ASSESSMENT OF EXPANDING LIGHT RAIL TRANSIT SYSTEMS VERSUS HIGHWAY SYSTEMS: INFLUENCE ON LANDUSE CHANGE AND HABITAT FRAGMENTATION

by

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Abstract

ASSESSMENT OF EXPANDING LIGHT RAIL TRANSIT (LRT) VERSUS HIGHWAY: INFLUENCE ON LANDUSE CHANGE AND HABITAT FRAGMENTATION

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The purpose of this research is to assess and investigate the impact of expanding the Light Rail Transit (LRT) systems versus conventional highway systems for land use change, land formation, and habitat fragmentation in the Dallas Fort Worth (DFW) metropolitan area as a highly developing urban area. The DFW metropolitan area is one of the fastest growing urban areas in the United States (U.S. Census Bureau, 2016). Successfully accommodating this population growth requires North Texans to collectively address important issues including: environmental degradation, suburbanization, suburban sprawl, landscape formation and fragmentation, lack of public transportation, community and well-being needs, transportation expansion, and energy.

Habitat fragmentation caused by transportation infrastructure has gained attention and importance during the last couple of decades. In the USA, for example; the density of public roads is ca. 0.66 km (Forman, 2000). With their larger size and higher traffic volumes, highways represent a serious threat to wildlife, affecting a wider range of wildlife species and presenting an almost impassable barrier for many species of reptiles, amphibians, and small mammals (Jackson, 2000). The impact of roads on wildlife can be pervasive as roads can cause numerous fatalities as a result of collisions with the vehicles that travel on them (Malo et al., 2004; Saeki and Macdonald, 2004; Ramp et al., 2005). These impacts raise serious concerns about the stability and sustainability of roadside wildlife in the road-affected environments, especially as the amount of transported goods and the number of people travelling on roads increases worldwide (Ramp, Wilson, and Croft 2006).The number of casualties and habitat fragmentation appears to be steadily growing as traffic increases and infrastructure expands (Davenport , 2006).

This research is based on ArcGIS spatial and historical mapping analysis to identify negative impacts of interstate highway 30 and the Trinity Railway Express on the land use change, landscape formation and fragmentation within the one mile buffer of these surrounding environments from 1995 to 2015. The findings of these procedures will provide valuable tools of knowledge for landscape architects, urban planners, transportation planners, and governmental agencies in addressing needs of ecology, and habitat conservation, by advocating for investment in the railroad transit systems as opposed to conventional highway systems.

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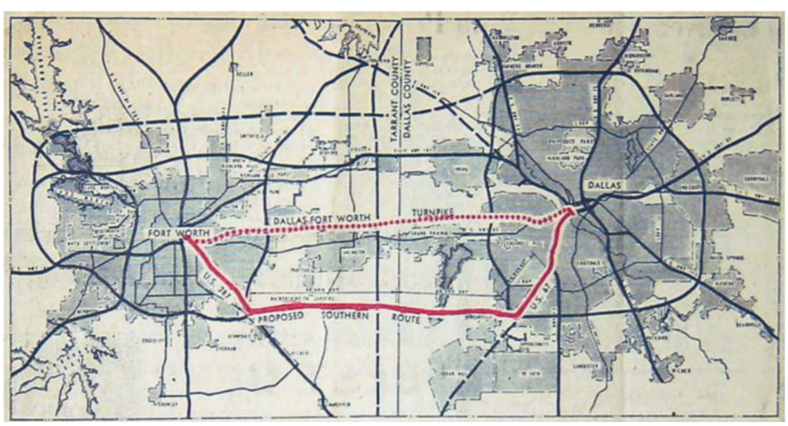
1 Chapter 1: Introduction

1.1 Introduction

The Dallas-Fort Worth (DFW), TX metropolitan area has a population of 7.1 million people and kept a steady growth the past years (US Census Data, 2017). Expanding highway system and road construction was the immediate answer for political and business leaders to this population growth. The original freeway plan in North Texas began in the late 1930s in Dallas and Fort Worth. In January 1953 TxDOT approved a long-range plan for Dallas which included present-day IH 30 (east and west), IH 35 south, the downtown Mixmaster interchange and IH 35E north. (Dallas-Fort Worth Freeway. Oscar Slotboom, 2014). The DFW historical map (1894) shows that, this region used to have an exceptional topography and hilly condition before aggressive construction of highways and roads. Changing direction of the Trinity River, deforestation, habitat fragmentation, and habitat mortality were only a few of major negative impacts of developing DFW area after World War II without consideration of natural habitat. Currently, there are more than 80 endangered and threatened species in the Dallas and Tarrant counties (Texas Parks and Wildlife Department, 2017). The focus of this research is in Dallas and Tarrant County because is one of the fastest growing metropolitanpolitan areas in the nation. Particularly the focus areas are one mile buffer of Highway I-30 and Trinity Railway Express (TRE).

Figure 1.1: historical map of Dallas Fort Worth metropolitan area, 1894 (UT-Arlington Library Special Collections).



This map published in The Dallas Morning News July 2, 1957, shows the planned regional freeway network which generally resembles the system which was actually built. In October 1957 the freeway alignments in west Fort Worth were adjusted to more closely match the as-built system.

Figure 1.2: Planned freeway between Dallas and Fort Worth area, 1957 (UT-Arlington Library Special Collections).

1.2 Research objectives

The objective of this research is to investigate the impact of Light Rail Transit (LRT) system versus Highway on land use change, Tree canopy cover loss, and Habitat fragmentation and habitat mortality in the highly developing urban areas, case study: Dallas and Tarrant County.

While the profession of Landscape Architecture brings creative solutions for clients in the more developed countries, the effect of the landscape on the habitat and human condition indicate that there are more ways the profession can contribute to local and global issues, for instance, habitat fragmentation, habitat loss, climate change and other crisis.

The role of politicians, environmentalists, ecologists, planners, engineers, and economists is clear and prominent. However, the role of landscape architects is unclear, even though they can bring an invaluable interdisciplinary knowledge to the table. Thus, it is very critical for landscape architecture educators, researchers, and professionals to take new challenges and open new doors for their profession.

1.3 Research Questions

1. How land use changed within one mile buffer of Interstate Highway 30 and Trinity Railway Express over past 20 years?
   i) What is the difference of Land use change within one mile buffer of IH 30 and TRE?
2. What is the fragmentation level within one mile buffer of IH 30 and TRE?
   i) How did fragmentation level change within those areas from 2000 to 2015?
   ii) What is the amount of habitat and vehicle crashes within one mile buffer of IH 30 and TRE?
      a) What are the effects of habitat fragmentation on habitat and vehicle crashed?

1.4 Research Methods

This study uses a quantitative research method using Spatial Analysis in ArcGIS (Geographic Information Systems) 10.3. Spatial Analysis is a set of techniques that analyze spatial data and GIS, in brief, is a system that implements spatial analysis processes both the locations of their objects and their attributes simultaneously. Moreover, it integrates statistics to support the analysis of geographic data and provides techniques to describe the distribution of data in the geographic space, analyze the spatial patterns of the data, identify and measure relationships through spatial regression, and creates easy to grasp graphics from sampled data through spatial interpolation, usually categorized as geo statics (Huq, Sanaul, 2015). For Landscape Architects spatial analysis is technology that allows a user to question 'what if' experiments with data once a geometric model is constructed. Although, spatial analysis has been used in urban planning and design for a long time, GIS-based technology has recently paralleled the advances of current computer technology (Huq, Sanaul, 2015). Another tool is the historical mapping from the past which, provided enough evidence for research goals. Thus, my investigation starts with research objectives and research questions in the following sections.

1.5 Definition of Terms

This research is focused on the assessment of expanding LTR versus highway and analyzing its influence on habitat fragmentation and wildlife mortality. The following definitions provide background information not otherwise provided within the body of the text.

Light Rail Transit (LRT) is an electric rail-borne form of transport that can be developed in stages from a tramway to a rapid transit system operated partially on its own right-of-way stated by the International Association of Public Transport.

Highway "Highway or street" means the width between the boundary lines of a publicly maintained way any part of which is open to the public for vehicular travel according to Texas Transportation Code (1995).

Habitat Fragmentation A large expanse of habitat transformed into a number of smaller patches of a smaller total area, isolated from each other by a matrix of habitats unlike the original.

Roadkill refers to an animal or animals that have been struck and killed by motor vehicles on highways.

Endangered Species: A taxon is endangered when it is not critically endangered but is facing a very high risk of extinction in the wild in the near future.

Ecological Region (Ecoregion): Ecoregions are areas where ecosystems (and the type, quality, and quantity of environmental resources) are generally similar (Omernik, 1987).

Blackland Prairie: One of the most critically threatened ecoregions in Texas. It stretches 300 miles from the Oklahoma border to near San Antonio. It lies along one of the most development-intensive areas in Texas, along with the IH-35 corridor. It is known for easily-eroded Cretaceous shales and marls that produce expansive, mineral-rich black clay soils (EPA, Level III Ecoregions, 2008).

Cross Timbers: Cross Timbers, also known as Ecoregion 29, Central Oklahoma/Texas Plains, is used to describe a strip of land in the United States that runs from southeastern Kansas across Central Oklahoma to Central Texas. Made up of a mix of prairie, savanna, and woodland, it forms part of the boundary between the more heavily forested eastern country and the almost treeless Great Plains and also marks the western habitat limit of many mammals and insects (EPA, Level III Ecoregions, 2008).

Vulnerable Species: A taxon is vulnerable when it is not critically endangered or endangered but is facing a high risk of extinction in the wild in the medium-term future.

GIS: Geographic Information System allows users to visualize, question, analyze, interpret, and understand data to reveal relationships between input variables (Esri 2012)

Land cover: The visible physical material at the surface of the earth that we see and which directly interacts with electromagnetic radiation thereby affecting the level of reflected energy. Land cover includes grass, asphalt, trees, bare ground, water, and so on (Comber et al. 2005).

Land use: A description of how people use the land. It includes urban land use, agricultural land use, institutional land use, residential land use, and so on (Comber et al. 2005).

North Central Texas Councils of Government (NCTCOG): A voluntary association of, by and for local governments, established to assist local governments in planning for common needs, cooperating for mutual benefit, and coordinating for sound regional development. It serves a 16-county region of North Central Texas which surrounds the urban centers of Dallas and Fort Worth.

Patch: A relatively small area that has distinctly different structure and function than the surrounding landscape (USDA, 2018)

Corridor or Buffer: A linear patch typically having certain enhanced functions due to its linear shape (USDA, 2018).

Matrix: The background within which patches and buffers exist (USDA, 2018).

1.6 Significance and Limitations of This Research Study

This research quantifies impacts of highway and light rail transit (LRT) networks on habitat fragmentation, land use change, and habitat mortality. This study maps land use change, fragmentation in the past 25 years and habitat mortality in the past 10 years. This research study is limited to 2 sample sites, Interstate Highway 30, Downtown Dallas-Fort Worth section and Trinity Railway Express (TRE). The results of this study can be used for decision and policy makers, designers, planners and engineers to make more environmentally friendly decisions and to develop more sustainable, equitable and accessible transportation system. Also, can increase the awareness of the general public to use more public transportation and be less dependent on their private cars.

The limitations of this study include lack of available historical data about animal and vehicle and train crashes for Dallas and Tarrant counties.

And research was obtained within a one-semester time-period which limited the number of detailed analysis and mappings. Published research in the discipline of effects of highway and railways on the landscape and land transformation is limited with research specific to North Central Texas especially lacking. Furthermore, while studies on sustainable transportation and new ways of transportation have increased in recent times, they are still limited.

1.7 Summary

This study presents an analysis of expanding light rail systems versus highway and their influence on land use change, habitat fragmentation and habitat mortality. The analysis is done using GIS techniques, Spatial analysis, mapping and visual reality with imagery from Dallas Fort Worth area in 1995, 2000, 2005, 2010, 2015 time period.

2 Chapter 2: Literature Review

Providing sufficient transportation is one of the major issues in developing urban areas. Expanding highways and investing in private transportation has created a massive highway system, the lack of an effective public transportation system. Roads are an essential part of the transportation infrastructures, which deliver a wide range of social and economic benefits such as providing connectivity for people and enabling communities to rapidly expand into previously remote or inaccessible areas (Freudenberger et al. 2013). However, there is also growing evidence of the negative impacts of roads and highway systems on the neighboring habitats, wildlife populations, and ecosystems. The effects of roads on biodiversity are cumulative, time-lagged, complex and often irreversible (Selva et al. 2011). Roads cause mortality, with over one million vertebrates run over each day on American roads (high country news organization, 2005). Habitat loss (Rico et al. 2007; Didham, 2007), reduction of habitat quality (Fahrig, 2002), isolation of populations, land-use and land cover change, and reducing the resilience of populations and ecosystems to climate change (Penuelas 2005) are other negative impacts of roads.

This research will investigate: How highway and light rail system has affected land use and canopy loss in the past years in Dallas and Tarrant County? What is the difference of land-use change near light Rail and highway? What are negative impacts of private car transportation on the habitat and wildlife? Where are the hotspot crashes (animals and vehicles) in Dallas and Tarrant County?

In this chapter, we are going through related scholarly journals and books to investigate fundamental information stated in the research questions, which are presented in the research questions section (1.6).

2.1 Landscape as Mosaics (Patch-Corridor-Matrix Model)

The landscape can appear as the spatially heterogeneous (an uneven, non-random distribution of objects) mosaic of local ecosystem (Forman, 1995). Spatial heterogeneity occurs in two forms. A gradient or series of gradient has gradual variation over space in the objects present. (Johnston, 1989). The mosaic appears in the pattern of patches, corridors, and matrix on land. Woods, fields, and housing zones are noticeable patches. Roads, hedgerows, rivers, and power lines are similar prominent corridors. The matrix appears as grassland, forest, rice culture, or another land use forms (Forman, 1995). Thus, every point in a landscape is either a patch, a corridor or the background matrix. The matrix can be extended to limited, continuous to perforated, and variegated to nearly homogeneous (Fig 2.1) (Lindenmayer, 2005).

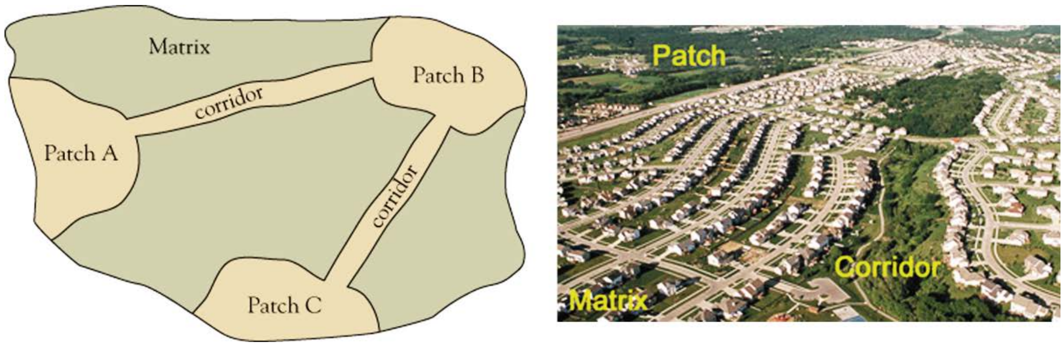


Figure 2.1: Patches, Corridor and Matrix

The patch-matrix-corridor model has been widely used in landscape conservation biology. It helps land managers, landscape architects, planners, and researchers to apply their ideas into a spatial context (Lindenmayer, 2005). In this study presented the same patch-matrix-corridor model was used. Trinity River ecosystem as a corridor, small fragmented prairies, woodlands, and wetlands as patches and Interstate Highway 30 (IH30), Trinity Railway Express (TRE), and different land use and land cover as a background matrix.

Ecological assessment of Human activities characterized in tangible and intangible elements (Table 2.1) (Brown, 2001). The human imprint on landscapes is adaptable in time and space and differs at a great quantity of different time and space scales (Brown, 2001).

Tangible Elements	Intangible Elements
Transportation corridors and junctions	Political and census boundaries
Utilities	Ownership boundaries
Land cover	Land use
Sites of cultural importance	
Key commercial and industrial concerns	

Table 2.1. Elements of the human imprint on landscapes that might be included in an ecological assessment.

Tangible landscape elements include transportation corridors and junctions, utilities, and land cover. Intangible landscape elements include political boundaries, ecoregional boundaries, ownership boundaries, and land use. For this research, both tangible and intangible elements of landscapes taken into consideration. The tangible elements are transportation corridors, and junctions, utilities, railroads and land cover and the intangible elements in this study include the land use and political and ecoregional boundaries. Tangible elements change the physical character of the landscape and often have a direct impact on ecosystems (Brown, 2001).For example, a road network introduced on an undisturbed forest decreases the quality of habitat for large mammals and cause canopy and habitat loss eventually.

2.2 Habitat Fragmentation

Habitat fragmentation is the primary cause of disappearing natural habitat across North American landscape (Marvier et al 2004). By far, the most significant single threat to biological diversity worldwide is the destruction of habitat, along with habitat alteration and fragmentation of large habitats into smaller patches (Maffe et al 1997). Habitat fragmentation typically begins with an external disturbance which divides original habitat into smaller patches (Fig.2.2) and smaller patches will transform into isolated landscapes and eventually habitat loss.

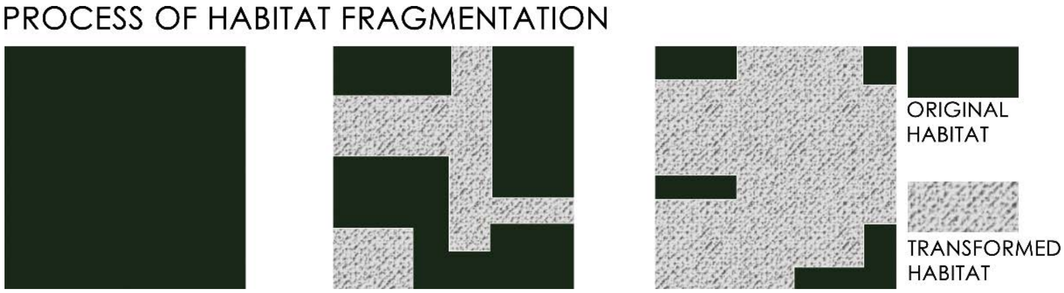


Figure.2.2 Process of habitat fragmentation

There are six major causes of habitat fragmentation and land transformation, such as deforestation, suburbanization, corridor construction, desertification, agriculture intensification, and reforestation (Forman, 1995). In this research, the focus is on the main cause of habitat fragmentation, which is corridor construction.

i. **Deforestation** is a cutting a forested landscape and a highly planned process. Deforestation changing the mosaic sequences of land and can cause patches and edge conditions.

ii. **Suburbanization** is the areas of highly planned housing development. Due to suburbanization: 1.small patches of vegetation moved around through attrition and appearance, but not in density, 2. Large woods became progressively smaller and narrower, 3. Towns grew in size and developed highly complex boundaries (Forman, 1995).

iii. **Corridor Construction** The construction of a new corridor, for instance, a highway or a railway opens up an area in a linear manner (Taafe and Gauthier, 1973).

iv. **Desertification** is a human-caused transformation of grasslands, savannas, and other areas into desert-like conditions of low vegetation cover and productivity in extensive universal. However, the causes of desertification are different, and the most important one is overgrazing which can cause soil erosion as well (Bagnold 1954).

v. **Agricultural intensification** Expansion of agricultural land is widely known as one of the most significant human alterations to the global environment (Matson et al 1997). Intensification usually results in a broad removal of usually small landscape elements.

vi. **Reforestation** is the reestablishment of a forested landscape generally is either unplanned or highly planned process. Unplanned forestation often causes soil erosion and degradation. On the other hand planned reforestation is almost always planting large and regular trees separated by a road corridor (Richard T. Foreman, 1995).

There is a long and deep history of ecological and scientific research on habitat fragmentation and its short and long term-effects (Fahrig 2003, Didham et al. 2012). However, short-term effects of habitat fragmentation are unclear yet, but patch-size effects, edge effects, and isolation effects are the long-term effects of habitat fragmentation on wildlife (Wildlife society 2014, Fahrig et al 1998, Hennings 2010, Young et al 1998). Habitat fragmentation can lead a species through habitat loss. Furthermore, habitat loss poses the greatest threat to species. The world's forests, swamps, plains, lakes, and other forms of micro and macro climates continue to disappear as they are cleared for development and their products harvested for human consumption (World Wide Fund for nature, 2011). It is clear that in order to save the natural habitat, all of us have to prevent habitat fragmentation and restore fragmented areas. Most ecologists and scientists suggest a variety of strategies, for instance; wildlife corridors, land acquisition, conservation easements, restoration, mitigation, zoning, and buffer zones (Wildlife Society, 2008).

While all of these strategies can be helpful there is lack of addressing human behavior. Changing human behavior in a more environmentally conscious mode can lead to different ways of exploring challenges of ecology and habitat. For instance, encouraging people to use more public transit systems rather than private cars will decrease traffic and can make a change in wildlife mortality.

2.3 Blackland Prairie and Cross Timbers Ecoregions

Texas is divided into twelve level III ecoregions (Figure 2.3). Ecoregions indicate as areas of general similarity in ecosystems and the type, quality, and quantity of environmental resources. Ecoregion frameworks are valuable tools for environmental research, assessment, management, and monitoring of ecosystems and its components (Griffith et al, EPA, 2007).

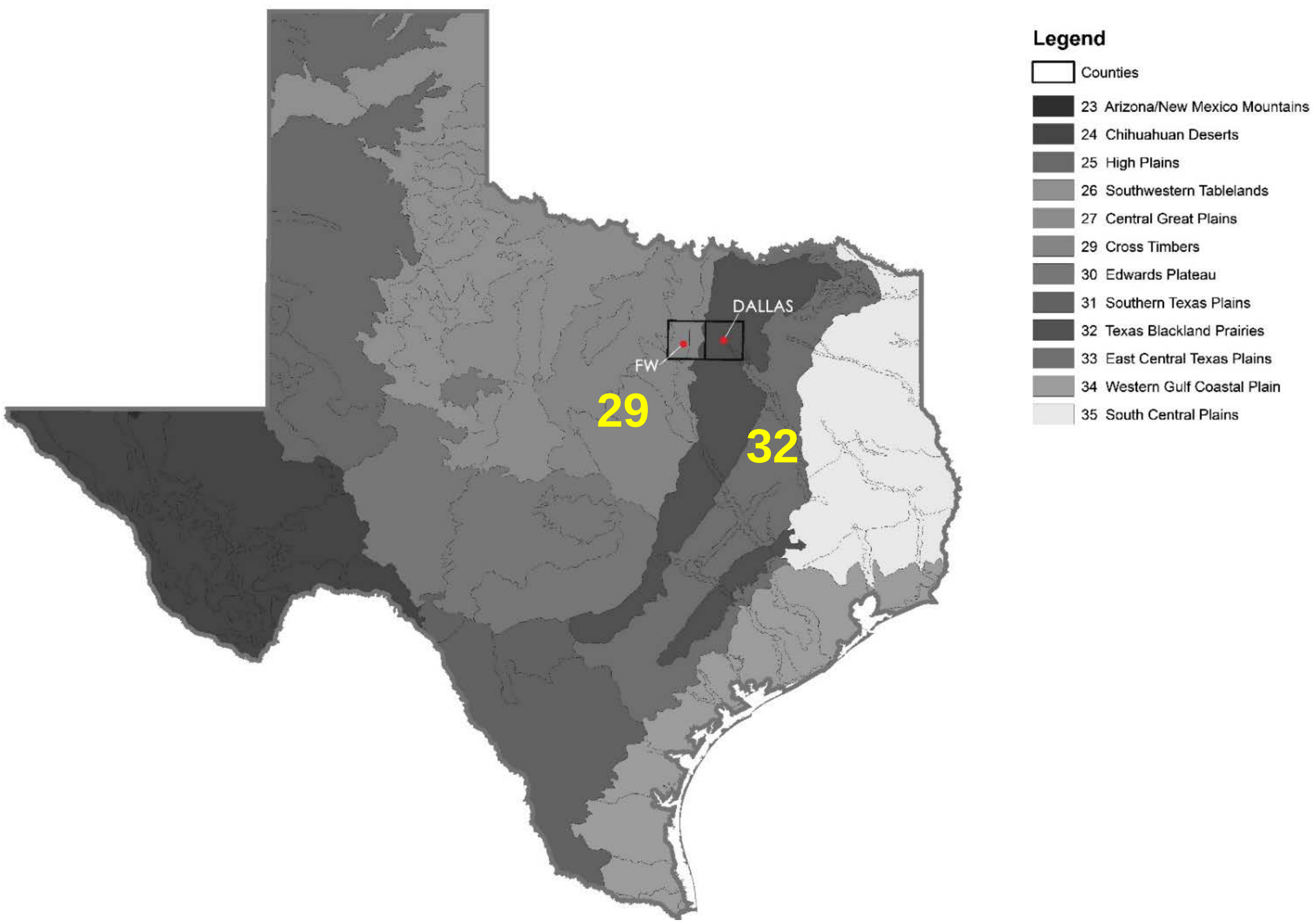


Figure.2.3 Level III ecoregions of Texas (source: EPA & ESRI)

In this research, the study area is located 55% of the Blackland Prairie (Ecoregion number 32) and 45% in the Cross Timbers (Ecoregion number 29).

