Economic** | |
| Aging Population | Mode Choice |
| | Funding |
| Urbanization | Car Ownership |
| | Mode Choice |
| | Vehicle Miles Traveled |
| | Safety |
| Information Society and Economy | Mode Choice |
| | Reduced Trips |
| | Shorter Commutes |
| Structural Economic Shifts | Travel Demand |
| | Land Use |
| | Last-Mile Delivery |
| | Vehicle Automation |
| | Technology Tools and Transportation Infrastructure |
| **Technology** | |
| Innovation in Transportation Choices | Car Ownership |
| | Vehicle Miles Traveled |
| | Safety |
| Electric Vehicles | Funding |
| | Development of Electric Grid |
| | Land Use |
| Connected and Automated Vehicles | Capacity |
| | Safety |
| | Travel Demand |
| | Mode Choice |
| | Infrastructure |
| Smart Infrastructure | Safety |
| | Traffic Mobility |
| | Emission Reductions |
| **External** | |
| Weather Extremes | Funding |
| | Safety |
| | Reliability and Delay |
| Federal Funding | Shift to System Preservation |
| | Congestion |
| | Tiering of the Highway System |
| | Increased Pressure on Local Governments |
| | Reduced Mobility |
| | Increased Telecommuting |

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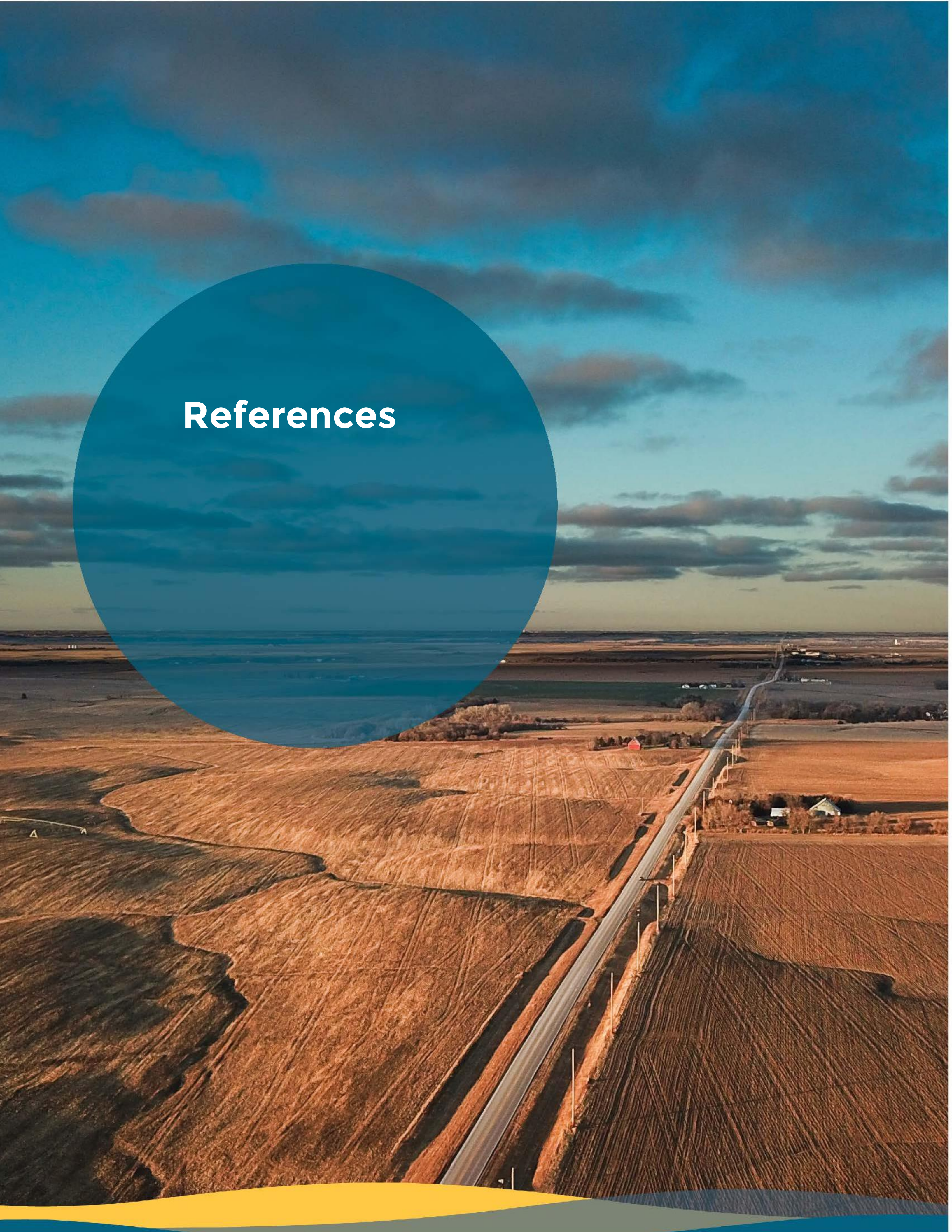

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