2.3.1 Cross Timbers ecoregion

The Cross Timbers ecoregion is a transitional area between the once prairie and the forested low mountains or hills of eastern Oklahoma and Texas. Cross Timbers is a mosaic of forest, woodland, savanna, and prairie. The transitional natural vegetation of little bluestem grassland with blackjack oak and post oak trees are mostly used for rangeland and pastureland, with some areas of woody plant invasion and closed forest (Glenn Griffith, Sandy Bryce, James Omernik, and Anne Rogers, EPA, 2007). Level III Cross Timbers consists of Eastern Cross Timbers, Western Cross Timbers, Grand Prairie, Limestone Cut Plain, and Carbonate Cross Timbers as level IV ecoregions (Fig 2.4).

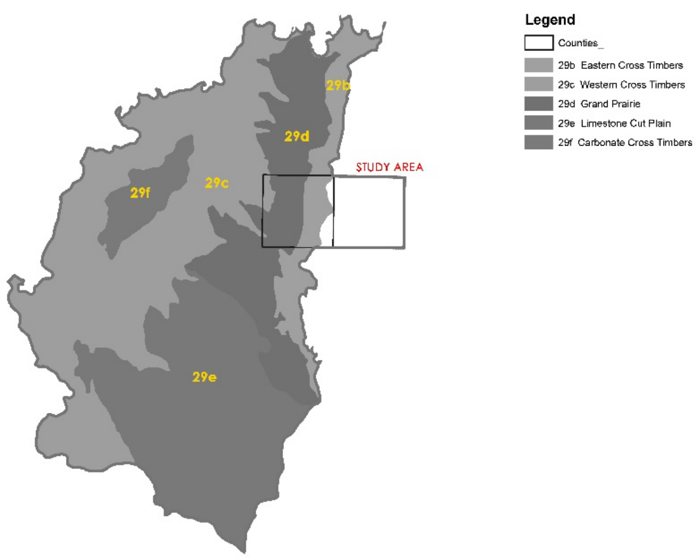


Figure.2.4 Level IV ecoregions of Cross Timbers (source: EPA & ESRI)

Taxon	Species Name	Common Name
Birds	Haliaeetus leucocephalus	Bald Eagle
Birds	Falco peregrinus	Peregrine Falcon
Birds	Falco peregrinus anatum	American Peregrine Falcon
Birds	Falco peregrinus tundrius	Arctic Peregrine Falcon
Birds	Grus americana	Whooping Crane
Birds	Calidris canutus rufa	Red Knot
Birds	Sterna antillarum athalassos	Interior Least Tern
Birds	Athene cunicularia hypogaea	Western Burrowing Owl
Birds	Anthus spragueii	Sprague's Pipit
Birds	Ammodramus henslowii	Henslow's Sparrow
Fishes	Scaphirhynchus platorynchus	Shovelnose sturgeon
Mammals	Canis rufus	Red wolf
Mammals	Canis lupus	Gray wolf
Mammals	Spilogale putorius interrupta	Plains spotted skunk
Reptiles	Phrynosoma cornutum	Texas horned lizard
Reptiles	Thamnophis sirtalis annectens	Texas garter snake
Reptiles	Crotalus horridus	Timber rattlesnake
Mollusks	Fusconaia askew	Texas pigtoe
Mollusks	Lampsilis satura	Sandbank pocketbook
Mollusks	Pleurobema riddellii	Louisiana pigtoe
Mollusks	Potamilus amphichaenus	Texas heelsplitter
Plants	Echinacea atrorubens	Topeka purple-coneflower
Plants	Astragalus reflexes	Texas milkvetch
Plants	Dalea hallii	Hall's prairie clover
Plants	Pediomelum reverchonii	Reverchon's curfpea
Plants	Agalinis auriculata	Auriculate false foxglove
Plants	Agalinis densiflora	Osage Plains false foxglove
Plants	Yucca necopina	Glen Rose yucca

Table 2.2. Endangered and threatened species in Tarrant County, (source: Texas Parks and Wildlife, 2017)

There are 28 species in endangered or threatened federal category for protection in Tarrant County, which needs serious attention otherwise they will go extinct.

2.3.2 Blackland Prairie ecoregion

The Texas Blackland Prairies form a disjoint ecological region, notable from surrounding regions by fine-textured, clayey soils and mainly prairie potential natural vegetation. Dominant grasses included little bluestem, big bluestem, yellow Indiangrass, and switchgrass. This region now contains a higher percentage of cropland than adjacent regions; pasture and forage production for livestock is common (Glenn Griffith, Sandy Bryce, James Omernik, and Anne Rogers, EPA, 2007). Large areas of the region are being converted to urban and industrial uses. Before Anglo settlement, animal species included bison, pronghorn antelope, mountain lion, bobcat, ocelot, black bear, collared peccary, deer, coyote, fox, badger, and river otter among others (Schmidley 2002, Diggs *et al.*,1999). Level III Blackland Prairie consists of Northern

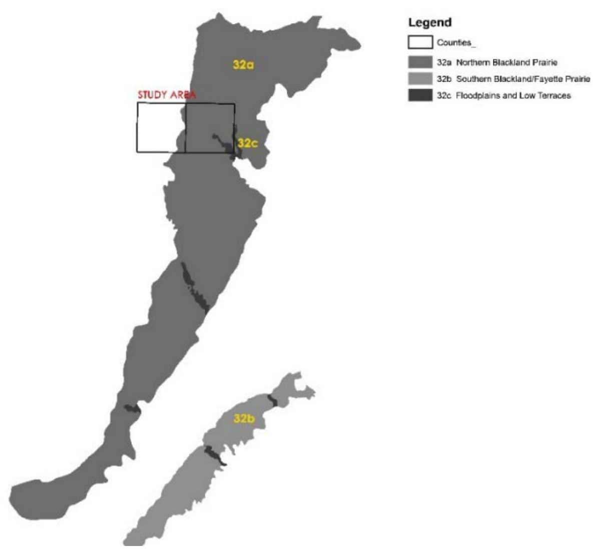


Figure.2.5 Level IV ecoregions of Blackland Prairie (source: EPA & ESRI)

Blackland Prairie, Southern Blackland Prairie, and Floodplains and Low Terraces as level IV ecoregions (Fig 2.5). This research assesses negative impacts of IH 30 and TRE on the Cross Timbers and Blackland Prairie ecoregions. As mentioned before Blackland prairie is the most critically threatened ecoregion because of aggressive development and land use change throughout the ecoregion and same behavior is moving toward west which Cross Timbers ecoregion is located (Table 2.3).

Taxon	**Species Name**	**Common Name**
Birds	Plegadis chihi	White-faced Ibis
Birds	Mycteria americana	Wood Stork
Birds	Haliaeetus leucocephalus	Bald Eagle
Birds	Falco peregrinus	Peregrine Falcon
Birds	Falco peregrinus anatum	American Peregrine Falcon
Birds	Falco peregrinus tundrius	Arctic Peregrine Falcon
Birds	Grus americana	Whooping Crane
Birds	Charadrius melodus	Piping Plover
Birds	Calidris canutus rufa	Red Knot
Birds	Sterna antillarum athalassos	Interior Least Tern
Birds	Athene cunicularia hypogaea	Western Burrowing Owl
Birds	Anthus spragueii	Sprague's Pipit
Birds	Vireo atricapilla	Black-capped Vireo
Birds	Setophaga chrysoparia	Golden-cheeked Warbler
Birds	Ammodramus henslowii	Henslow's Sparrow
Mammals	Myotis velifer	Cave myotis bat
Mammals	Spilogale putorius interrupta	Plains spotted skunk
Reptiles	Macrochelys temminckii	Alligator snapping turtle
Reptiles	Phrynosoma cornutum	Texas horned lizard
Reptiles	Thamnophis sirtalis annectens	Texas garter snake
Reptiles	Crotalus horridus	Timber rattlesnake
Insects	Lordithon niger	Black Lordithon rove beetle
Mollusks	Fusconaia askew	Texas pigtoe
Mollusks	Lampsilis satura	Sandbank pocketbook
Mollusks	Pleurobema riddellii	Louisiana pigtoe

Mollusks	Potamilus amphichaenus	Texas heelsplitter
Plants	Matelea edwardsensis	Plateau milkvine
Plants	Cuscuta exaltata	Tree dodder
Plants	Astragalus reflexus	Texas milk vetch
Plants	Dalea hallii	Hall's prairie clover
Plants	Agalinis densiflora	Osage Plains false foxglove
Plants	Yucca necopina	Glen Rose yucca
Plants	Hexalectris nitida	Glass Mountains coral-root
Plants	Hexalectris warnockii	Warnock's coral-root

Table 2.3. Endangered and threatened species in Dallas County, (source: Texas Parks and Wildlife, 2017)

In the Dallas County (which is part of Blackland Prairie) there are 34 endangered or threatened species.

2.4 The negative impact of Highways on habitat fragmentation and wildlife mortality

Transportation networks for cars and trains are physically threatened individual animals that stray onto roads and railroads, but the resulting fragmentation of the landscape also can potentially endanger species, populations, communities, and hence entire ecosystems (World Resource Institute, 1990).

As the transportation networks of roads increase, the number of fragmented areas, and wildlife mortality due to collision raises. In Europe, Netherlands has the highest level of fragmented lands as road length has increased from 40,000 to 70,000 km over the past 30 years (Bruinderink and Hazebroek, 1996). Similar fragmentation has occurred in other larger countries within

Europe and the United States as the network of roads develops (Vos and Opdam, 1993). The density of roads is a benchmark parameter to measure usability of the roads. By comparing density of roads in Netherlands and Australia as world leaders of road ecology and to the United States for useful data (Foreman and Alexander, 1998). In the Netherlands, the density of main roads is 3.3 km/km2, with a traffic density of generally between 10,000 and 50,000 vehicles per commuter day (Reijnen R. 1995). Australia has nearly 910,000 km of roads for 24 million people (Lamont DA, 1995) and in the United States, 6.2 million km of public roads are used by 200 million vehicles (Foreman and Alexander, 1998). In the United States road density is 1.2km/km2, 10 percent of the road length is in national forests, one percent is an interstate highway and Americans drive their cars 1h/day. More importantly, road density is increasing slowly, while vehicle kilometers traveled is growing rapidly (Foreman and Alexander, 1998). Certainly, there is a need for growing and expanding transportation systems. In order to minimize the negative effects of roads on habitat, prevent habitat fragmentation and wildlife mortality planners, designers, and decision makers need to focus on more eco-friendly ways of transit systems. Ecological effects of roads categorized in i. Effects during construction ii. Short-term effects of new roads and iii. Long-term effects (Table 2.2) (Ian F. Spellerberg, 1998).

Effects of roads on habitat are unquestionable, road design, management, and restoration need to be more carefully adapted to address the full range of ecological processes and terrestrial species that may be affected (Trombulak and Frissell, 2000).

Table 2.2 Summary of ecological effects of roads (Spellerberg, 1998).

Effects during construction

There is a direct loss of habitat and biota.

There are effects resulting from the infrastructure and supporting activities for construction.

The impacts may occur beyond the immediate vicinity of the road; for example changes in the hydrology. Mining for aggregates for the road may take place in a different area. It is important therefore to agree on the geographical boundary for an impact assessment.

Short term effects (of a new road)

The new linear surface creates a new microclimate and a change in other physical conditions extends varying distances from the road edge.

The newly created edge provides habitat for edge species.

Plant mortality increases along the edge; and such mortalities may extend from the road edge for varying distances.

The mortality of plants has direct and secondary effects on other organisms.

Some fauna will move from the area of the road as a result of habitat loss and physical disturbance.

Animals are killed by traffic.

Long term effects

Animals continue to be killed by traffic.

The road kills have secondary effects as carrion.

The loss of habitat and change in habitat extends beyond the edge of the road.

The changes in the biological communities may extend for varying distances from the road edge.

There is fragmentation of habitat and this in turn has implications for habitat damage and loss, for dispersal and vagility of organisms, and for isolation of populations.

The edge habitat (or ecotone) and traffic on the road may facilitate dispersal for some taxa, including pest species.

The dispersal of pest species via ecotones or traffic may have secondary effects on biological communities.

Associated structures such as bridges and tunnels may provide habitats for some taxa.

The run-off from the roads affects aquatic communities.

Emissions, litter, noise and other physical disturbances may extend into the roadside vegetation for varying distances and result in changes in species composition.

In this research as mentioned in the first chapter we will investigate effects of IH 30 on Land use change, vegetation and wildlife habitat, fragmentation, and habitat mortality due to collision and comparing them with the Trinity Rail Express (TRE) results.

2.5 Light Rail Transit (LRT) versus Highway

In this section, I am going to review existing scholarly researchers about advantages of LRTs over highway systems from the ecological point of view. As discussed in the previous sections above, the highway system is the leading source of mortality for many wildlife species. While the road systems have both positive and negative ecological benefits, understanding of both aspects will help us identify problem areas. One of the greatest advantages of roads is its ability to transport people and goods. However, roads mostly cause negative impacts on ecology, surrounding matrix against disturbance by off-road vehicles and maintenance of native grassland plants and of nesting sites on roadsides in the landscape are positive impacts of roads for the ecology (Forman, 2000).

While LRTs are not free from negative impacts on habitat, however it is more environmentally friendly than highway systems in many ways. A study by the Federal Transit Administration shows the use LRTs and public transportation will (Federal Transit Administration, 2016):

- *Reduce greenhouse gas emissions*

29 percent of greenhouse gas emissions in the United States is caused by transportation. Encouraging more use of public transportation can reduce greenhouse gas emission up to 76 percent. Figure 2 shows an estimated pound of CO2 per passenger mile for average and full occupancy of vehicles.

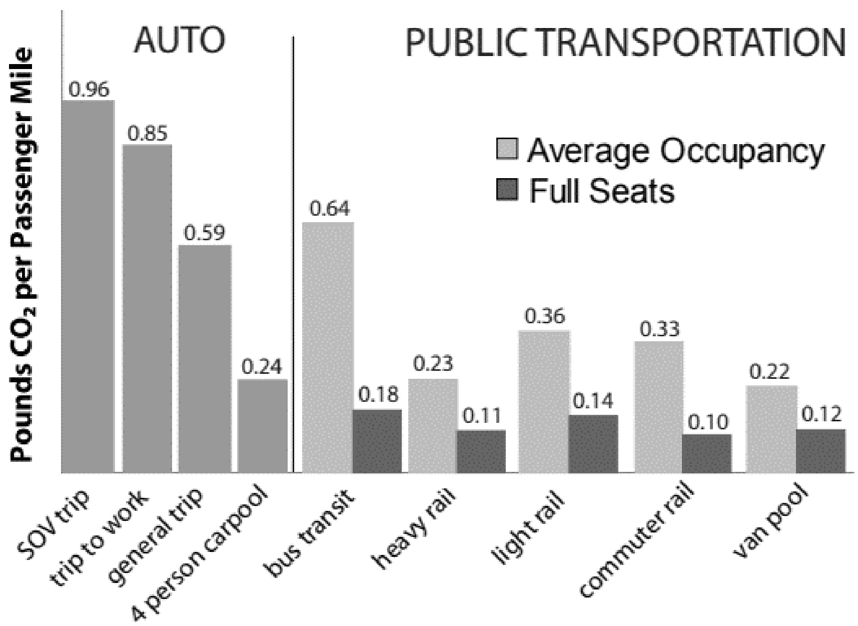


Figure. 2.5 Comparison on CO2 emission per passenger mile in private auto versus public transportation (Federal Transit Administration, 2010)

For instance, U.S. bus transit, which has about a quarter (28%) of its seats occupied on average, emits an estimated 33% lower greenhouse gas emissions per passenger mile than the average U.S. single occupancy vehicle. The savings increases to 82% for a typical diesel transit bus when it is full of 40 passengers. (U.S.

Department of transportation, 2010). Most of LRTs are powered by electricity and hydroelectric- which have much lower emissions than those relying on electricity from coal power plants.

- *Facilitate compact development*

  LRTs can support higher density land development as well and suburb areas, which reduce the distance and time people need to travel to their destinations meaning fewer emissions from transportation.

- *Conserving land*

  LRTs also require less land acquisition in compare with constructing a massive highway system. Investing more in LRTs and public transportation can save more land for parks, wildlife preservation, forests, lakes, swamps, and can reduce the amount of habitat fragmentation and habitat loss.

- *Saving energy*

  Petroleum use in private vehicles and growth in vehicle miles traveled are among the main causes of growth in energy usage in the United States. LRTs and public transportation encourages energy conservation, as the average number of passengers on a transit vehicle (10 for the bus, 25 for a rail car) far exceeds that a private vehicle.

Benefits of LRTs and public transportation are found on the Federal Transit Administration study and they have a noticeable advantage over private cars in terms of environmental and ecological factors especially in highly developing urban areas like Dallas Fort Worth (DFW) metropolitan area. It is crucial to advance forward the habit of using LRTs and public transportation which is beneficial for human, ecology, and wildlife.

2.6 Summary

The literature demonstrated the negative impacts of highway system on the environment and land transformation and fragmentation. Consequences of land transformation and fragmentation are severe and irreversible. These negative consequences are characterized in during construction, short-term, and long-term.

Although, Interstate highway 30 playing an necessary role in Dallas Fort Worth (DFW) metropolitan area, these negative impacts on Blackland Prairie and Cross Timbers ecoregions are unquestionable. However, Trinity Railway Express (TRE) has a rich history in this metropolitan area, although it is not efficient and accessible enough for the residents. Literature demonstrates that Light Rail Transit (LRT) system has several environmental and economic advantages over conventional highway system. This study assesses the changes that highway and railroad systems have been applying to landscape, environment, and habitats in the past 25 years.

3 Chapter3: Research Methods

3.1 Introduction

The previous literature review has provided background information of both negative and positive impacts of highway and rail systems on the environment and land transformation. Moreover, verifying the current application of spatial analysis and mapping technologies on identifying those impacts. This chapter discuss the methods used to complete this research. Also outlines the research design, the data used for spatial analysis in GIS, and describes tools used in spatial analysis. This research uses the GIS spatial quantitative methodology to conduct impacts of IH 30 and TRE on environmental variables. The variables for this study identified through literature review chapter. Interstate Highway 30 from downtown Dallas to Fort Worth, Trinity Railway Express, land use data 1995-2015, tree canopy loss, and habitat mortality (car and train with wildlife collision) data 2007-2018 are variables used for this study.

3.2 Study Area

The Dallas Fort Worth Arlington TX metropolitan area contains 16 counties within the U.S. state of Texas. The population of the Dallas Fort Worth (DFW) the metropolitan area is 7.3 million (US Census, 2017). DFW is the largest metropolitan area in Texas, the largest in the South and the fourth largest

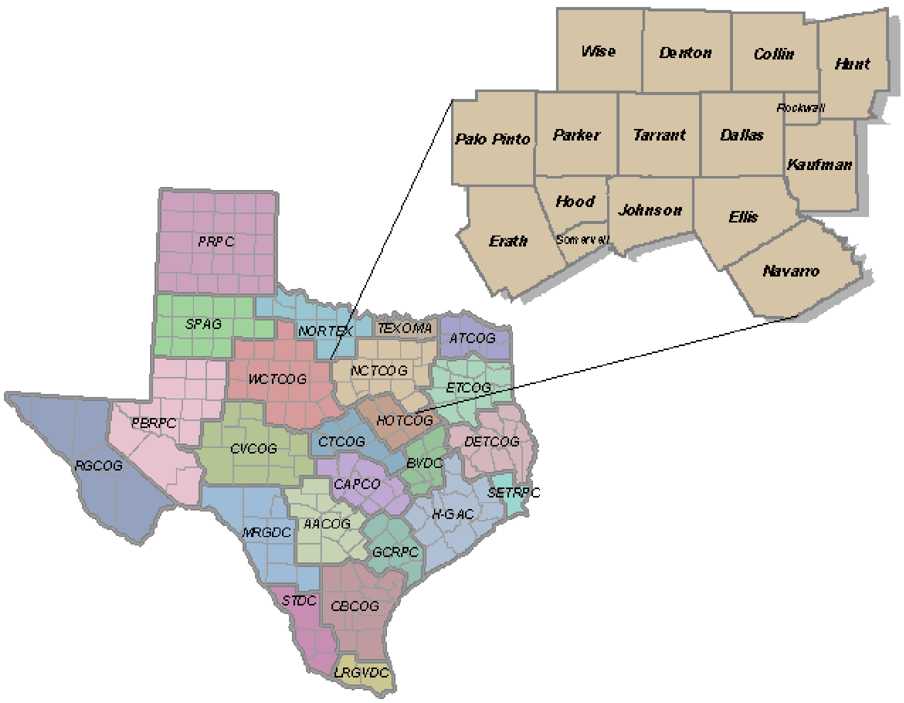


Figure 3.1: DFW Region Map- North Central Texas Councils of Government (Source:NCTCOG)

in the United States. DFW has the 10th largest economy in the world and the fourth largest employment center in the nation (behind New York City, Los Angeles, and Chicago) with more than three million non-farm jobs (U.S. Department of labor, 2013). The DFW area encompasses 9.286 square miles of total area: 8.991 sq mi is categorized as land, while 295 sq mi is water surface.

DFW metropolitan area is suited in the Texas Blackland Prairies and Cross Timbers ecological regions (Texas Parks and Wildlife,2018). Texas Blackland Prairies region so named for its fertile black soil found especially in the rural areas of Collin, Dallas, Ellis, Hunt, Kaufman, and Rockwall counties. Many areas of Denton, Johnson, Parker, Tarrant, and Wise counties are located in the Fort Worth Prairies region of North Texas, which has less fertile and rockier soil than that of the Texas Blackland prairie; most

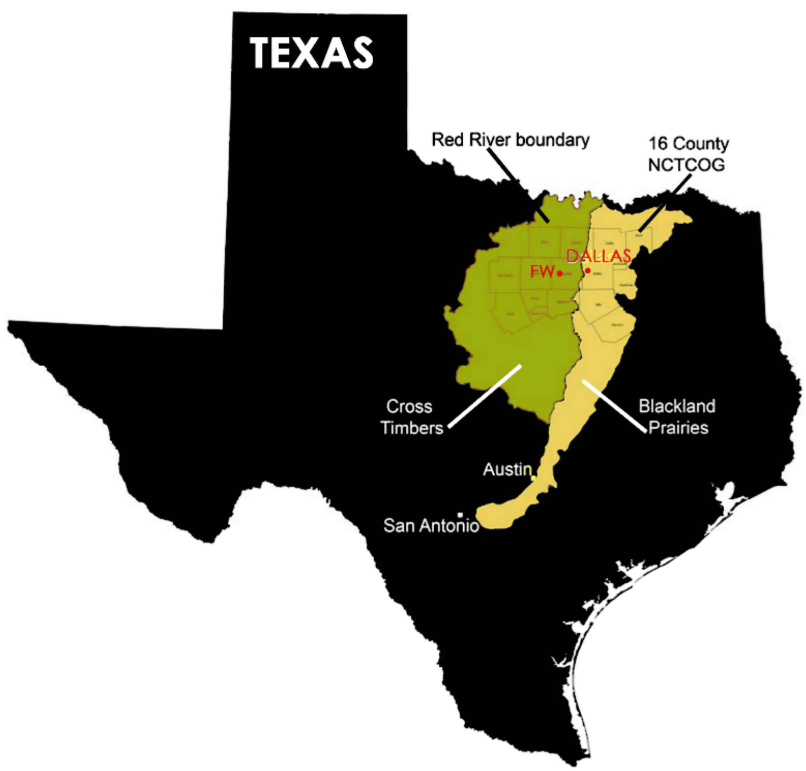


Figure 3.2: DFW area Ecological regions (Data source: EPA)

of the rural land on the Fort Worth Prairie is ranch land. (Texas Parks and Wildlife, 2018). South of Dallas and Fort Worth is a line of rugged hills that goes north to south about 15 miles (24 km) that looks similar to the Texas Hill Country 200 miles (320 km) to the south.

Dallas Fort Worth metropolitan area has thousands of miles of freeways, highways, and interstates. The metropolitan area has the second largest number of freeway-miles per capita in the nation, behind the Kansas City metropolitan area (Transit Utilization and Traffic Congestion: Is There a Connection?, Reason.org, 2013). North-south interstates include I-35 and I-45. East-west routes include I-30 and I-20. I-35 splits into I-35E and I-35W from Denton to Hillsboro: I-35W goes through Fort Worth while I-35E goes through Dallas. I-30 connects Dallas and Fort Worth, and I-45 connects Dallas to Houston. HOV lanes exist along I-35E, I-30, I-635, US 67, and US 75. I-20 bypasses both Dallas and Fort Worth to the south while its loop, I-820, and goes around Fort Worth. I-635 splits to the north of I-20 and loops around east and north Dallas, ending at SH 121 north of DFW Airport (Fig 3.3).

I-35E, Loop 12, and Spur 408 ultimately connect to I-20 southwest of Dallas, completing the west bypass loop around Dallas.

Public transit continues to expand, however, it is limited in several suburbs and in the city of Arlington, which is the largest city in the nation without any public transportation. Dallas County and parts of Collin and Rockwall counties have bus service and light rail transit system operated by Dallas Area Rapid Transit (DART). DART's rail network currently sprawls for 93 miles throughout the area and moves more than 220,000 passengers per day across its 700 square miles service area (Dart.org, 2018).

Denton County has a limited bus service to Denton, Highland Village, and Lewisville provided by the Denton County Transportation Authority (DCTA). The A-train, a diesel commuter rail line, parallels I-35E to connect Denton,

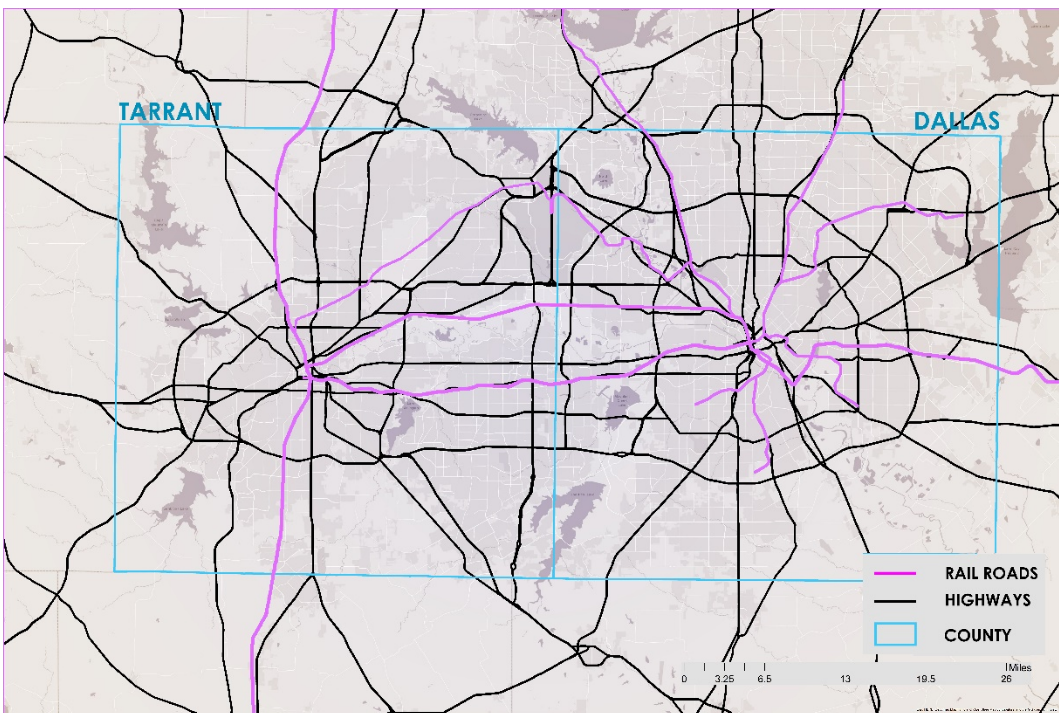


Figure 3.3: DFW highway and rail network (Data source: NCTCOG)

Highland Village, Lewisville, and Carrollton. Several smaller towns along this line, Corinth, Shady Shores, and Lake Dallas, voted to abstain from DCTA and do not have stations. (DCTA.net, 2018). Tarrant County has bus

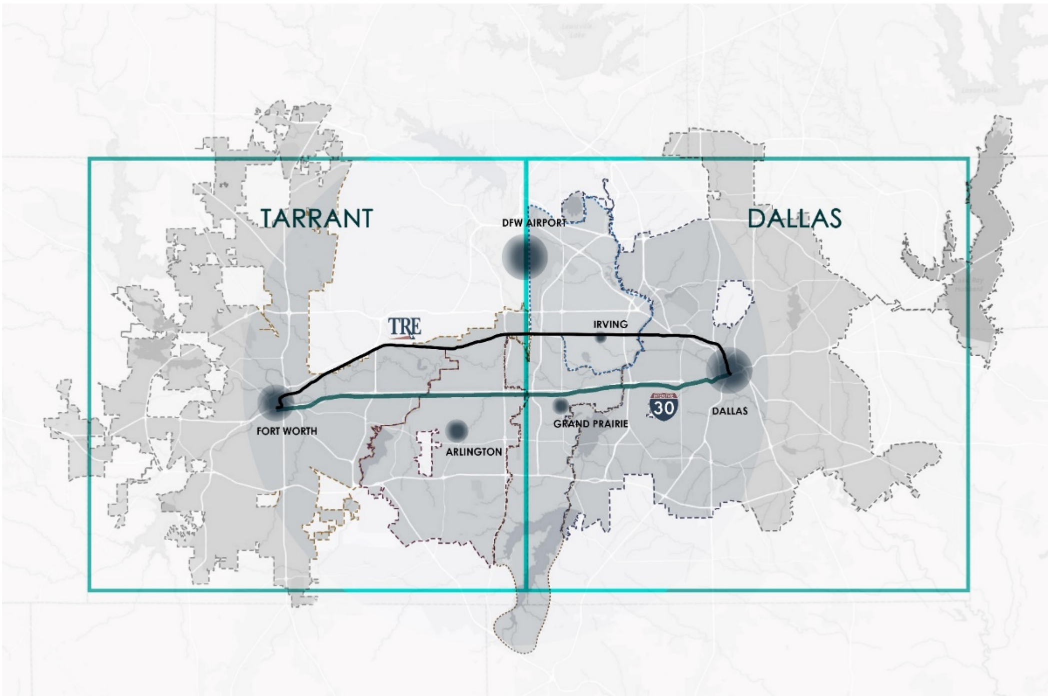


Figure 3.4: Study area (Data source: NCTCOG)

service operated by the Fort Worth Transportation Authority, available only in Fort Worth. The diesel commuter train that serves Fort Worth and its eastern suburbs is operated by Trinity Railway Express (TRE) which, connects downtown Fort Worth to downtown Dallas, connecting the DART light rail system. The study area of this research is Dallas and Tarrant counties, between Dallas and Fort Worth urban areas (Fig 3.4). The Dallas Fort Worth Turnpike which is part of Interstate 30 (I-30) and Trinity Railway Express (TRE) is going to be analyzed in more detail for this research.

3.2.1 Dallas Fort Worth Turnpike:

History: The construction proposition to create the Dallas Fort Worth Turnpike, was prompted by means of the engineering firm (HNTB) to the Texas Capitol on March 1, 1955. A territory expansion, at about 30-miles toll highway from downtown Dallas to Fort Worth.The executed plan was completed in 2 years at the cost of $52,000,000. (Dallas-Fort Worth Turnpike, HNTB, March 1955).

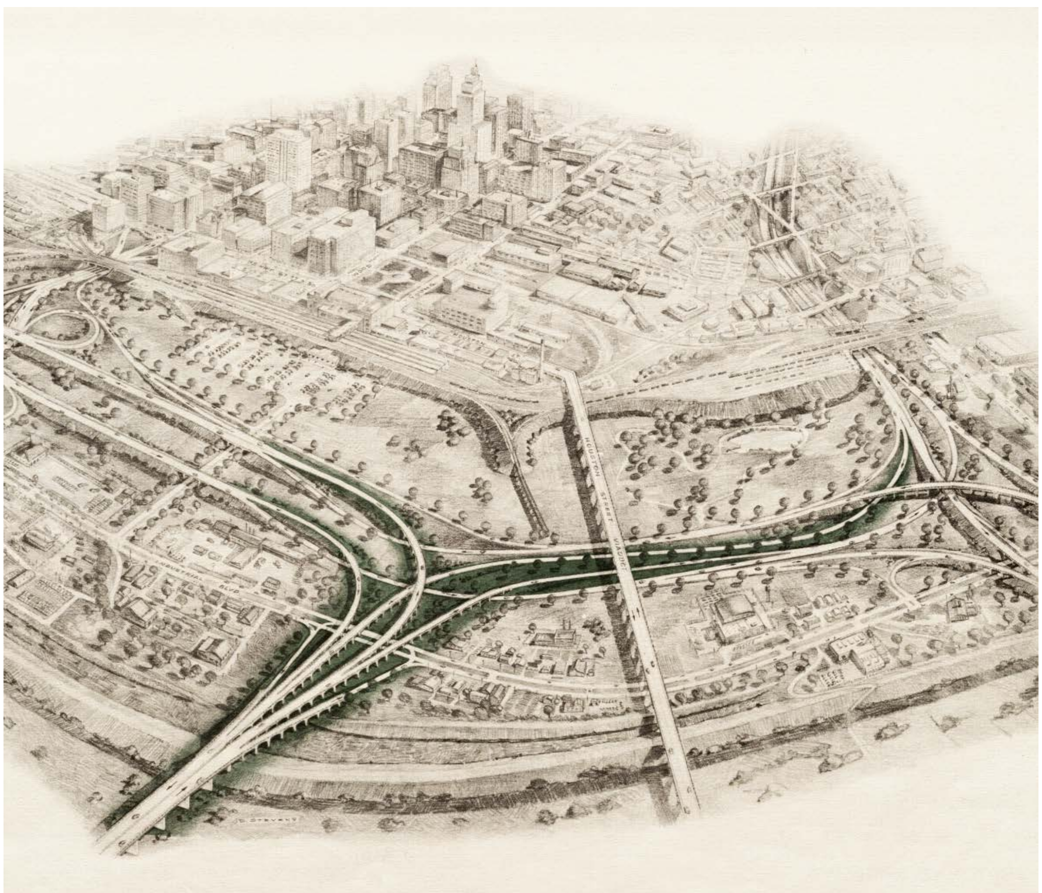


Figure 3.5: Dallas Terminal Connection, HNTB, 1955 (UT-Arlington Library Special Collections)

Figure 3.6: Fort Worth Terminal Connection, HNTB, 1955 (UT-Arlington Library Special Collections)

The Dallas–Fort Worth Turnpike operated between 1957 and 1977, afterward became a nondescript part of I-30. The road, three lanes in each direction but later widened, is the only direct connection between downtown Fort Worth and downtown Dallas, Texas. In October 2001, the former turnpike was named the Tom Landry Highway, after the late Dallas Cowboys coach Tom Landry. (Wilonsky, 2010).

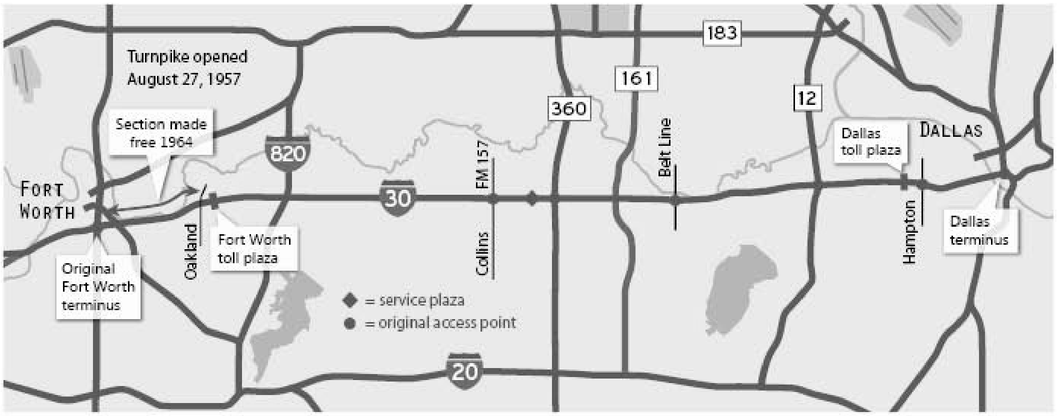


Figure 3.7: Interstate Highway 30 (Source: (UT-Arlington Library Special Collections)

Environmental Assessment: Even though Dallas Fort Worth Turnpike was a significant improvement for DFW metropolitan area, but it destroyed a huge amount of tree canopy and natural prairie habitats and wildlife. After almost 50 years of opening Dallas, Fort Worth Turnpike was recently widened to over 16 lanes in some parts and turned into a massive highway. This section of interstate highway 30 (IH 30) has the various potential consequence of constructing and operating the facility on the human and natural environment. These consequences fall into two categories of Impacts. First are the direct impacts that result from constructing the facility within the project construction footprint. Second are the impacts that extend beyond the construction footprint either during or after the construction of the facility (TxDOT, Environmental Assessment of IH 30, May 2015).

Figure 3.8: Construction of the downtown Dallas connections to the turnpike over Trinity River and Blackland prairie (UT-Arlington Library Special Collections)

Examples of these impacts include the potential sedimentation of streams by soil eroded from construction sites, increases in traffic noise experienced on properties near the project after completion, or the contribution to ambient air quality in local areas near the completed project or throughout the region (TxDOT, Environmental Assessment of IH 30, 2015). There are several impacts that IH30 can influence directly, such as:

1. Community Impacts

    i. ROW/Easement Acquisitions, Displacements, and Relocations
    ii. Land Use
    iii. Transportation and Access
    iv. Economic Effects
    v. Bicycle and Pedestrian Accommodations
    vi. Public Facilities
    vii. Environmental Justice
    viii. Visual Impacts

2. Cultural Resources

    i. Historic-Age Properties
    ii. Archeological Resources

3. Water Resources And Water Quality

    i. Waters of the U.S., Including Wetlands
    ii. Water Quality Certification
    iii. Rivers
    iv. Water Quality
    v. Erosion
    vi. Storm Sewer System
    vii. Floodplains

4. Vegetation And Wildlife Habitat

    i. Project Area Vegetation Features and Impacts
    ii. Invasive Species and Beneficial Landscaping
    iii. Federal and State-listed Endangered Species
    iv. Migratory Bird Treaty Act
    v. Fish and Wildlife Coordination Act

5. Farmland Protection
6. Hazardous Material
7. Traffic Noise
8. Air Quality
    i. Transportation Conformity
    ii. Congestion Management Process
    iii. Carbon Monoxide and Traffic Air Quality
    iv. Mobile Source Air Toxics

In this research, we will focus on direct impacts of HI 30 on Land use and Vegetation and Wildlife habitat and compare them with the Trinity Rail Express (TRE) results.

3.2.2 Trinity Railway Express (TRE):

The Trinity Railway Express (TRE) is a commuter railroad (also called a regional passenger rail) that operates on a 35-mile east-west track with 10 stations between downtown Fort Worth and downtown Dallas. It was the first commuter railroad in the Southwest (Fort Worth Transportation Authority, Trinity Railway Express, 2017).

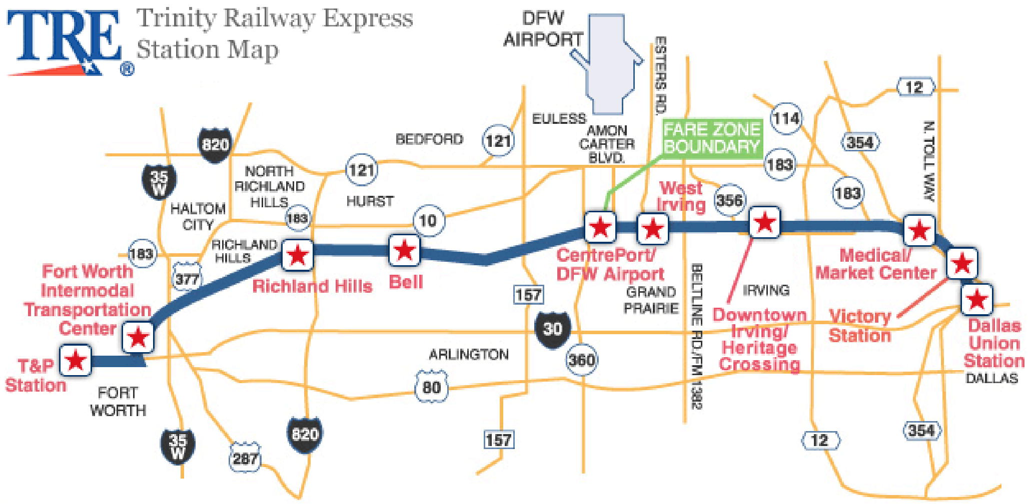


Figure 3.9: TRE Stations (Source: Trinity Railway Express, 2018)

History: Cities of Dallas and Fort Worth purchased the corridor and track from the bankrupt Burlington-Rock Island Railroad in 1983 for future use as a passenger rail between the two cities. The track is now jointly owned by FWTA and DART(Fort Worth Transportation Authority, Trinity Railway Express, June 2017). Burlington-Rock Island Railroad (BRI) was initiated by the Trinity and Brazos Valley Railway Company on October 9, 1902. Brazos Valley Railway Company started completing a railway to go through Fort Worth, Dallas, Santa Fe. Colorado, Houston, and Galveston. But they faced serious financial problems and ownership was reorganized as the

Burlington-Rock Island on July 7, 1930 (George C. Werner, Texas State Historical Association, 2016).

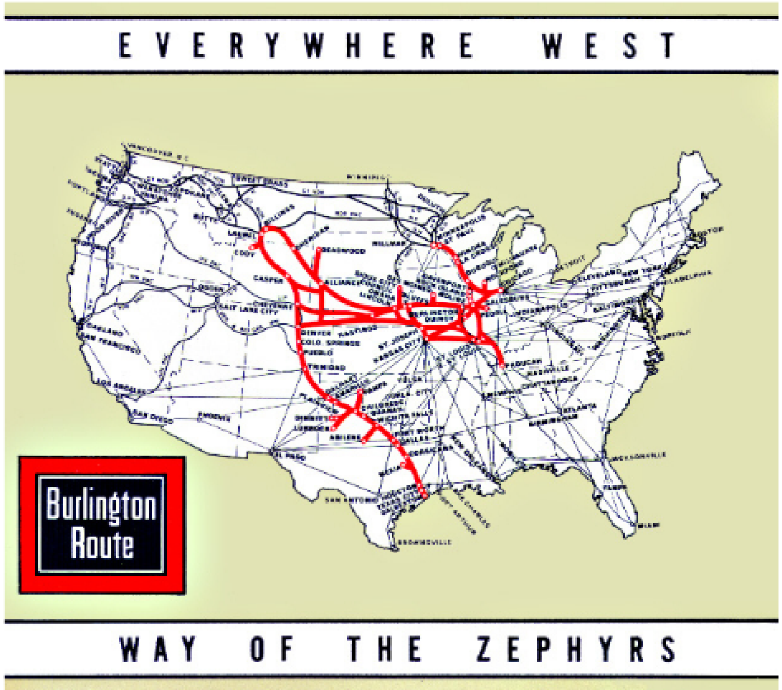


Figure 3.10: Burlington System Railways (Source:Texas State Historical Association)

A major change occurred on June 1, 1950, when the Fort Worth and Denver and the Rock Island leased the rest of the railroad from Teague to Houston to be operated as the Joint Texas Division. In April 1964 the railroad was purchased at foreclosure by the parent companies, with each company obtaining an undivided half interest in the property. The physical property was merged into the Fort Worth and Denver and the Rock Island in 1965, and the Burlington-Rock Island dissolved. The Rock Island ceased operations on March 31, 1980, leaving the Fort Worth and Denver as the sole operator of the former Burlington-Rock Island. The Fort Worth and

Denver was merged into the Burlington Northern Railroad on December 31, 1982 (George C. Werner, Texas State Historical Association, September 2016). After the City of Dallas and Fort Worth purchase named changed after the Trinity River, which flows between Fort Worth and Dallas. The TRE was Launched on December 30, 1996. Currently, TRE serves 2.3 million passengers annually (8,300 average daily ridership) (Fort Worth Transportation Authority, Trinity Railway Express, June 2017).

3.3 Background of the Research Area

The area of focus for this research is the Dallas and Tarrant counties located in the north part of the state Texas (Fig 3.1). As of the 2016 United States census data, there were 4,591,856 people 1,577,509 households 2,406 population per square mile (US Census Bureau, 2016), and 2,293,657 registered vehicle (TxDMV, 2013).

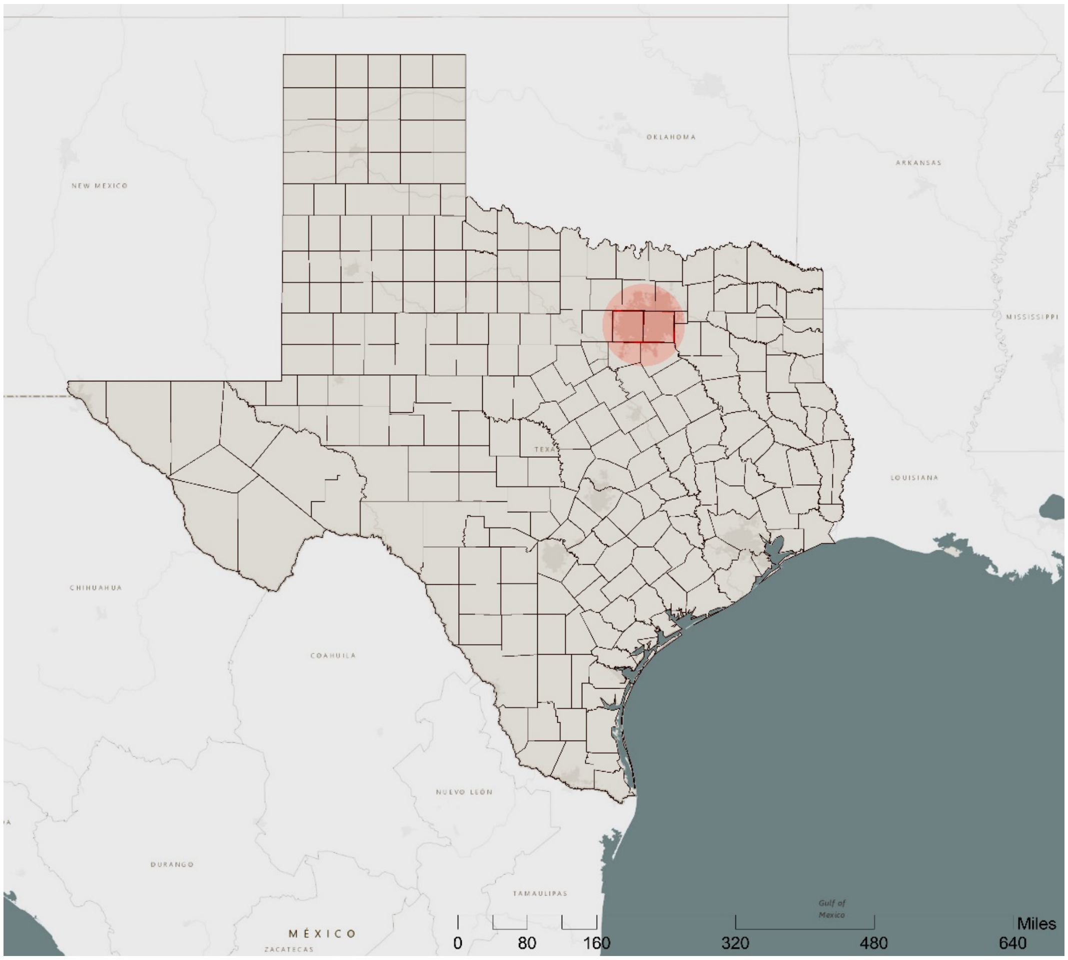


Figure 3.11: Location of Dallas Fort Worth metropolitan area in the state of Texas

As a multi-city metropolitan region located in North Texas, the metropolitan area experienced a drastic growth in the past 25 years. The increasing amount of highway construction projects and traffic has dramatically impacted the DFW metropolitan area, decreasing the quality of life and affecting environmental issues.

Spatial analysis and historic mapping have been widely used in land use and land cover assessment for the urban ecosystem and land transformation. Foresman et al. 1997 used this method to assess land use and cover for urban ecosystems and application in the greater Baltimore-Chesapeake region. They aimed to 1. Critique the combination of land use and land cover; 2. Evaluate spatial analysis and historic mapping methods that can be used to assess past and on-going land transformation; and 3. Show how these methods are used to construct a temporal model of land transformation in the Baltimore-Washington region (Foresman et al, 1997). The Baltimore-Washington project accumulated historic maps, demographic data, environmental parameters, and satellite images to map land transformations from 1792 to 1992 (Fig. 3.12)

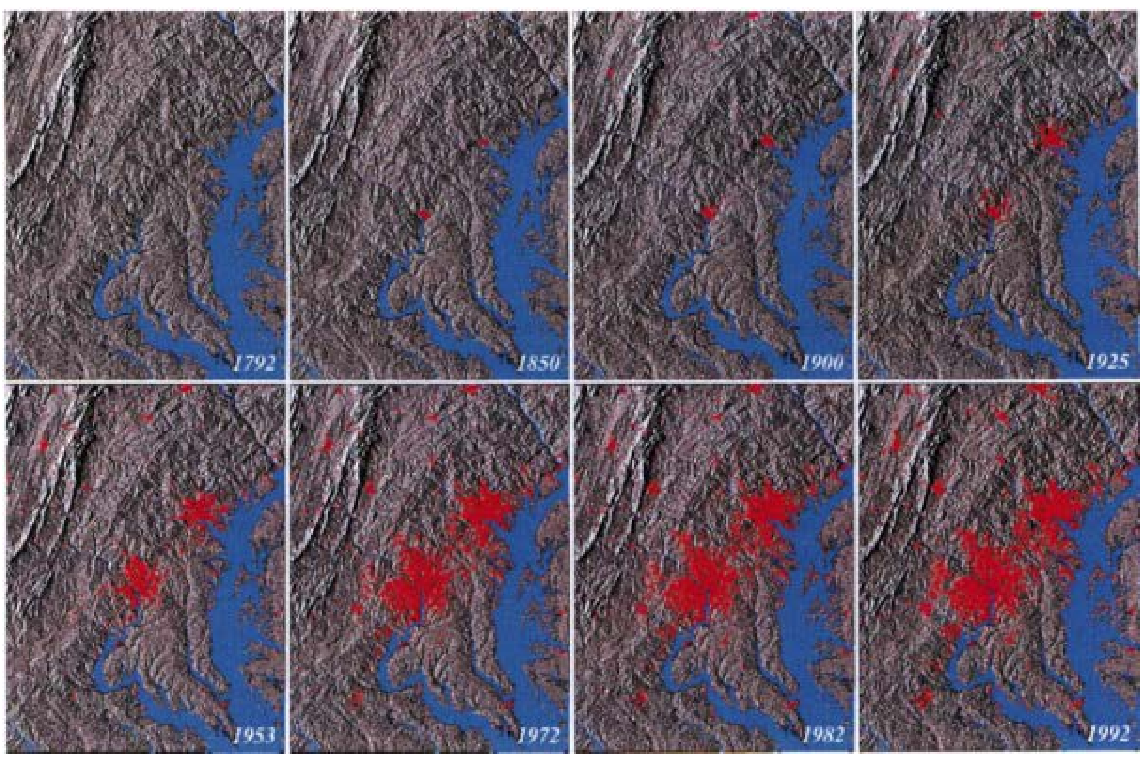


Figure 3.12 Two-hundred years of urban growth for the Baltimore-Washington region (Foresman et al, 1997)

3.4 Research Design

3.4.1 Site Selection

To assess the negative impacts of highways versus railroad system, this research is completed on two samples using five timeframes: 1995, 2000, 2005, 2010, and 2015. As mentioned in chapter 1, the transportation network travels thousands of miles weaving through Dallas Fort Worth metropolitan area. Several interstate and railroads make the condition of this area very complex to work with. In order to select IH 30 and TRE, its important to analyze the transportation data as well as environmental and demographic data.

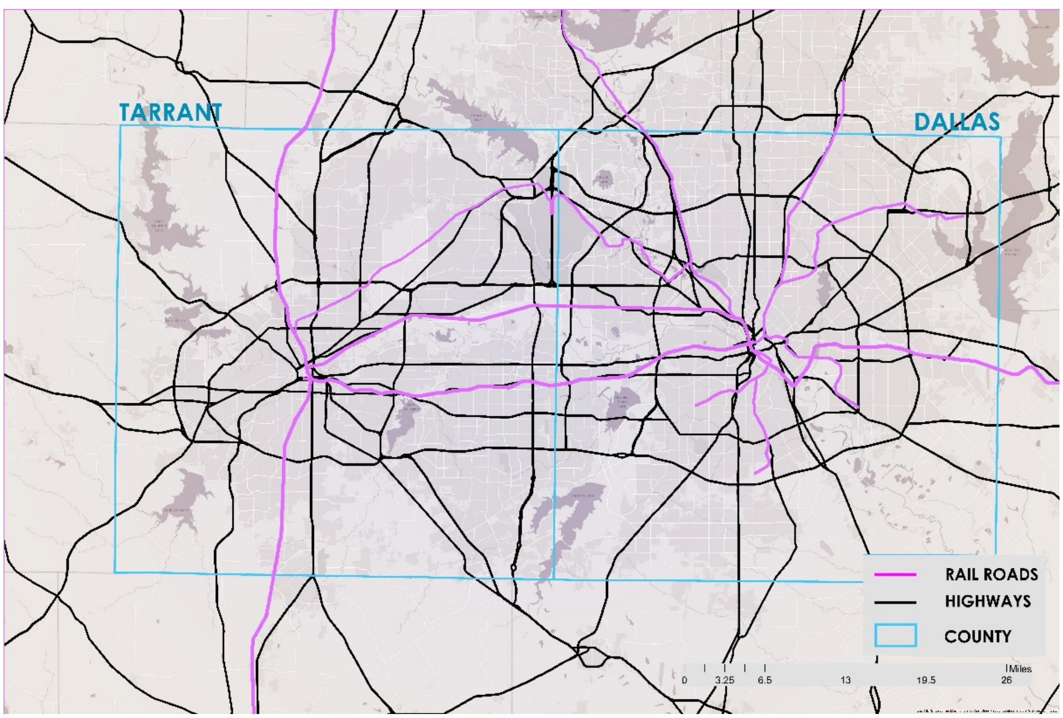


Figure 3.13 Dallas Fort Worth major transit network

3.4.1.1 Transportation Data

For the site selection, the highway is evaluated traffic counts data and railroads by ridership data. Based on spatial analysis tools in GIS, it created a traffic density map for the highway network system (Fig 3.14) and compared ridership data for railroads (Table 3.1).

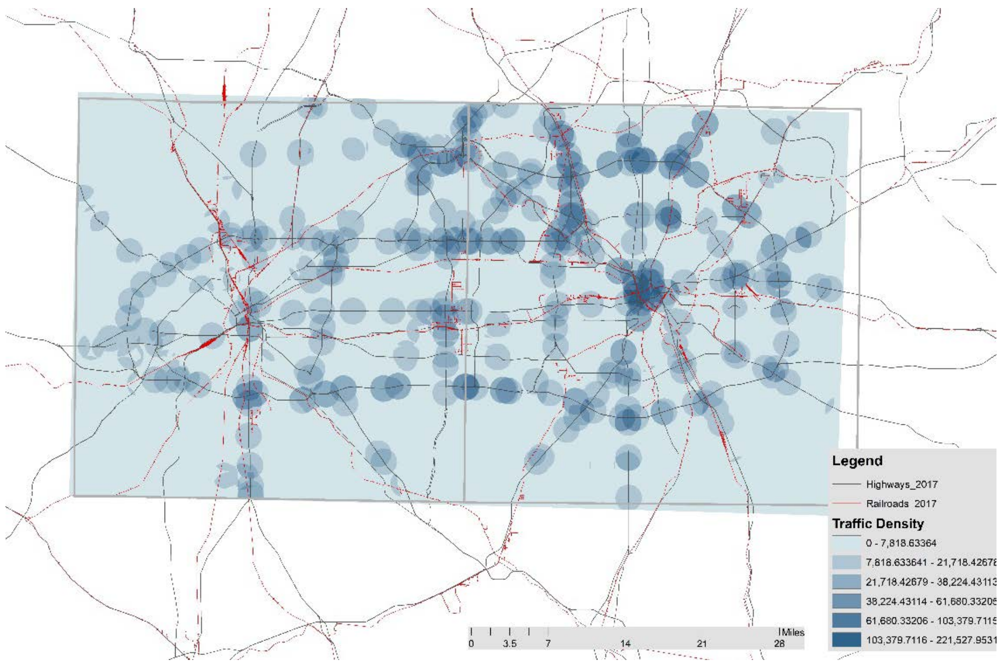


Figure 3.14 Traffic Density Map (data source: TxDOT, 2018)

Traffic density map is indicated that downtown Dallas and Fort Worth have the highest amount of traffic in specific the following: Interstate Highways 30, 20, 35 E, 35W, and 635 and lastly, highway 183 on the north has the highest amount of traffic.

Year	Average Weekday Riders on DART	Average Weekday Riders on the TRE	Average Weekday Riders on Rail (4)	Average Weekday Transit Riders
2004	690584	91376	781960	2557689
2005	712729	95746	808475	2733179
2006	743990	103753	847743	2936422
2007	731437	108397	839834	2922305
2008	808030	121143	929173	3050705
2009	763027	115438	878465	2828763
2010	715734	101613	817347	2665493
2011	938599	100349	1050176	2856593
2012	1117425	94456	1231242	3154990
2013	1139651	92580	1255263	3089697
2014	1167007	98680	1290458	3145167
2015	1183161	93289	1298312	3062639
2016	1146124	87707	1258254	2890083
2017	1158509	88870	1268711	2814486

Table 3.1 Ridership Data for DART and TRE (data source: NCTCOG, 2017)

Table 3.1 shows a gradual increase in DART passengers from 2004 to 2017 and pretty much a stable passenger volume for TRE.

3.4.1.2 Environmental Data

Because the aim of this research is to assess land use and land cover change, land transformation and fragmentation as an impact of expanding transportation infrastructure, these two sites are selected in a highly developed and fragmented landscape condition caused by human activities (Fig 3.15). Another reason for selecting Dallas and Tarrant County and IH 30 and TRE is the unique post oak vegetation cover which is surrounded by growing urban lands. And Trinity River ecosystem is barely surviving among exploding amount of development (Fig 3.16).

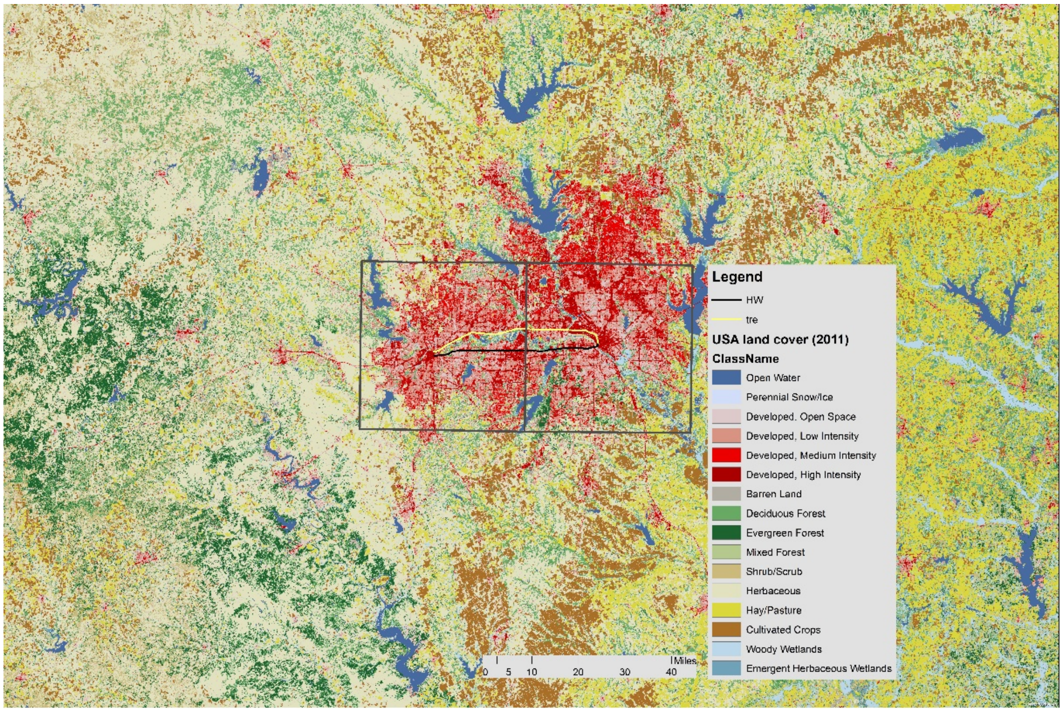


Figure 3.15 Land cover, Dallas-Fort Worth area (USDA Land cover, 2011)

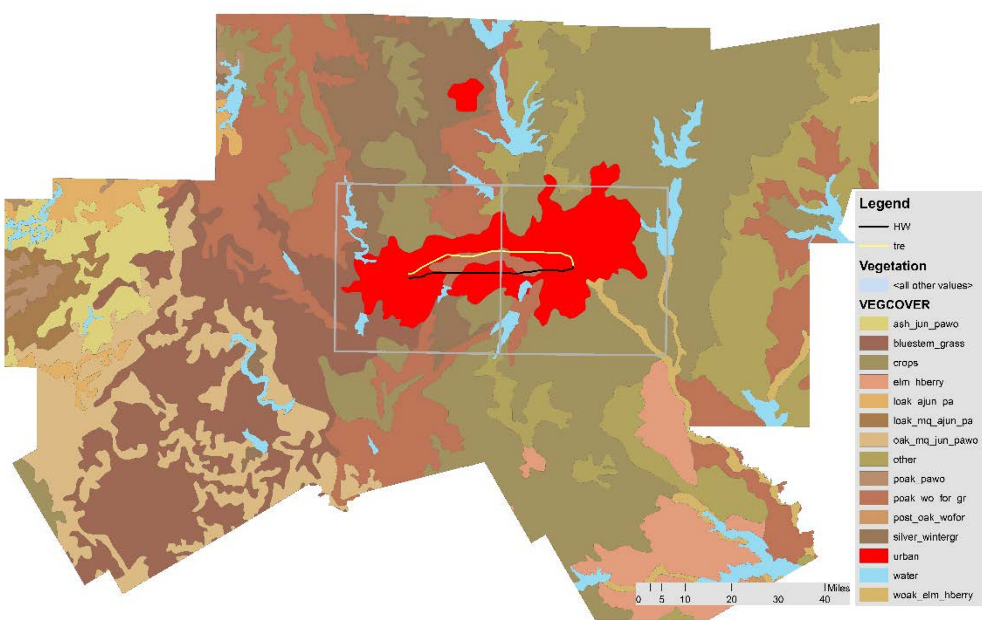


Figure 3.16 Vegetation cover, Dallas-Fort Worth area (Texas Park and Wildlife, 2017)

Land cover and vegetation cover maps clearly describe the current condition of the Dallas Fort Worth metropolitan area as a highly developing urban area with a unique ecology and climate features. More importantly, IH 30 and TRE are located on the south and north of Post Oak vegetation cover as well as Cross Timbers and Blackland prairie level III ecoregion and Trinity River which flows in the middle of the IH 30 and TRE (Fig 3.17).This condition doesn't exist for other for other highways and railroads.

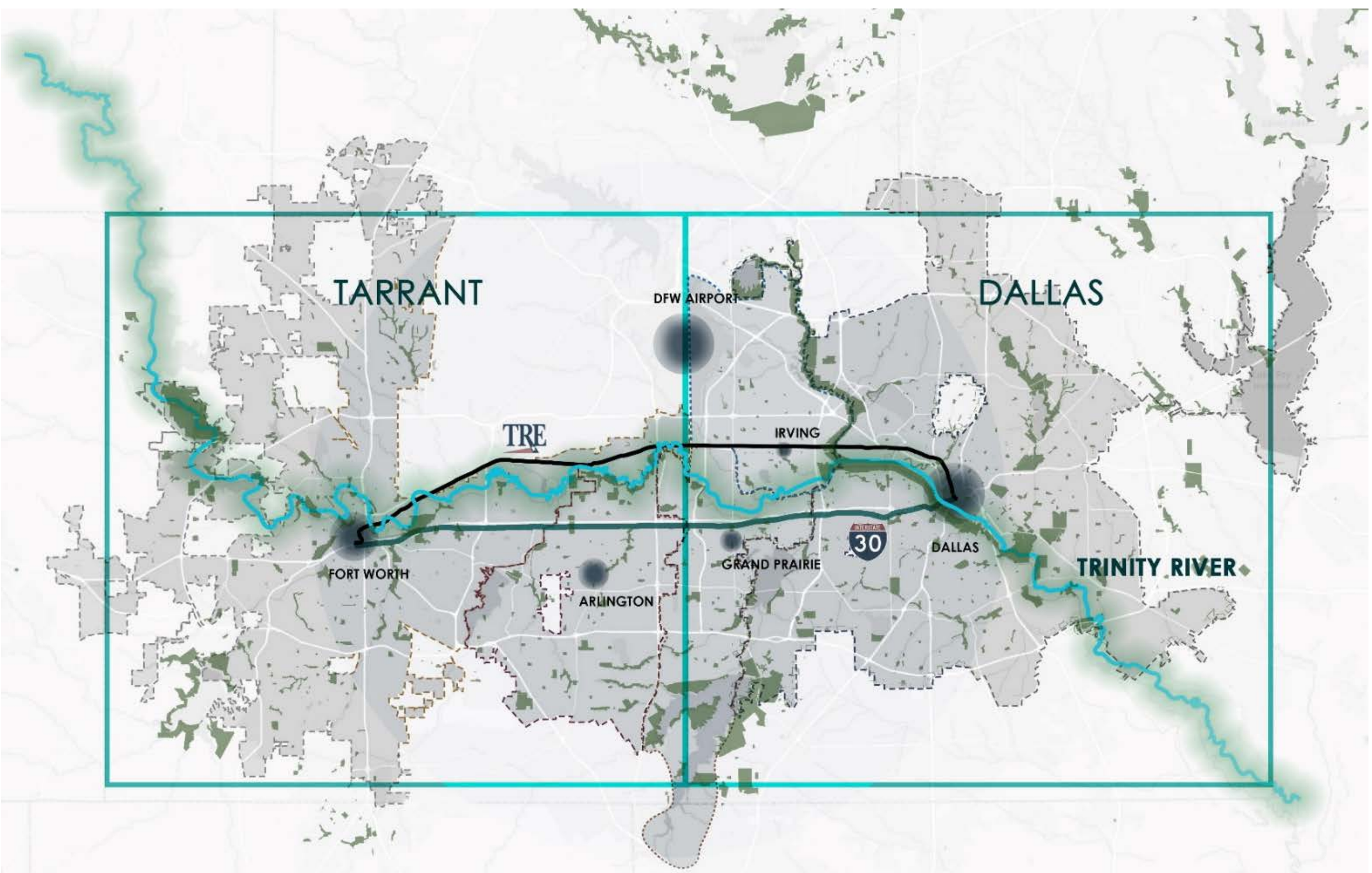


Figure 3.17 Dallas and Tarrant County focus study area (Data source: NCTCOG)

Wildlife mortality is another data selected the site based on. The car and train crash data with large animals for Dallas and Tarrant counties year period of 2010-2017, collected from the Texas Department of Transportation (TxDOT) (Table 3.2).

Reportable Motor Vehicle Traffic Crashes in Dallas and Tarrant Counties

First Harmful Event Equals Animal
2010 Thru 2017 Year to Date

County	Crash Year	Total Crashes
Dallas	2010	24
	2011	17
	2012	27
	2013	27
	2014	15
	2015	21
	2016	20
	2017 YTD	19
Tarrant	2010	32
	2011	30
	2012	28
	2013	34
	2014	40
	2015	33
	2016	32
	2017 YTD	32

Table 3.2 Vehicle and Animal reportable crashes in Dallas and Tarrant counties (TxDOT, 2017)

Vehicle and animal reportable data shows a consistant amount of crashes in Dallas and Tarrant counties from 2010 to 2017. Crash points density map

(Fig 3.18) shows there is a higher volume of crashes on the highways with the higher traffic and closer to ecological features.

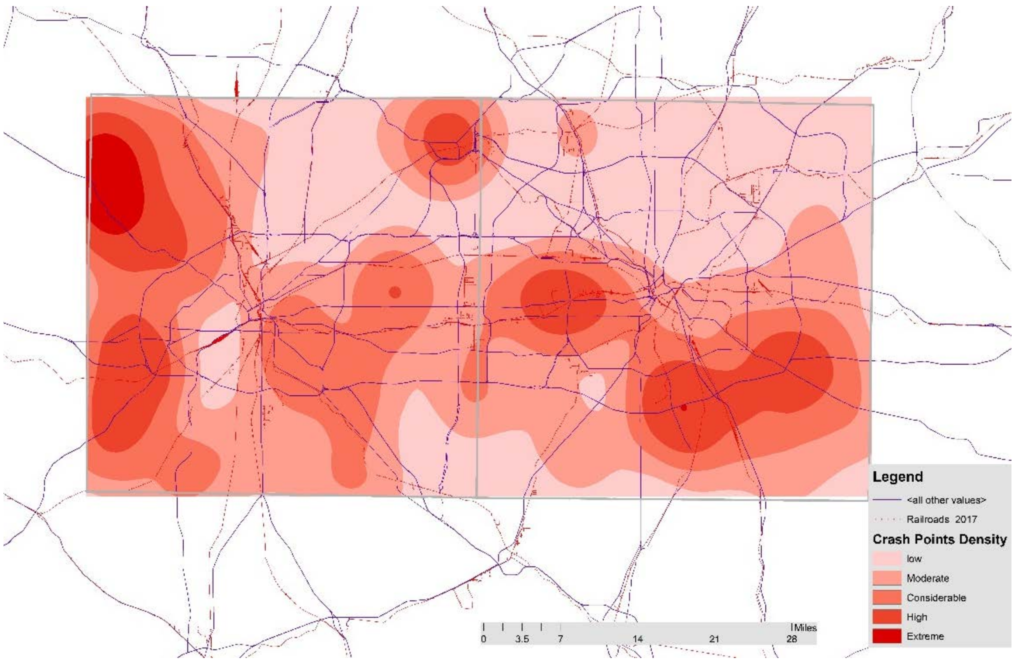


Figure 3.18 Crash point density map (Data source: TxDOT, 2017)

Crash point density was generated with Spatial Analyst (kernel density) in GIS. On the map there are a higher number of crashes in the Interstate Highway 30, 20, and Highway 199 located on the northwestern side of Fort Worth. Highway 199 is located in a special environmental and ecological location because of lakes and Fort Worth Nature Center and Refuge.

Other variables for instance: population, history, number of cars were used for the site selection.

3.4.2 Methodology

To assess the negative of IH30 and TRE, the Spatial Analyst and historic mapping is used to quantify the degree of land use and land cover changes, land transformation, and fragmentation, and tree canopy loss over the chosen timeframes of 1995, 2000, 2005, 2010, and 2015.

The methodology chosen for this study is GIS-based spatial analysis and historic mapping.

3.4.2.1 GIS-Based Spatial Analysis Tools

Spatial analysis is a well-defined subsection of the methods of analysis available to a project (M F Goodchild and P A Longley, 1999). The GIS-based spatial analysis tools allow the user to see patterns and relationships between features and data in basic and regular analytical methods. Spatial analysis creates new information from existing data, based on single or multiple layers of data and shapefiles. The most common GIS analysis tools include:

I. Proximity analysis
II. Reclassification
III. Queries
IV. Overlay operations
V. Density analysis
VI. Statistical analysis
VII. Change analysis
VIII. Topographic analysis
IX. Suitability studies

While some of the spatial analysis tools work in a cycle as a process in order to generate the desired spatial analysis results, other tools work as separate tools. Below the spatial analysis tools used in this research study:

I. *Proximity Analysis*

Proximity analysis can be used to identify proximity relationships. These tools output information with buffer features or tables. Buffers are usually used to define protected zones around features or to show influenced areas (ArcGIS, 2017). Buffers may be used both as one-ring or multiple-ring distances.

II. *Reclassification*

Reclassification tools reclassify or change cell values to alternative values using different kinds of methods. This tool is very helpful for combining different layers of data to generate a combined dataset.

III. *Queries*

One of the simplest GIS tasks is querying the GIS database in spatial analysis. A simple query helps the user to look through the database for features that meet certain defined criteria. It can identify points and data points based on their location or by other attributes associated with features.

IV. Density analysis

"Density analysis takes known quantities of some phenomenon and spreads them across the landscape based on the quantity that is measured at each location and the spatial relationship of the locations of the measured quantities" (ArcGIS, 2017). Density analysis also lets the user visualize the patterns and concentration of data and landscape features. Kernel Density, Line density, and Point density are three tools that you can find in the Density analysis toolbox.

3.4.2.2 Historic Mapping

Historical mapping is another method used in this research to identify land use and land cover changes and land transformation over the chosen timeframe. This method is appropriate for most North American continent in terms of defining processes of land transformation and urban landscape, as well as other environmental and ecological feature (Brondizio et al. 1996; Skole and Tucker, 1993, Foresman et al. 1997).

3.5 Limitation of the Methodology

This research study is done by analyzing, assessing and comparing the historic mapping in Dallas and Tarrant counties for the period of 1995-2015. The limitations of this methodology are the quality of given data used for spatial analysis, resolution quality of historic mapping, and spatial analysis challenges and technical difficulties in the capacity to quickly create realistic spatial models.

3.5.1 Limitations of data

Land use, land cover, and historical mapping data have certain limitations need to be borne in mind. The major constraints are:

3.5.1.1 Precision of boundaries

Regularly, the boundary between two land systems is fairly unclear and depends on identification of areas of most rapid change in the relevant parameters of landform, geology, soil and vegetation. This confusion in land boundaries may cause an inbuilt error in the determination of the areas (Agriculture Victoria).

3.5.1.2 Scale

Scale can change for many various reasons in a project. The thickness of the line work on the map has the potential errors. While enlargement of the map won't increase the accuracy or reliability of the data, it will introduce more errors (Agriculture Victoria).

3.5.1.3 Quality and evenness of the base data

Perfectly, data sets such as land use and land cover built up from smaller units of similar scale and detail. While, the power of the dataset is in its scope, assimilating information to form a consistent format for the whole of the state, rather than in presenting accurately located site-specific data. It takes an uneven database and excerpts a common, if limited, set of descriptors (Agriculture Victoria).

4 Chapter 4: Analysis and Findings

4.1 Introduction

This chapter, outlines the analysis and findings on the assessment of impacts of IH 30 and TRE on land use and land cover change, land formation, and fragmentation. The chapter includes a description of IH 30 and TRE in each study timeframe and provides analysis for each variable. Interstate Highway 30 (IH30) and Trinity Railway Express (TRE) each differentiate in terms of land use and land cover, density, habitat mortality and land transformation.

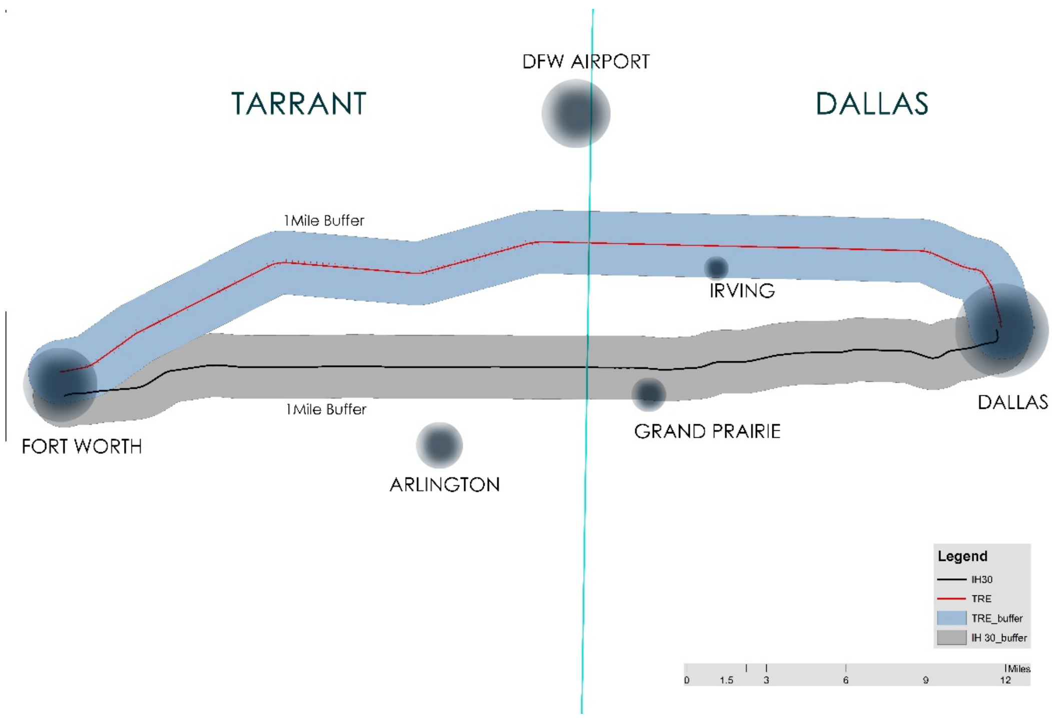


Figure 4.1 1 mile buffer study for IH30 and TRE (Data source: NCTCOG, 2017)

I analyzed impacts of IH 30 and TRE within 1-mile buffer around them. With spatial analysis tool (proximity tools) in ArcGIS, a 1-mile PLANAR buffer was created around both IH30 and TRE (Figure 4.1). In total, 186 square miles (119040 acres) were analyzed, which 90 sq. mi surrounds IH30 and 96 sq. mi in 1-mile buffer of TRE. This chapter first focuses on analyzing changes of each variables over the 1995-2015 timeframe within the one-mile buffer of IH 30 and TRE. Later on, having a comparison between the amount of changes within one mile buffer of IH 30 and TRE.

4.2 Analysis and Findings

4.2.1 Land use change

Based on U.S. Department of the Interior and Bureau of Land Management, Land use is "the human use of territory for economic, residential, recreational, conservational, and governmental purposes. The concept of land use is closely intertwined with human community development. Patterns of human development and land use have shaped the environment locally and globally since prehistoric times" (Bureau of Land Management, U.S. Department of the interior, 2005). In this study seven major land uses include: commercial, residential, institutional, industrial, open area, water, and transportation were analyzed (Table 4.1).

Commercial	
Residential	
Institutional	
Industrial	
Open space	
Water	
Transportation	

Table 4.1 major land uses

Land use was analyzed over five periods of times 1995, 2000, 2005, 2010, and 2015 to assess impacts of IH 30 and TRE on changes in acreage for each major uses. Figure 4.2 shows the Land use map for Dallas and Tarrant County in 2015. As shown in the map the major part of the land use is Residential which consists of single family, multi-family, mobile homes, residential acreage, and group quarters. Other land uses such as commercial land use consists of retail, mixed-use, hotel, office, parking and large stadiums. Cemeteries, communication, education, and institutional and semi-public entities are part of Institutional land use. Farmlands, industrial properties, landfill, and utilities were considered as industrial land use. Open space land use is consists of parks, ranch lands, timberlands and vacant lands.

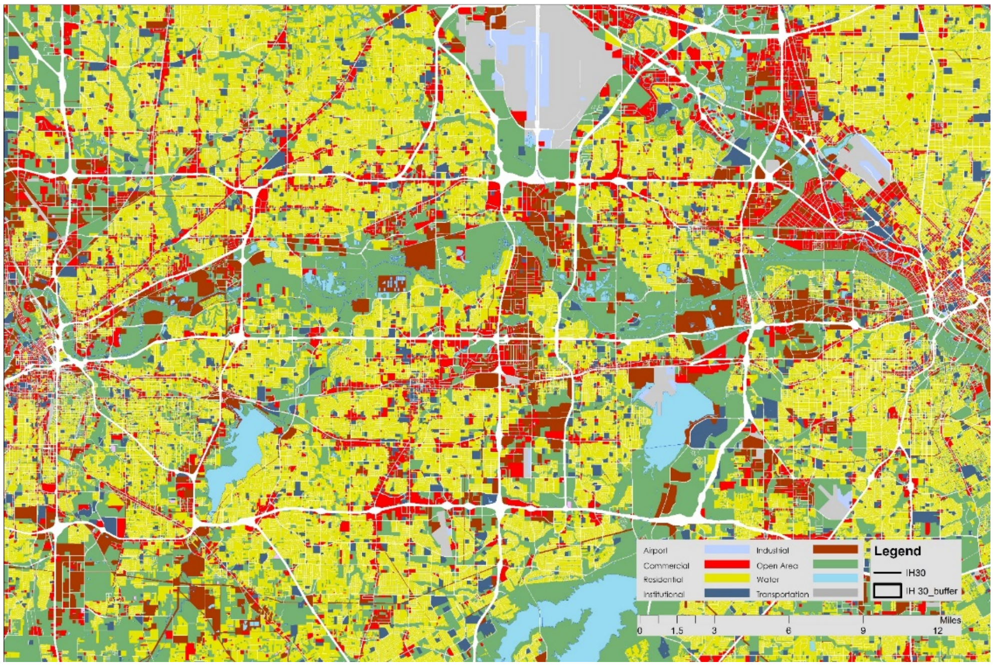


Figure 4.2 Land use map Dallas and Tarrant County, (Data source: NCTCOG, 2015)

4.2.1.1 Interstate Highway 30 -Downtown Dallas to Downtown Fort Worth

Land use change was analyzed in every five timeframes to investigate impacts of highway on the land use change, following maps and charts shows the percentage of each land use and compare changes of each land use from 1995-2015.

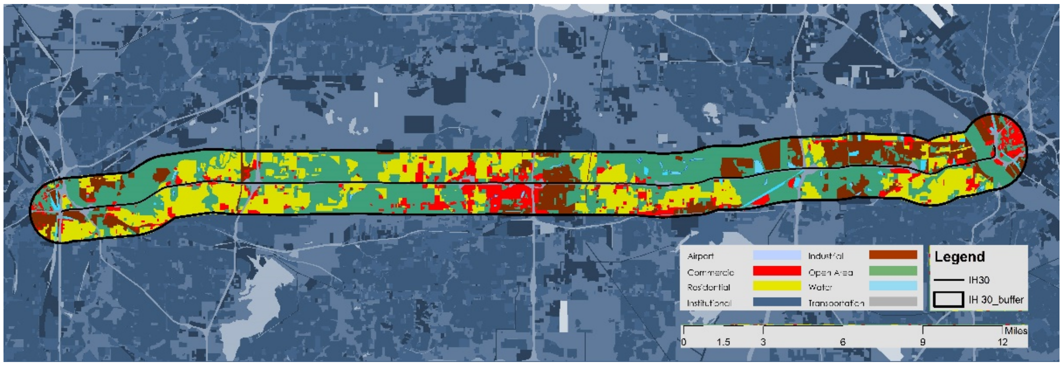


Figure 4.3 Land use map within 1-mile radius of IH 30, 1995

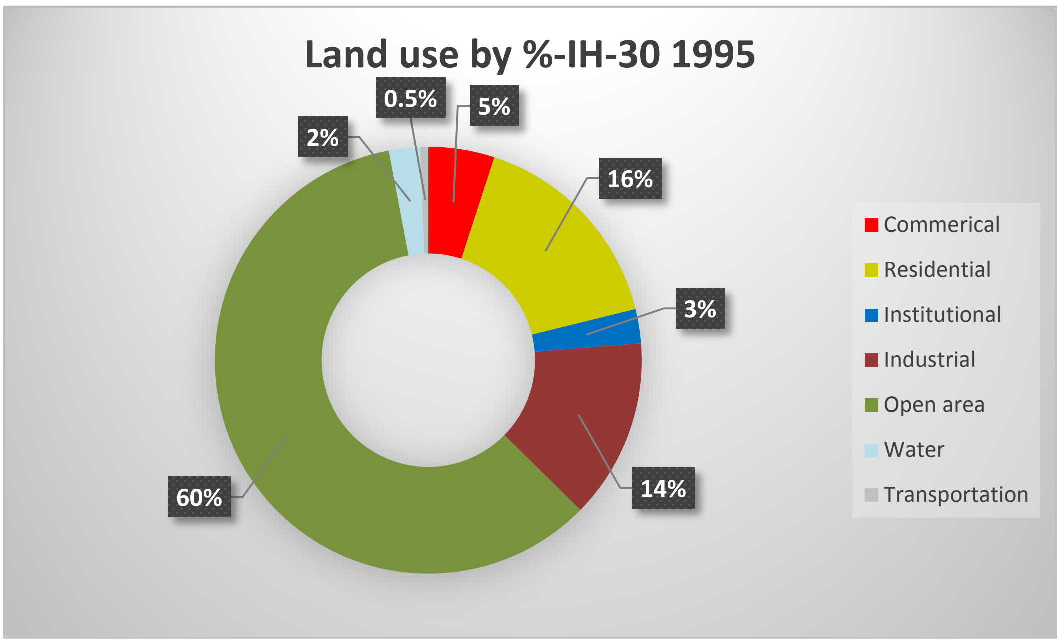


Chart 4.1 Land use by % within 1-mile radius of IH 30, 1995

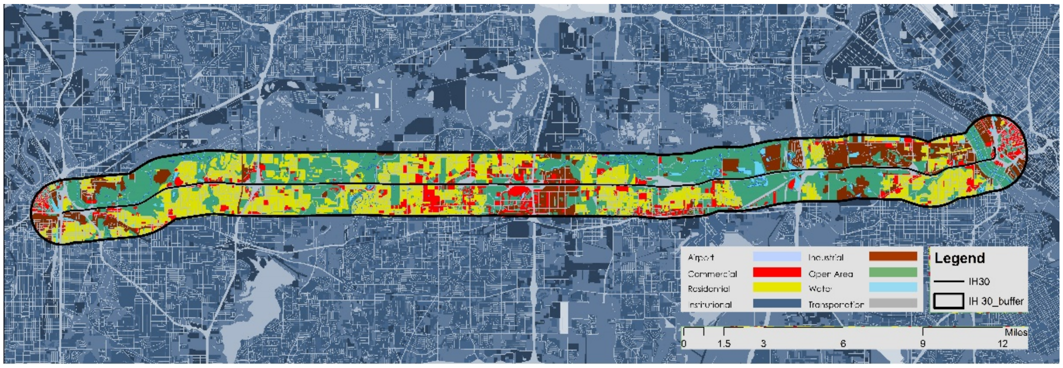


Figure 4.4 Land use map within 1-mile radius of IH 30, 2000

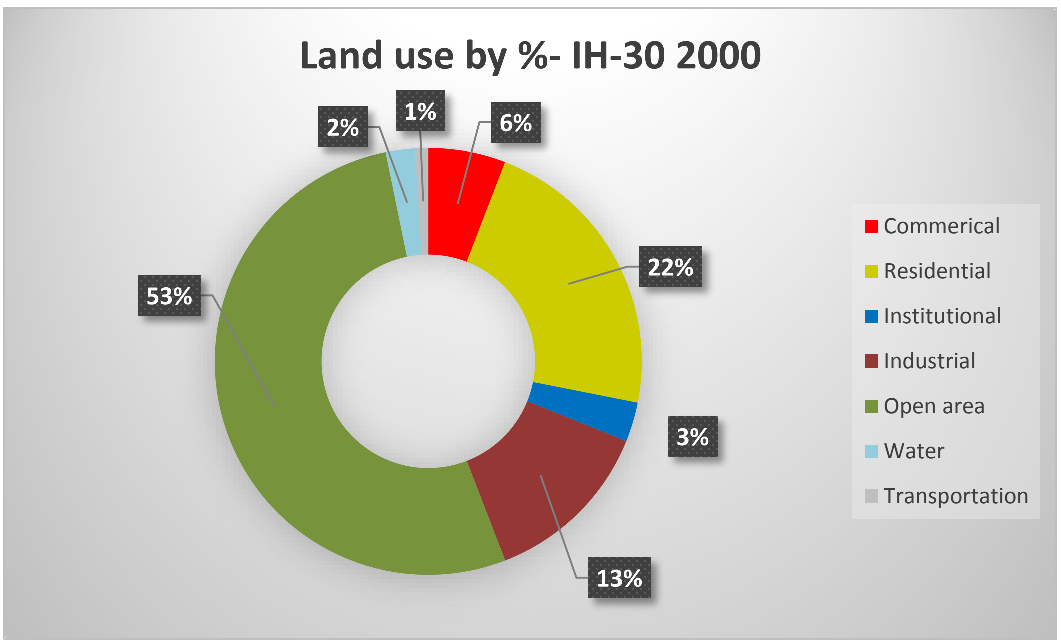


Chart 4.2 Land use by % within 1-mile radius of IH 30, 2000

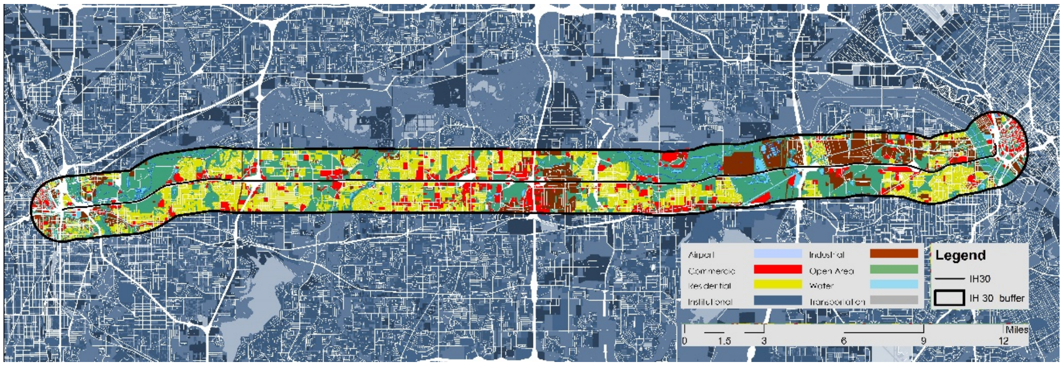


Figure 4.5 Land use map within 1-mile radius of IH 30, 2005

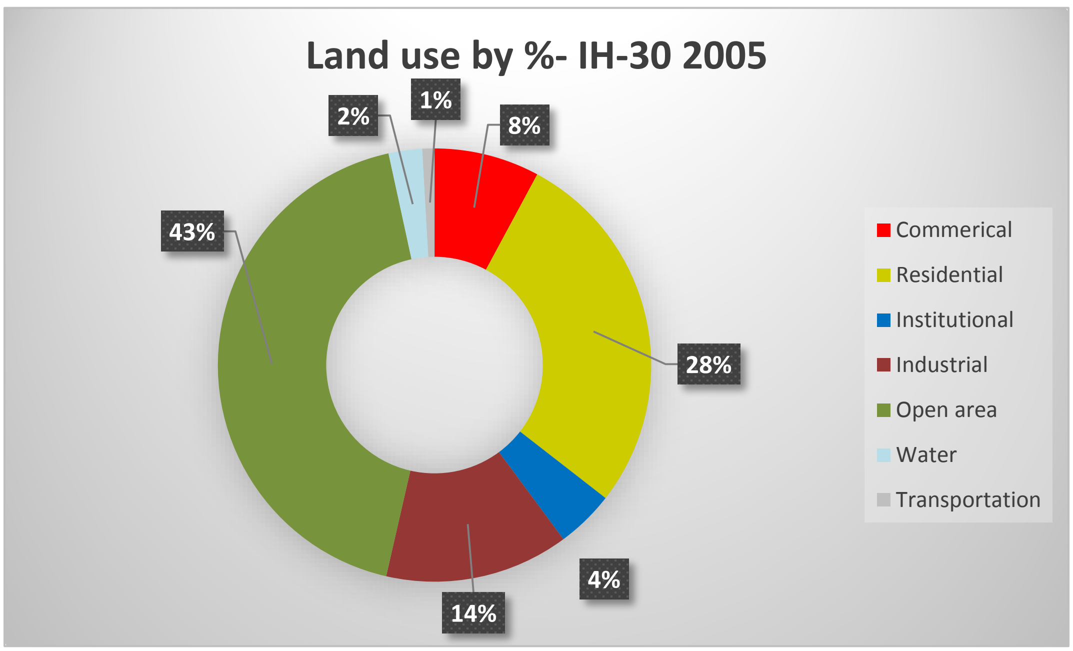


Chart 4.3 Land use by % within 1-mile radius of IH 30, 2005

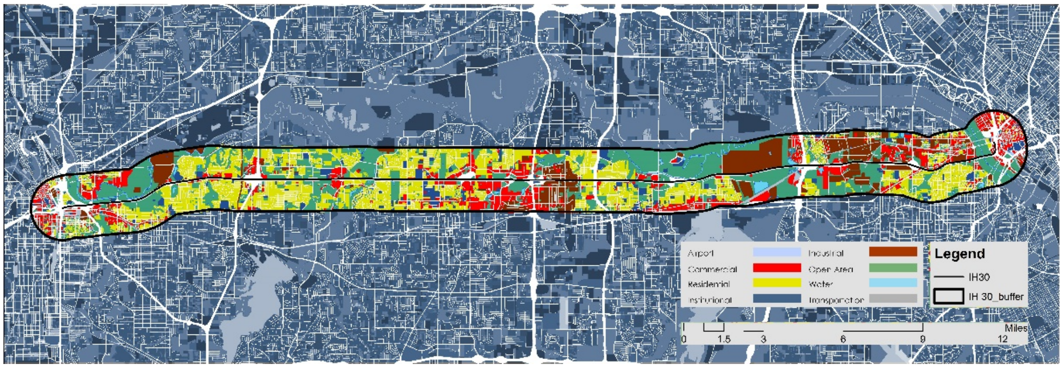


Figure 4.6 Land use map within 1-mile radius of IH 30, 2010

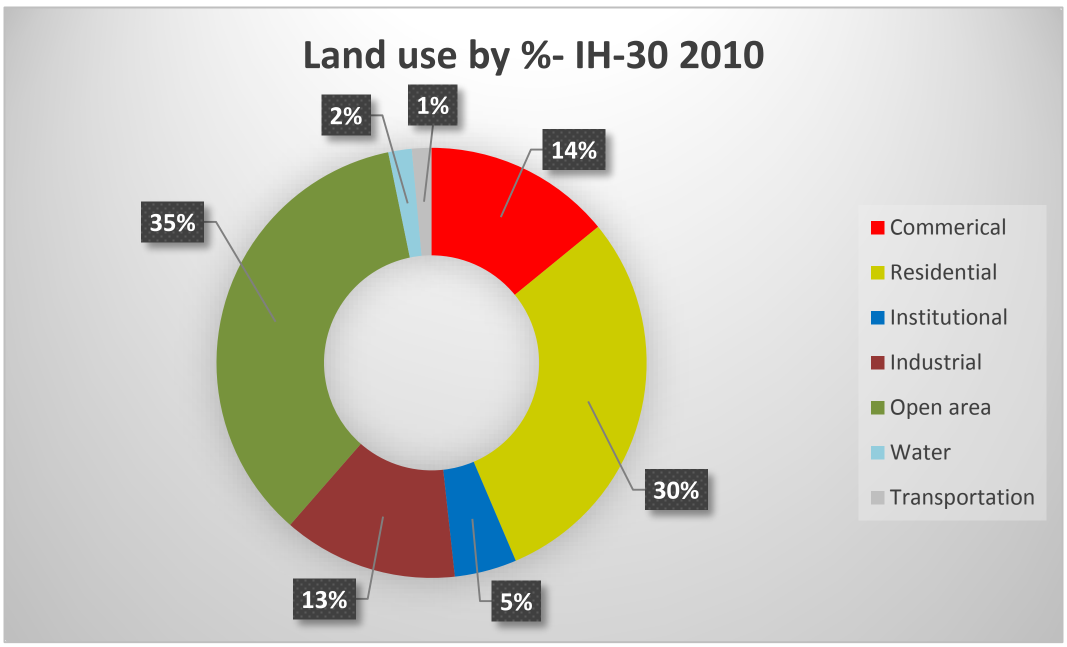


Chart 4.4 Land use by % within 1-mile radius of IH 30, 2010

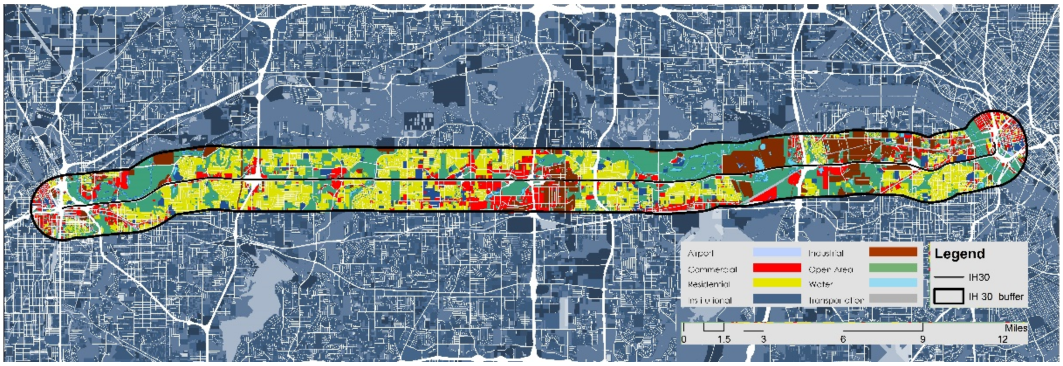


Figure 4.7 Land use map within 1-mile radius of IH 30, 2015

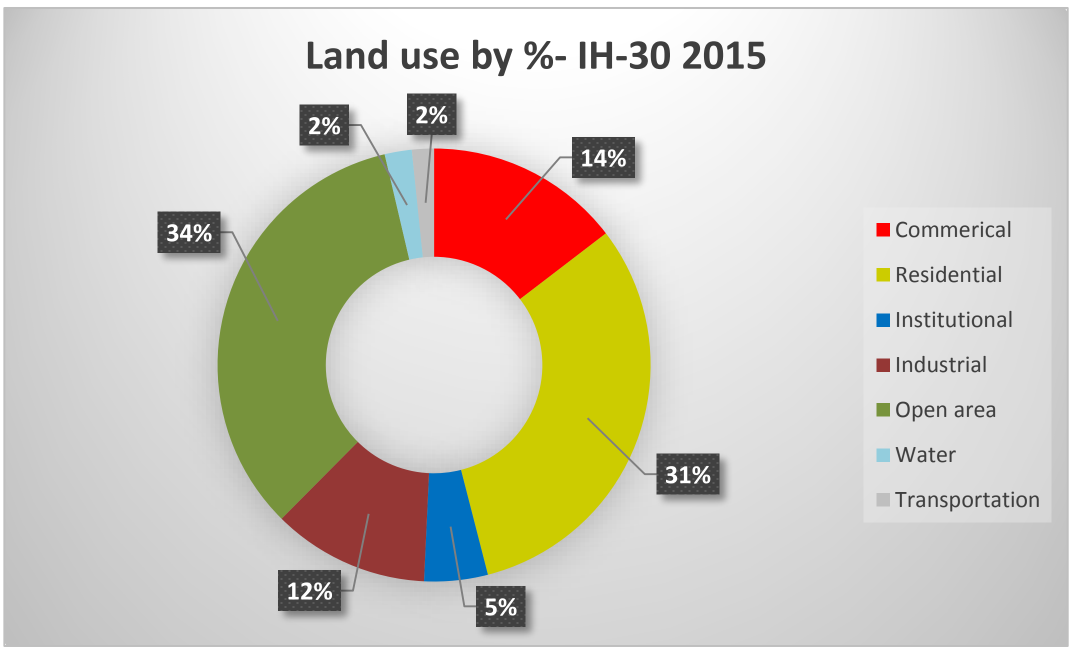
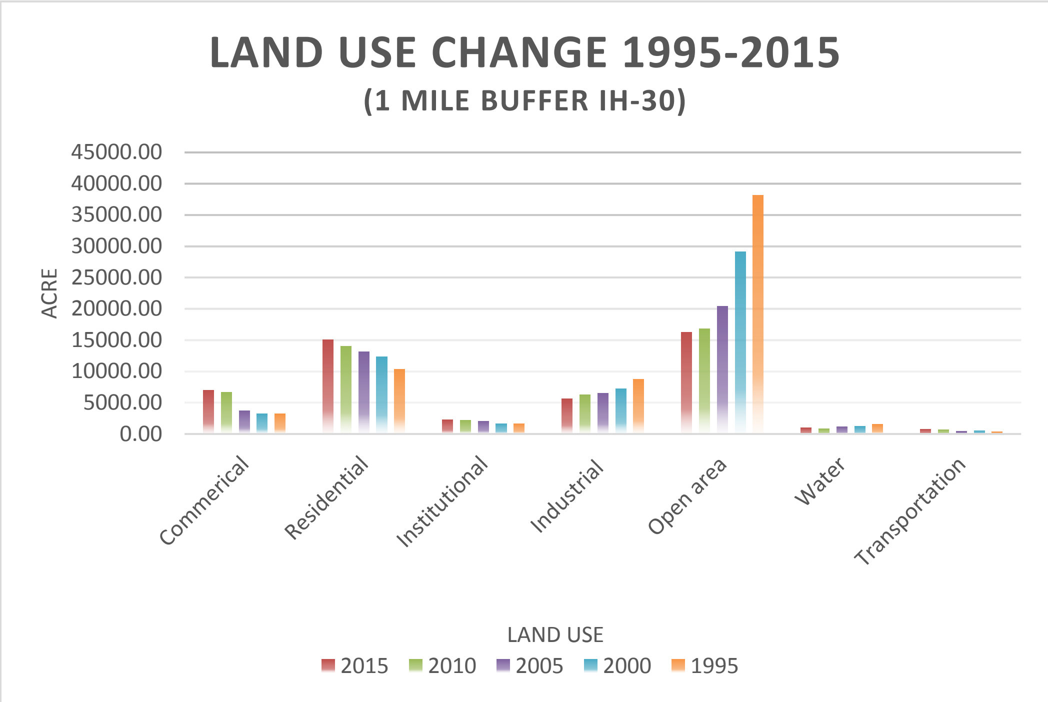


Chart 4.5 Land use by % within 1-mile radius of IH 30, 2015

The analysis of the land use over the past 20 years, show that the amount of the green and open space decreased drastically from 60% to 34%, which means over 16,000 sq. ft. of timberlands, ranch lands, forests in Cross Timbers and Blackland Prairies ecoregions were lost. Whereas, there is a gradual increase in residential and commercial land uses by 16% and 9% respectively. Transportation and institutional land uses increase slightly over past 20 years by 2% and slightly decrease in industrial land use by 2%. Chart 4.6 is summary of an area of each land use in sq. ft. from 1995 to 2015. As you see the biggest land use change is in open areas, residential and commercial.

Chart 4.6 Land use change 1995-2015



4.2.1.2 Trinity Railway Express- Downtown Dallas to Downtown Fort Worth

In order to investigate the impacts of TRE on land use change and have an accurate comparison with IH 30 same land use change analysis were conducted for TRE as well. Following maps and charts shows the percentage of each land use within the given 1-mile buffer around Trinity Railway Express. Nevertheless, compare changes of each land use over the time to have a better understanding about which land use was influenced more from development around TRE.

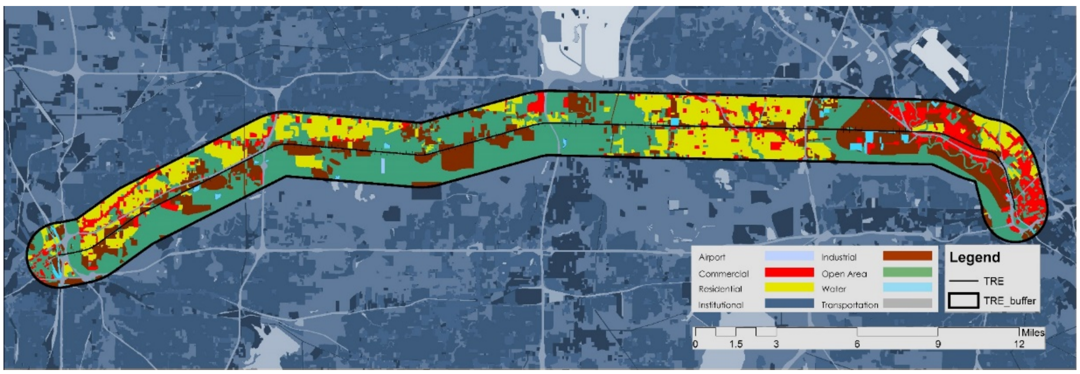


Figure 4.8 Land use map within 1-mile radius of TRE, 1995

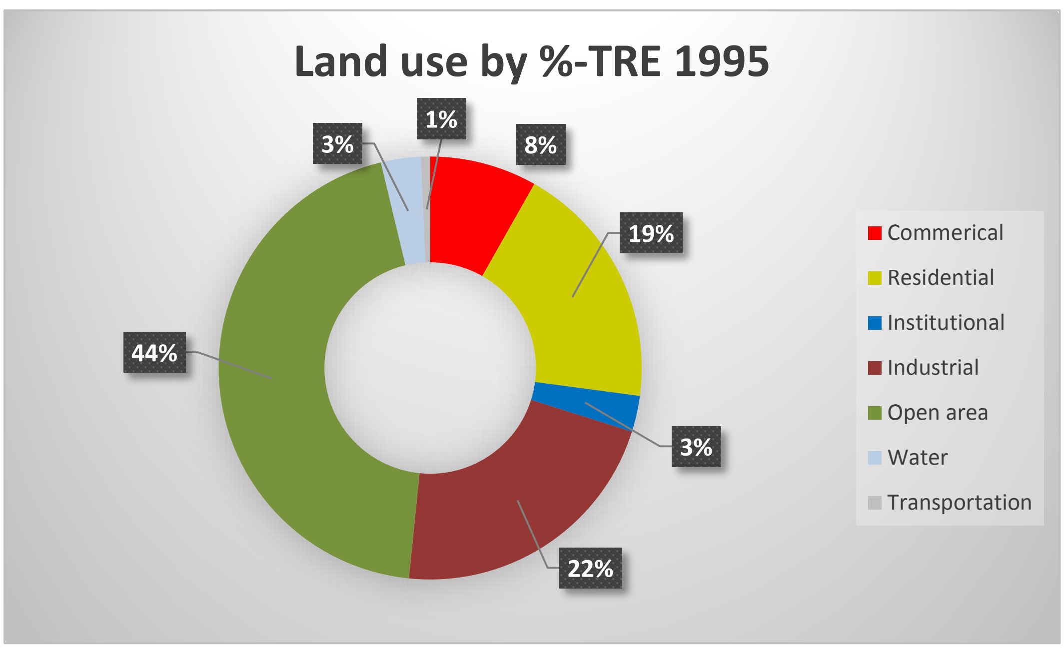


Chart 4.7 Land use by % within 1-mile radius of TRE, 1995

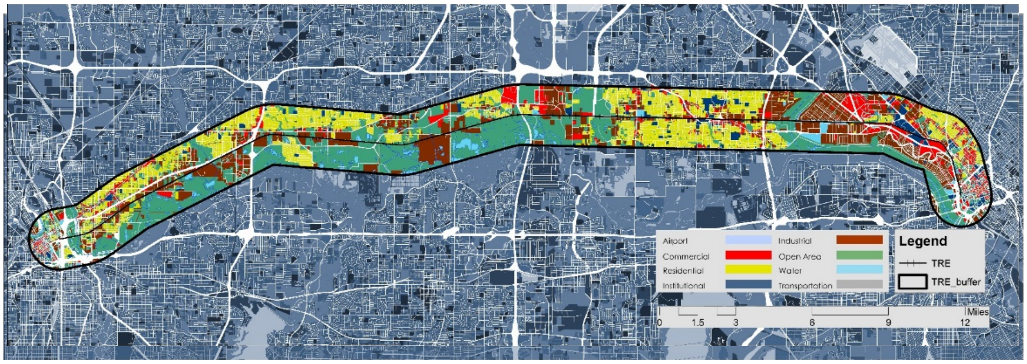


Figure 4.9 Land use map within 1-mile radius of TRE, 2000

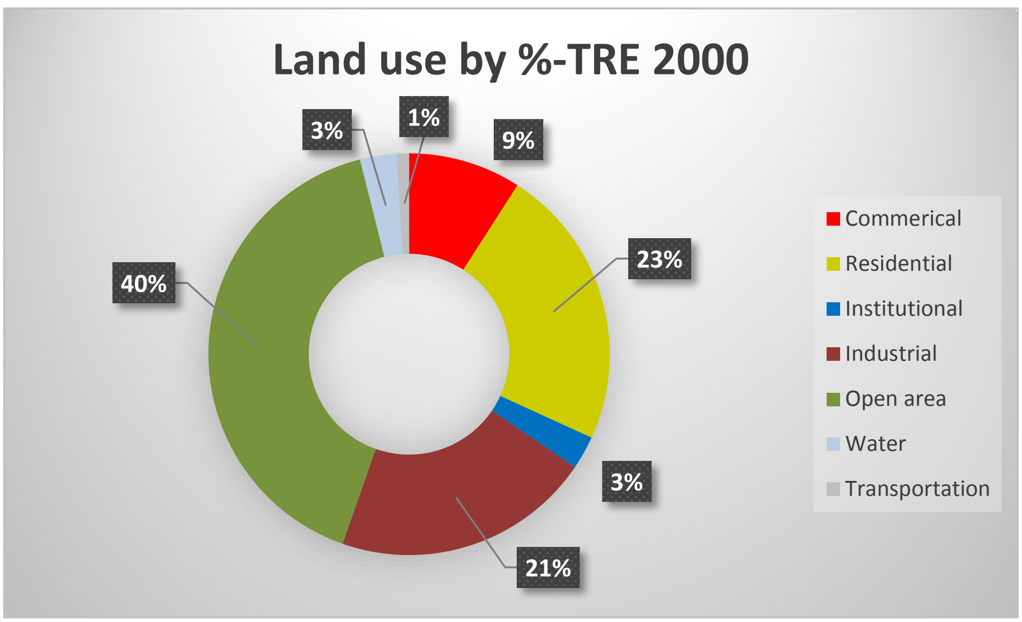


Chart 4.8 Land use by % within 1-mile radius of TRE, 2000

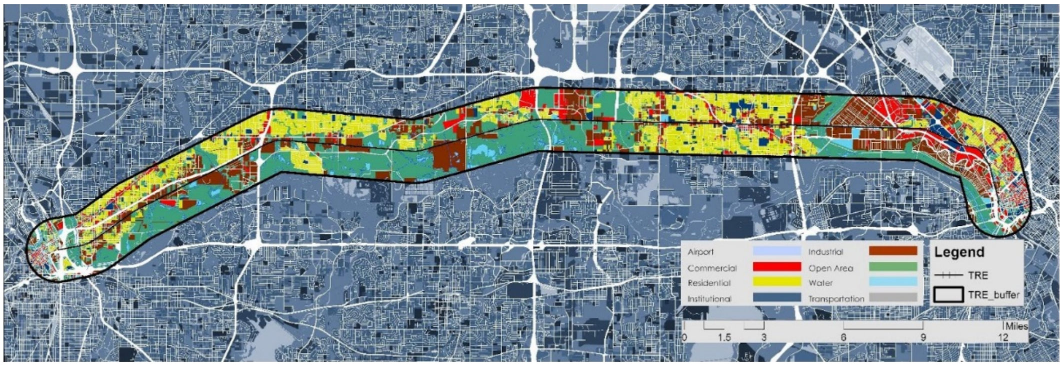


Figure 4.10 Land use map within 1-mile radius of TRE, 2005

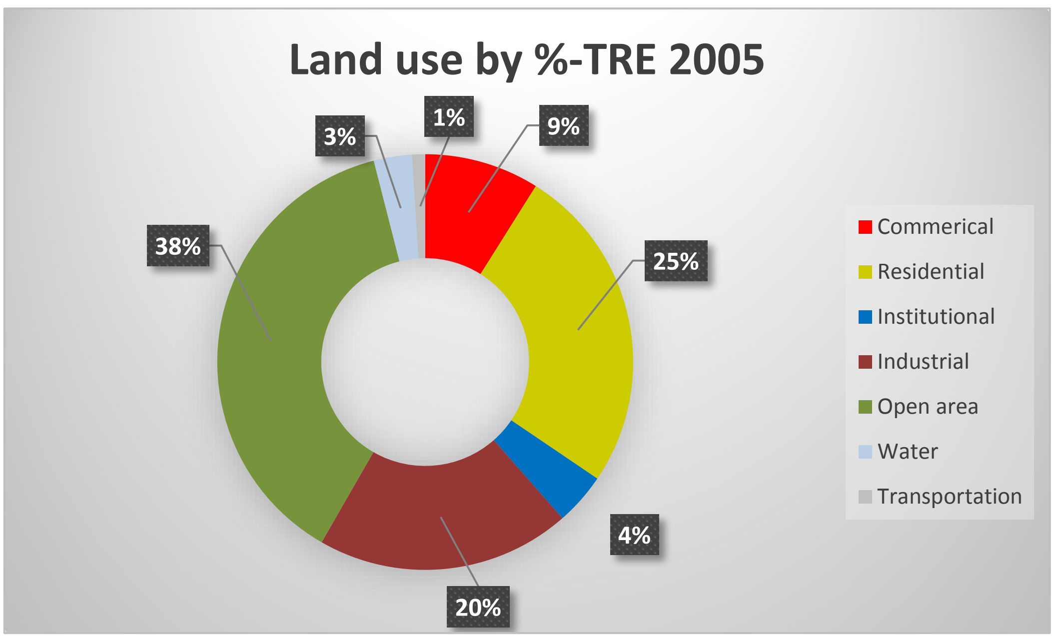


Chart 4.9 Land use by % within 1-mile radius of TRE, 2005

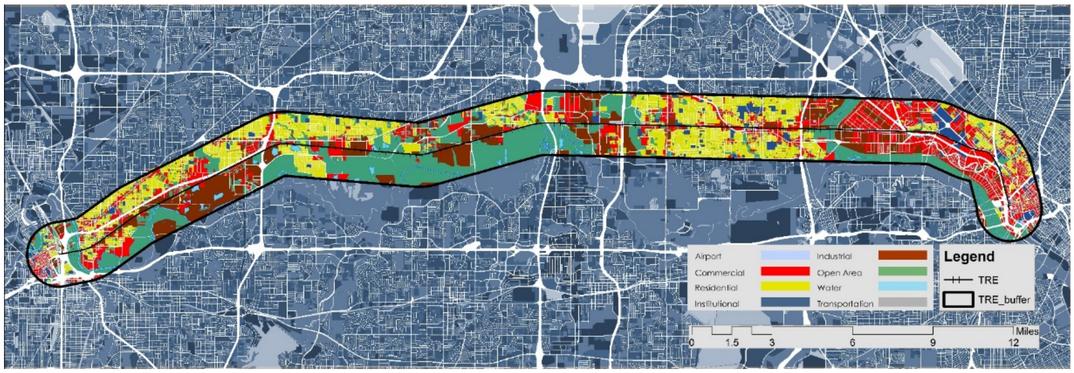


Figure 4.11 Land use map within 1-mile radius of TRE, 2010

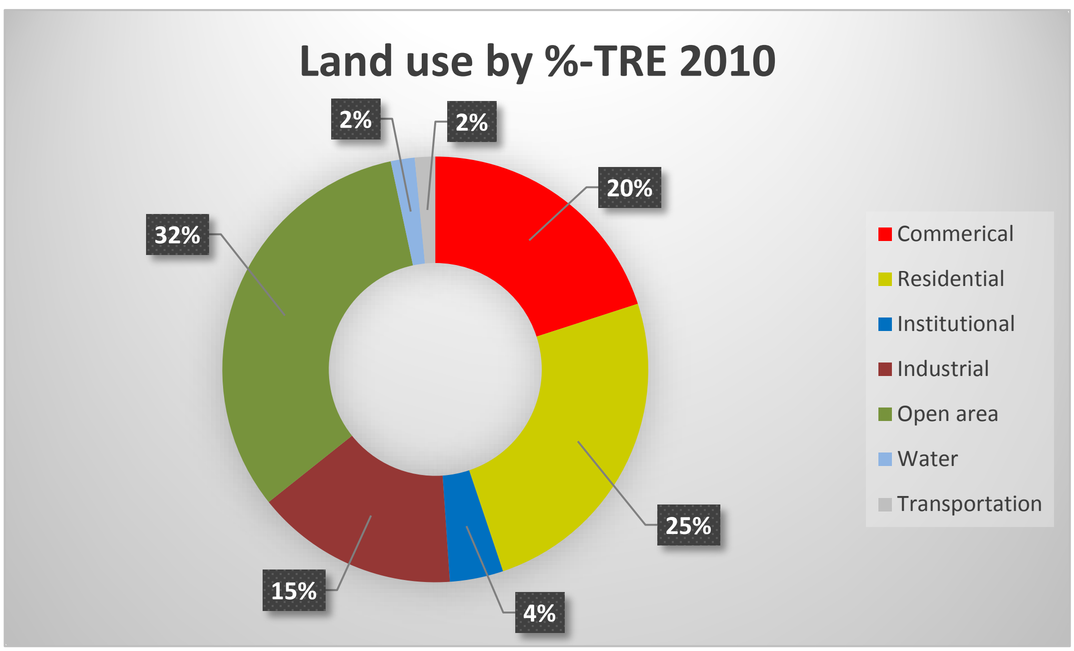


Chart 4.10 Land use by % within 1-mile radius of TRE, 2010

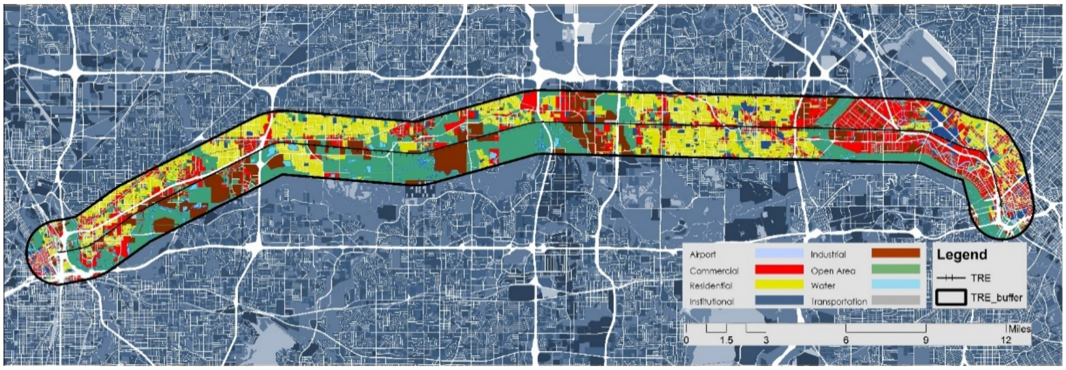


Figure 4.11 Land use map within 1-mile radius of TRE, 2015

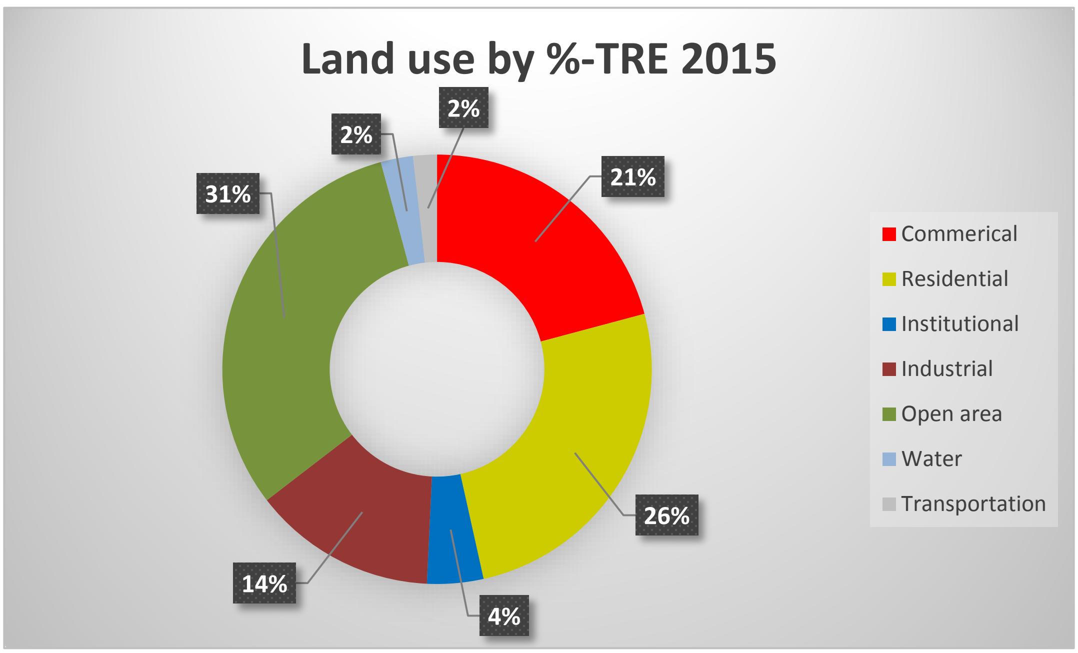


Chart 4.11 Land use by % within 1-mile radius of TRE, 2015

By comparing analyzing results of past 20 years within 1-mile buffer of TRE, the biggest change in land use happened in the open area and commercial uses. In 1995, open space covered 44% percent of the area, whereas in

2015 covered 31 % of the area. There was a decrease of 13 % in open space land use equals over 9,000 sq. ft. of land that changed to commercial, residential and transportation uses. Another significant change happened in commercial use which increased drastically from 8% in 1995 to 21% in 2015. Over 5,000 acres of industrial land use changed mostly to commercial and residential uses in areas closer to Dallas and Irving uses in the past 20 years. Because of the history of TRE mentioned in chapter 1, industrial facilities and factories were a major use of this area after WWII till around 70s. Since, then by increasing population and forming urban areas industrial use changed to other uses. Residential use increased gradually from 1995 to 2015 from 19% to 26% respectively. Institutional and transportation use increased by 1% and water sources decreased by 1% during past 20 years. In an overall view, commercial land use changed drastically because of expansion of cities and infrastructure needs for the population. And open area, residential and industrial experienced a gradual change over the studied timeframe (Chart 4.12).

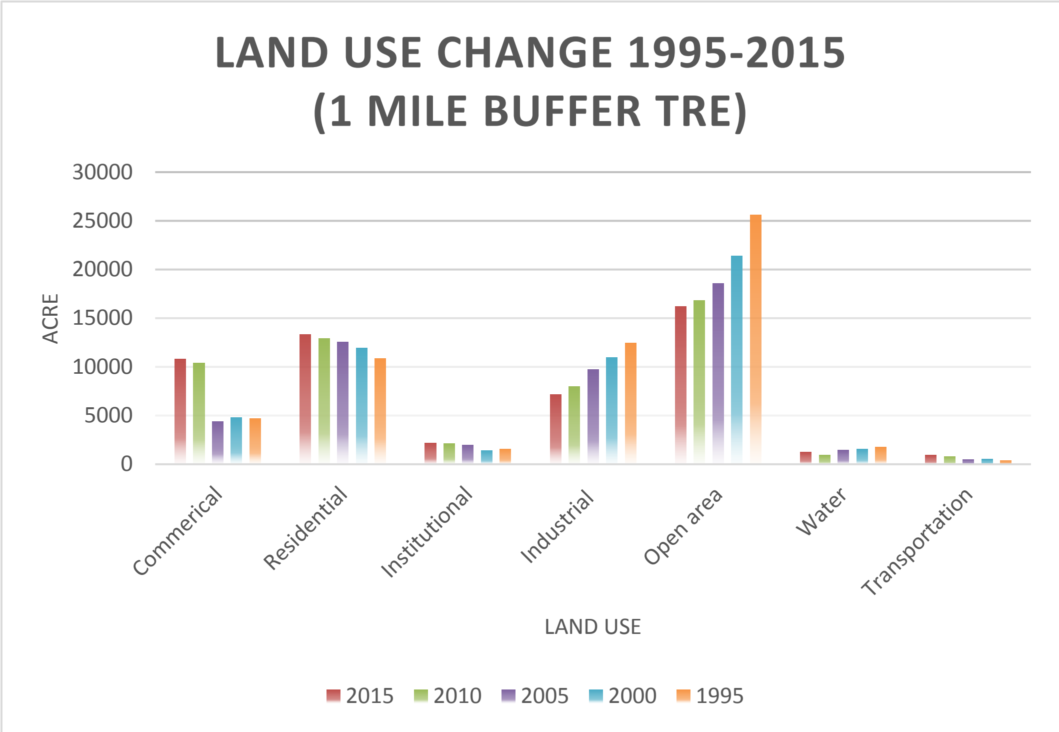


Chart 4.12 Land use by % within 1-mile radius of TRE

4.2.1.3 IH-30 versus TRE

The aim of this research is to compare impacts of each transportation corridor in changing land use pattern. Therefore, after studying and analyzing land use changes within a one-mile buffer of each transportation corridor. Results show, a comparison between changes in trend of each corridor will help us to understand which one had higher impacts on changing land use pattern.

A closer look at charts 4.6 and 4.12 shows same land use changes in both buffer areas but with different aggregate. For instance, open area land use decreased with a higher rate with a one-mile buffer of IH 30 than TRE (Chart 4.13).

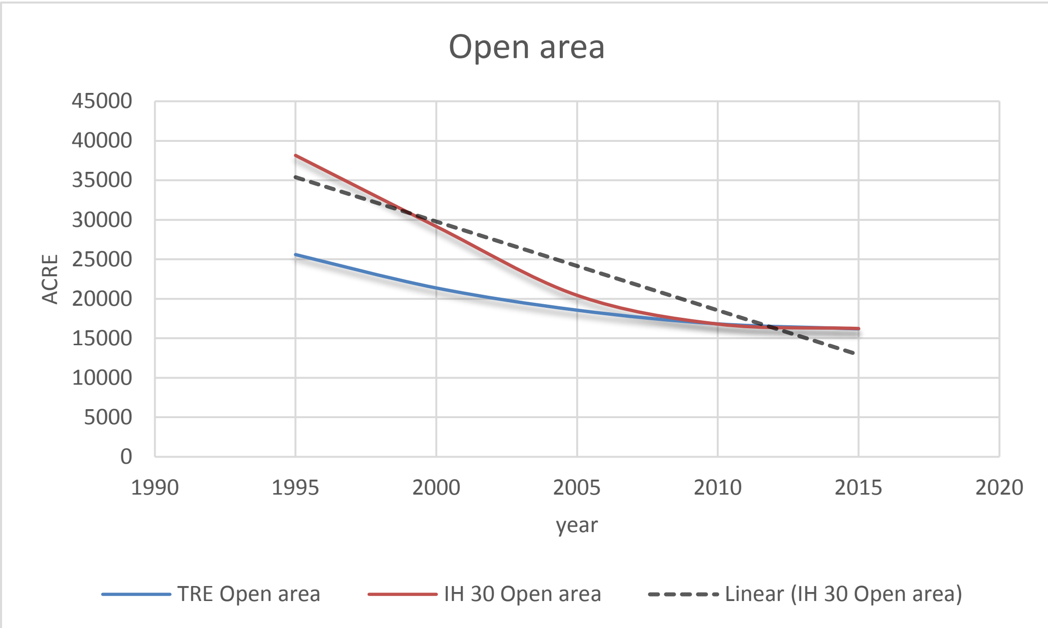


Chart 4.13 TRE and IH30 Open area trend, 1995-2015

As you see in the chart 4.13, in 1995 amount of open area was higher than TRE but in 2015 both buffered areas had almost the same acreage of open areas. One of the reasons for this drastic change is an aggressive expansion of IH-30 after 2005, which transferred an enormous amount of land from open area to concrete and more development came after the expansion. Figure 4.12 is one of the best examples of the expansion of IH-30 from 6 lanes to 13 lanes right by the Six Flags Hurricane Harbor in Arlington, TX. By comparing historical mapping from 1995-2015, adding 7 lanes, overhead bridge, and 2 ramps required massive land acquisition and changes in land uses (Fig 4.12). This phenomenon happened in almost every major connection of IH 30 in the past 20 years. Three major points were identified as the highest land use change in one- mile buffer of TRE such as TRE connection and facility center, Downtown Irving and the industrial area close to downtown Dallas. In Figure 4.13 by comparing historical images it can be clear how much land a commuter rail (TRE) needs and how much land a new connection to highway over the railroad. Figure 4.13 is located west of Fort Worth and is a major connection point and facility center for Trinity Railway Express system. From 1995 to 2007 land use remained unchanged. But from 2009 to 2015 with the construction of new George W Bush tollway on the west side and Roy Orr Blvd on the east, land use started changing from open area to commercial and more transportation.

1995

2007

2009

2011

2015

Figure 4.12 Expansion of IH 30 by Hurricane Harbor in Arlington, TX, 1995-2015

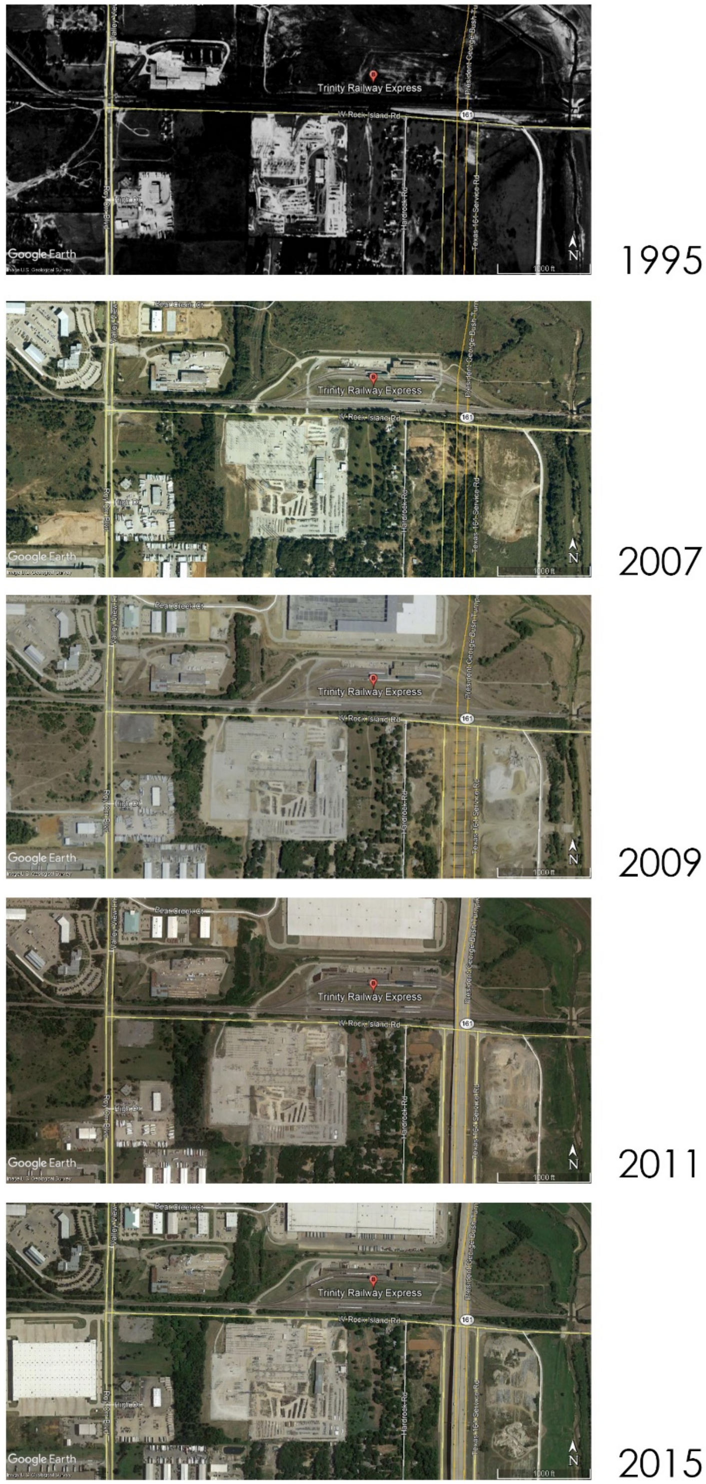


Figure 4.13 TRE connection center in west Fort Worth, TX, 1995-2015

Other significant changes happened in commercial land use mostly in TRE 1 mile buffer by transferring industrial uses to commercial in downtown Irving and close to downtown Dallas (Chart 4.14).

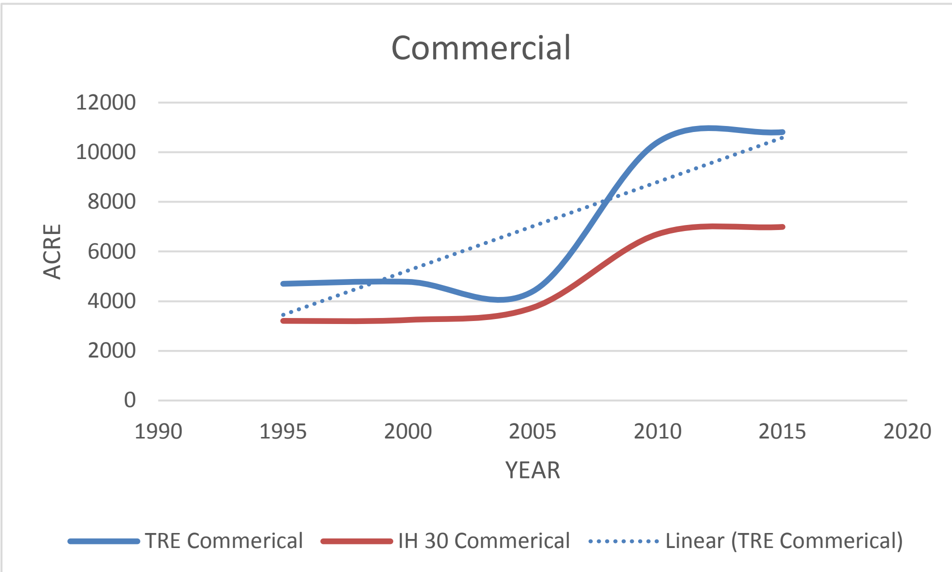


Chart 4.14 TRE and IH30 Commercial trend, 1995-2015

Residential and industrial land uses were increased and decreased respectively with the similar trend in both IH 30 and TRE 1 mile buffers. (Chart 4.15 and 4.16). Open area had the biggest transfer to the growing residential developments. Due to the population growth of DFW metropolitan area, residential land use has been growing gradually over the 20 years' timeframe and continue to grow in the future as well (Chart 4.15). By moving more population to urban areas, industrial land use it tends to change to commercial in order to serve growing population. The best example of this change is around downtown Irving and downtown Dallas which both of them are within the 1-mile buffer of TRE.

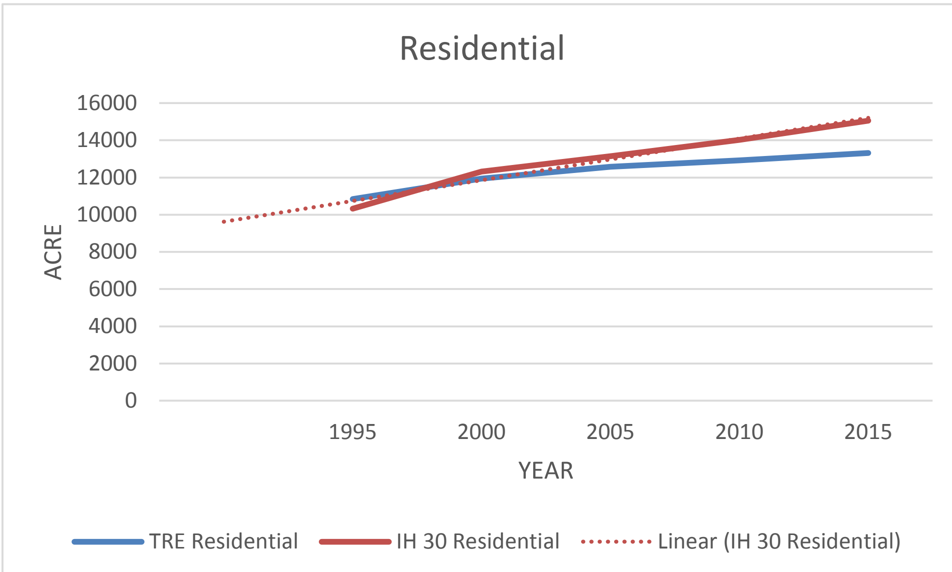


Chart 4.15 TRE and IH30 Residential trend, 1995-2015

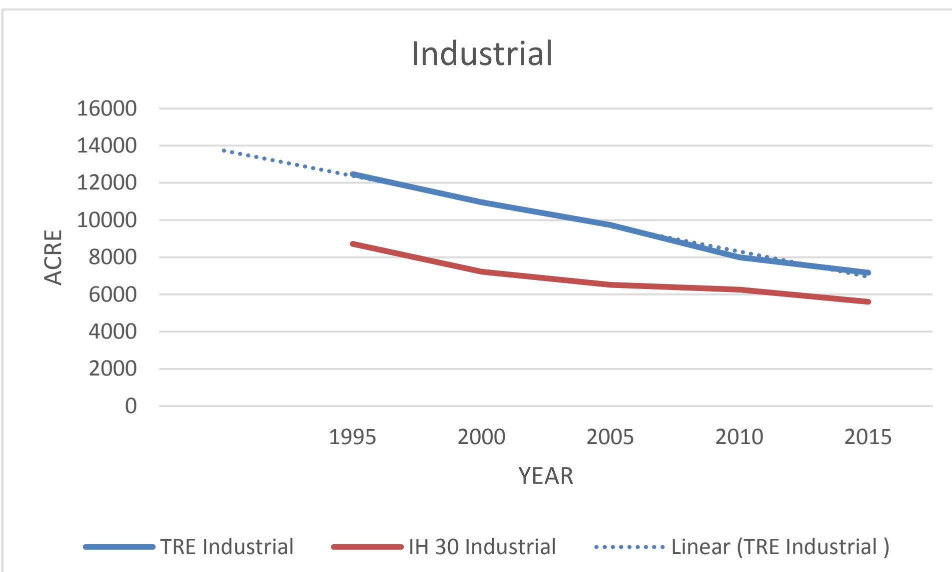


Chart 4.16 TRE and IH30 Industrial trend, 1995-2015

Water surface area was not following a steady trend within the 1-mile buffer of TRE but it has been gradually decreasing within the 1-mile buffer of IH30 (Chart 4.17). Transportation and institutional has been growing gradually over the past 20 years with the both studied areas. But it is very critical to understand that a slight increase in transportation use and constructing a new highway or adding extra lanes to existing one can affect not only all other uses drastically but ecosystems and wildlife (Chart 4.18).

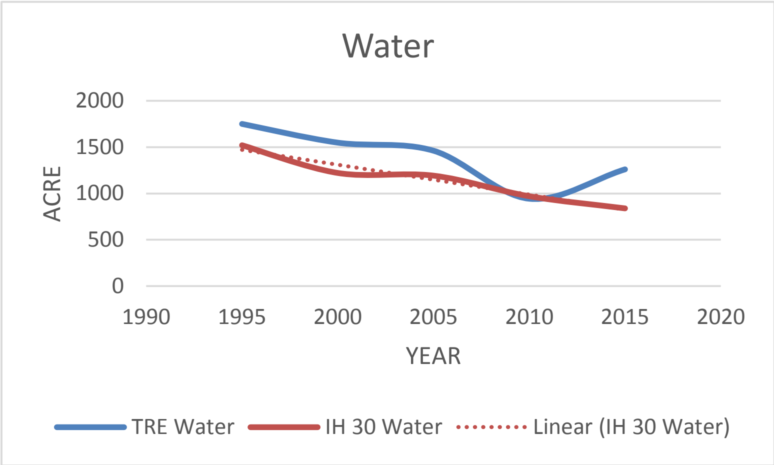


Chart 4.17 TRE and IH30 Water trend, 1995-2015

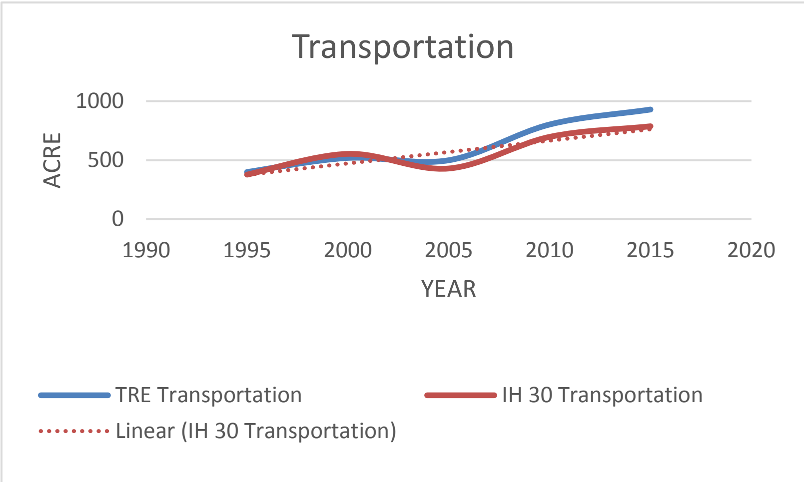


Chart 4.18 TRE and IH30 Transportation trend, 1995-2015

4.2.2 Tree Canopy Cover Change

Dallas and Tarrant counties are located in a unique geographical region. The tree canopy is the layer of leaves, branches, and stems of trees that cover the ground when viewed from above. Researchers estimate that tree canopy cover in urban areas and across the U.S. averages 27% and 33%, respectively (Dwyer and Nowak, 2000). Total canopy tree cover in the Dallas and Tarrant Counties in 2000 was over 242,000 acres which equal 13% of the entire DFW area (Fig 4.14).

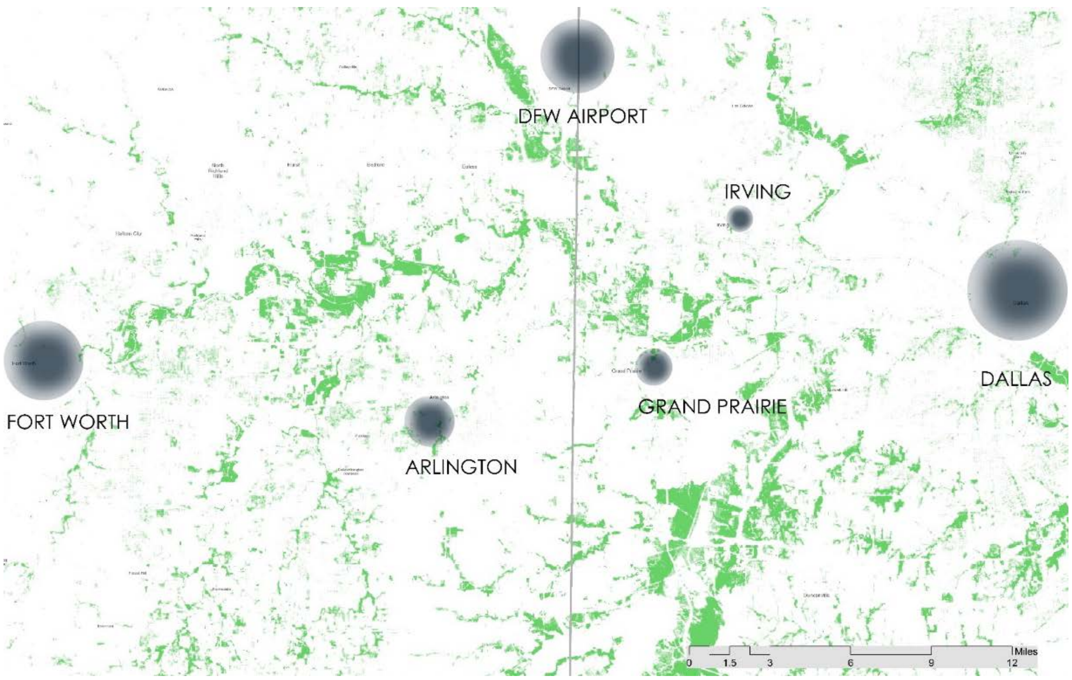


Figure 4.14 Tree canopy cover, 2000 (source: Hansen, University of Maryland, 2015)

Figure 4.15 shows tree canopy cover loss over the 2002-2015 time period in Dallas and Tarrant County. During 2002-2015 timeframe over 6% of tree canopy cover were lost which equals 14,500 sq. ft. Tree canopy cover lost rate is higher in some areas because of different development projects in DFW metropolitan area. For instance within 1-mile buffer of IH-30 and TRE is 15% and 9% respectively.

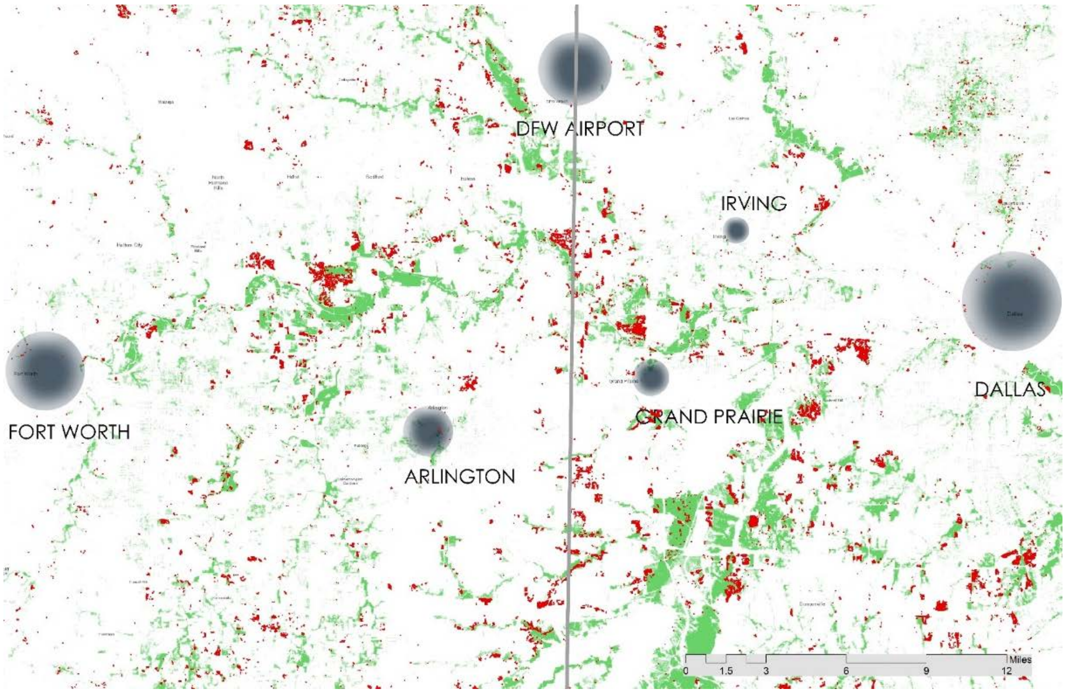


Figure 4.15 Tree canopy loss, 2015 (source: Hansen, University of Maryland, 2015)

4.2.2.1 Interstate Highway 30 -Downtown Dallas to Downtown Fort Worth

Tree canopy cover and canopy loss were analyzed to investigate how much canopy of trees was lost during the past 15 years because of development, expansion of IH 30, and land use change. The total covered area by tree canopies were 17% which equals 10,383 acres within the IH 30 1 mile buffer in 2000 (Fig 4.16). The total tree coverage decreased to 13% in 15 years mostly due to expanding IH 30, constructing new constructions to IH 30 and

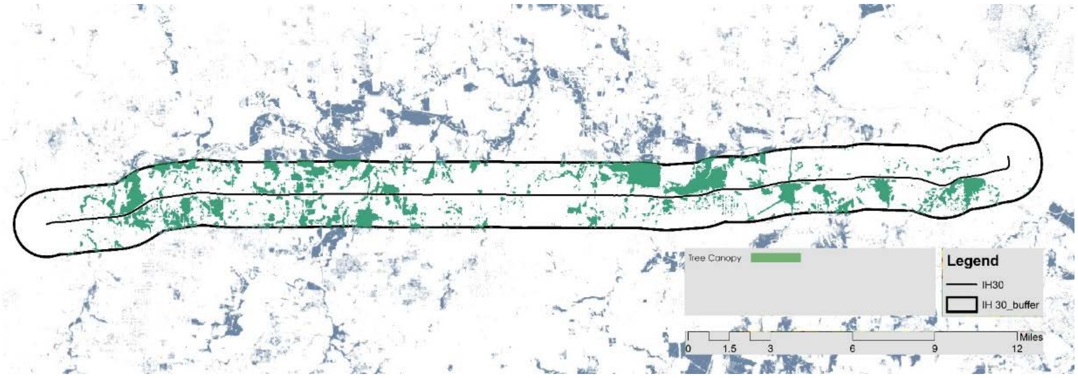


Figure 4.16 Tree canopy cover, IH 30 1 mile buffer, 2000 (source: Hansen, University of Maryland, 2015)

residential developments. Tree canopy cover loss map (Fig. 4.17) identifies areas of land that canopy lost occurred. These areas are the potential habitat of several valuable endangered and threatened species such as the Bald eagle, Falcons, Henslow's sparrow, Timber rattle and some valuable plants such as Plateau milkvine, Tree dodder, Texas milk vetch, Glen rose yucca and Coralroots (Texas Parks and Wildlife, 2017). With the closer look at tree canopy cover loss map, there is two major clusters and plenty of minor areas that lost trees covers. Cluster one is located on the edge of the south side of IH 30 close to downtown Dallas. This canopy loss caused by adding a connection and ramp to IH-30 and after that developing the area with commercial land use (Fig 4.18). On the middle and north part of the 1-mile buffer of IH-30 is another cluster loss of tree cover due to housing and

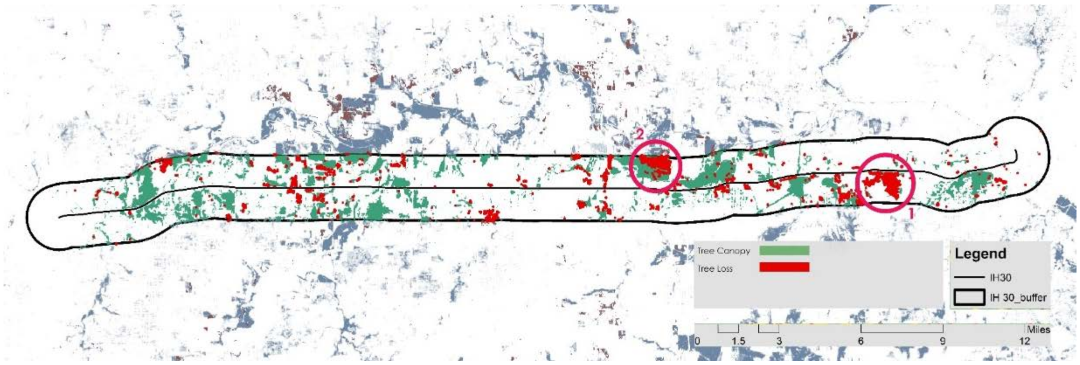


Figure 4.17 Tree canopy cover loss, IH 30 1 mile buffer, 2000 (source: Hansen, University of Maryland, 2015)

commercial development (Fig 4.19). But it is obvious that during 1980-2000 this area used to be all tree canopy cover that has been changed to different other land uses. Economy, population growth, policy, social and, cultural factor may be other reasons for changing the use of land.

Figure 4.18 and 4.19 Historical mapping of locations 1 and 2, 2000-2015 (Source: Google)

4.2.2.2 Trinity Railway Express -Downtown Dallas to Downtown Fort Worth

Similar to IH 30, tree canopy cover suffered a loss during the years 2000 to 2015. Later on analyzed to identify possible impacts made by the Trinity Railway Express on the canopy cover loss. Total covered area by canopy of trees were more than 9,000 sq. ft. (13%) within 1 mile buffer of TRE in 2000. After 15 years total amount of trees covered areas decreased by 10% (1,037 sq. ft.). Tree canopy cover map within 1 mile buffer of TRE (Fig 4.20) shows scattered placement of patches of tree canopies. As mentioned in chapter 1 TRE used to be a cargo railway and most of canopy covers were lost before 2000 due to construction of industrial and commercial facilities close to Dallas and Irving. But after 1980s industrial facilities mostly rezoned to commercial and residential uses.

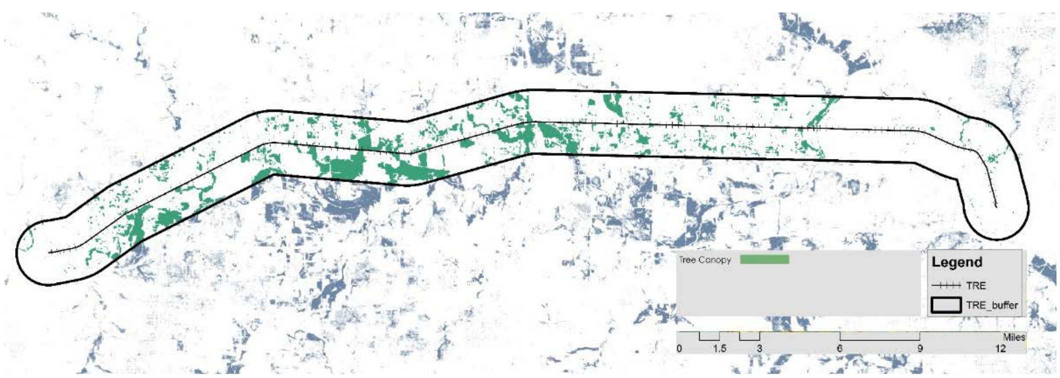


Figure 4.20 Tree canopy cover, TRE 1 mile buffer, 2000 (source: Hansen, University of Maryland, 2015)

Tree canopy cover loss map (Fig 4.21) depicts the areas affected. These areas were part of Cross Timbers and Blackland Prairies ecoregion and potential habitat of unique wildlife and plants such as: Bald eagle, Red knot, Sprague’s pipit, Red and Gray wolf , Texas horned lizard, Sandbank pocketbook, Topeka purple-coneflower, Texas milk vetch, False foxgloves, and Glen rose yucca (Texas Parks and Wildlife, 2017). Taking a closer look at tree canopy cover loss, there are 2 major clusters of trees and several other tree canopy loss. Cluster 1 is within a 1-mile radius of TRE Bell station (Fig 4.22). Most of the tree canopy cover loss is caused by the development of new residential developments and construction of new roads and infrastructure. Another cluster is located near Centerport station, one of the major TRE stations in the west of Fort Worth.

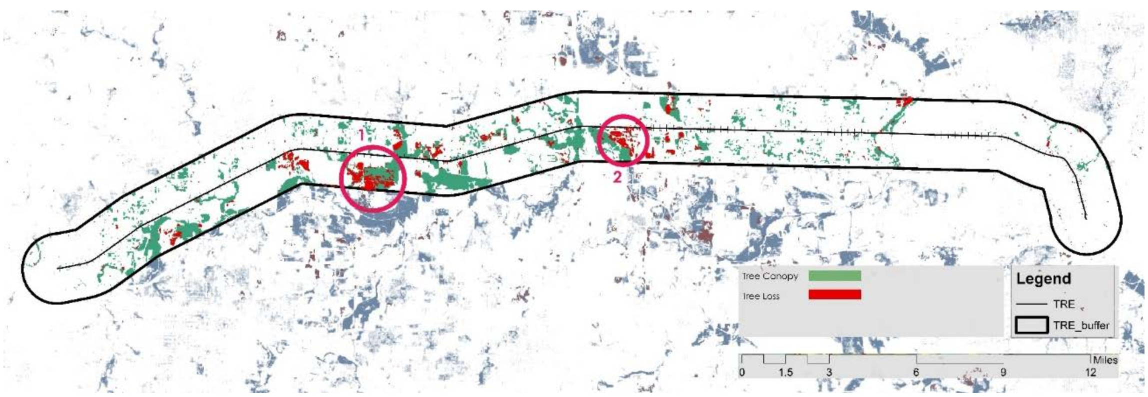


Figure 4.21 Tree canopy cover loss, TRE 1 mile buffer, 2000 (source: Hansen, University of Maryland, 2015)

The same story applies to this cluster as well, development of residential and commercial land uses by cutting out the canopy of trees (Fig 4.23).

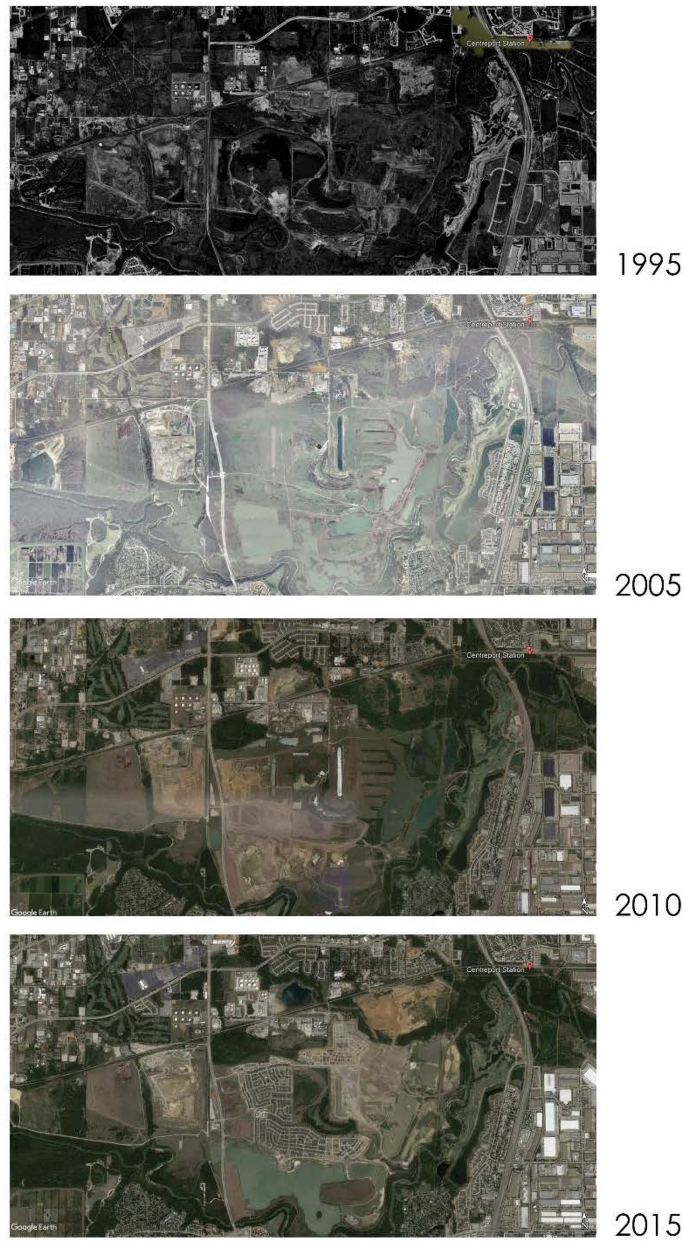


Figure 4.22 and 4.23 Historical mapping of locations 1 and 2, 2000-2015 (Source: Google)

4.2.2.3 IH-30 versus TRE

Tree canopy cover decreased in the whole DFW area by 6% from 2000-2015. As mentioned before decrease rate within 1-mile buffer of IH 30 and TRE is 15% and 10% respectively. As it appears below, in the tree canopy cover trend chart (Chart 4.19) trees are destroyed with a higher rate within 1-mile buffer of IH 30 in comparison with TRE.

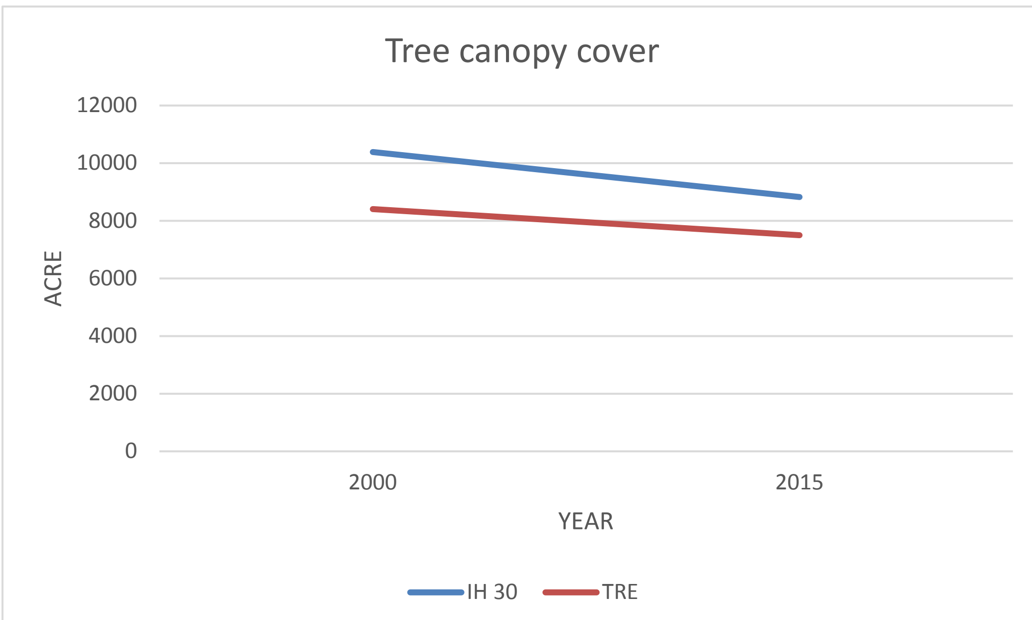


Chart 4.19 TRE and IH30 Tree canopy cover trend, 2000-2015

Several major reasons were identified as causal factors for this deforestation. The biggest reason is an expansion of highway and roadway infrastructure through both buffers. Transportation Land use increased about 1% in the past 20 years but its directly affecting other land uses significantly. We can categorize effects of transit infrastructure systems on tree canopy loss into direct and indirect effects.

Direct effects of IH-30 and TRE began with construction phase and continues with maintenance and potential expansion of them. It is critical to realize that direct effect of IH 30 system is higher than a direct effect of TRE. IH-30 from downtown Dallas to downtown Fort Worth expanded from 4 lanes to 16 lanes in the last 50 years. However, TRE remained same 2 lanes in the last 80 years. In addition to the expansion of IH 30, connecting new links, constructing ramps and HOVs should be considered as well. All of these constructions requires enormous land acquisition and rezoning process. On the other hand, most of the times after construction of railroads, expansion is not going to happen on the short-term and mid-term basis and the only direct effect is maintenance. So by comparing historical mapping of studied areas in sections 4.2.2.1 and 4.2.2.2, the direct effect of IH 30 is obviously more noticeable on tree canopy cover loss than TRE. So one of the major reasons for more canopy lost within IH 30 1 mile buffer is the higher direct effect of IH 30 in short-term, mid-term, and long-term basis on tree canopy cover areas.

Indirect effects of transit infrastructure systems began after completion of construction and are continuous with short-term, mid-term, and long-term effects on changing land use and canopy covers. One of the indirect causes that are more obvious in both studied buffers include the uprise of population and developments to that area. The residential land use is the first type of land use to start growing to amplify highways and commuter railroads. The best example of this types of developments is Transit Oriented Developments (TOD). TODs are more common in public train and bus stations. Residential and commercial development is the biggest reason for tree canopy loss within 1-mile buffer of TRE. There are several residential and commercial developments that came to around IH-30 either because of the expansion of a new line or a new road/highway was added. In summary, both direct and indirect effects of IH-30 and TRE on canopy loss and deforestation is undeniable. However direct effects of IH-30 in short-term, mid-term, and long-term is higher, on the other hand, the indirect effect of TRE on the development of residential and commercial uses influenced canopy loss as well.

4.2.3 Habitat Fragmentation and Habitat Mortality

Landscape fragmentation and land transformation have been happening in Dallas Fort Worth metropolitan area due to the expansion of transit infrastructure and urban development after World War II. In a highly fragmented area like DFW metropolitan, soil erosion via water and wind have high rates as well as increased rates of river sedimentation (Leitao et al, 2012). Wildlife population is expected to suffer dramatic effects in fragmented landscapes.

Human activities such as the construction of roads, agriculture, and urban developments are obvious causes of habitat fragmentation and loss. Roads can be a significant starting factor for fragmentation because they create access for humans to involve in mining, recreational, or residential developments. Roads also can isolate wildlife species and limit moving behavior of animals. Roads also create artificial edges that can be a major cause of mortality when individuals try to cross roads (Garland and Bradly, 1984). For measuring landscape fragmentation and land transformation Patch-Corridor-Matrix model were used as quantifying metrics for landscape fragmentation within 1-mile buffer of IH 30 and TRE. And Mean Patch Size method was used for comparing the level of fragmentation between one mile buffer of IH 30 and TRE.

4.2.3.1 Interstate Highway 30- Downtown Dallas to Downtown Fort Worth

Interstate Highway 30 was starting factor for habitat fragmentation between Downtown Dallas and Fort Worth. Its effects started from construction phase and until now has negative effects on habitat and land transformation, because of its expansion and adding more connection. In this study, we compared patch sizes from 2000 to 2015.

In order to have more accurate analysis, the area within one mile buffer of IH-30 divided into 240*240 meters squares. Each square was categorized as tree canopy (light gray), developed the open area (medium gray), developed area (dark gray), and roadways and railroads (black) (Fig. 4.24).

Figure 4.24 Landscape analysis, one mile buffer IH30, 2000

As you see in figure 4.24 this area is already highly fragmented with small isolated patches. However, there are still some bigger patches closer to Trinity River and far from highway connections, expansion and adding new connections to IH 30 will make patch sizes smaller and more isolated.

Fig 4.25 shows landscape analysis after 15 years. By adding a new connection to IH 30, an enormous amount of canopy was lost. Amount of fragmentation is higher closer to Dallas. But it is moving aggressively toward the west.

One of the major areas that landscape fragmentation is more obvious marked with pink on both maps. By comparing 2000 and 2015, adding a new connection to IH 30 caused tree canopy lost, and isolation of patches. By having a closer look to this area, before construction of IH 30 until now,

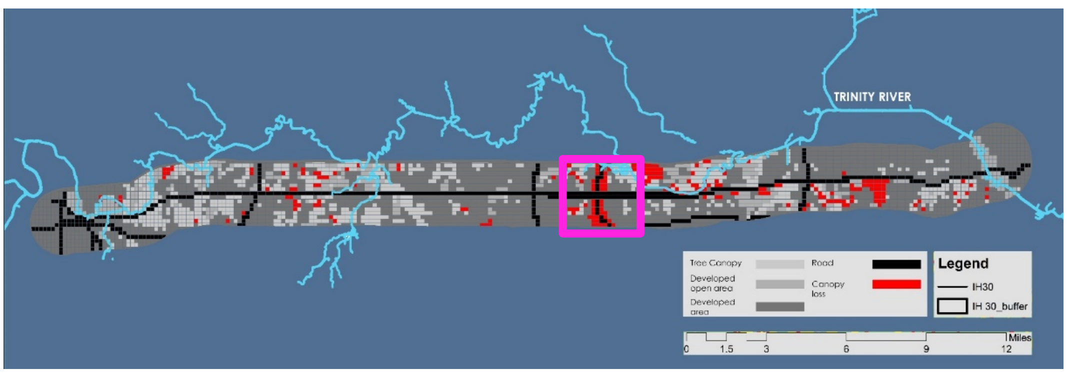


Figure 4.25 Landscape analysis, one mile buffer IH30, 2015

significant effects of IH 30 on land transformation and fragmentation is clearly obvious. Figure 4.26 shows the sequence of land transformation in which landscape changed from forested Blackland Prairie to an urban highway. This sequence clearly shows how patch sizes of tree canopy and open areas started to decrease and isolation increase. The highest change during the sequence happened from D to E by adding a new connection to IH 30 in 2005.

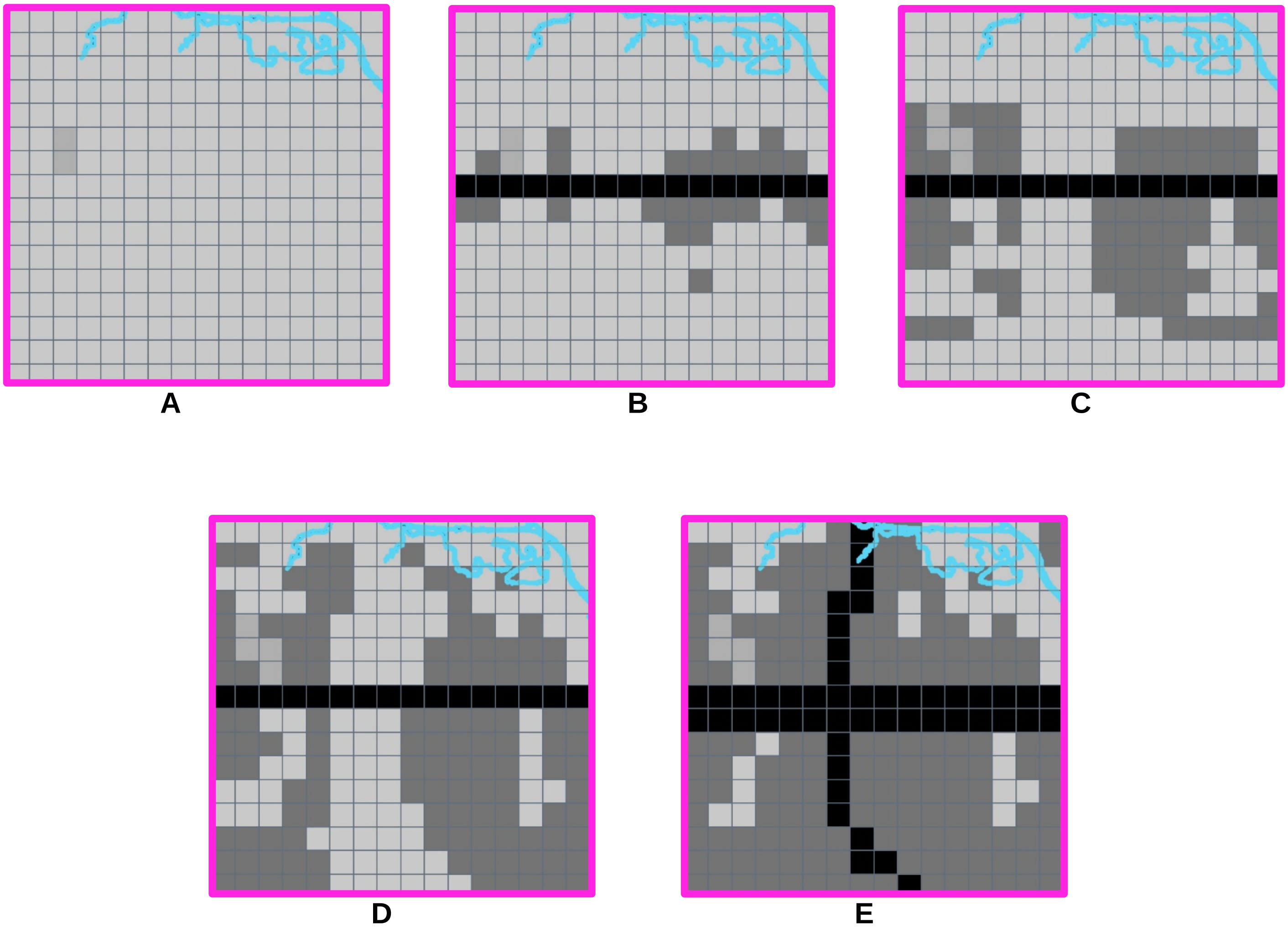


Figure 4.26 Landscape transformation associated with transit infrastructure development (1950-2015)

Another effect of IH 30 is changing background Matrix from forested to urban development background. Another location that has the similar condition is located on the south side of IH 30 close to Downtown Dallas.

4.2.3.2 Trinity Railway Express- Downtown Dallas to Downtown Fort Worth

Trinity Railway Express was the starting factor of habitat fragmentation within one mile buffer of TRE as well. The same grid network of 240*240 meters squares was to analyzed landscape transportation from 2000-2015. As shown in Fig 4.27 amount of canopy cover and developed open areas are higher in the south side of TRE which is closer to Trinity River. Missing patches and isolated patches are located close to areas where the density of roads and railway is higher. By analyzing landscape transformation in the

Figure 4.27 Landscape analysis, one mile buffer TRE, 2000

year 2015 it can be noticeable that TRE by itself didn't cause that much of a land transformation and fragmentation.

Fig 2.28 shows landscape transformation over a time period of 15 years. The largest fragmentation and habitat loss in 15 years was caused by a highway over TRE.

Other patches were lost due to residential and recreational developments. Same as IH 30, closer to Dallas area and major developments patch sizes and canopy covers are smaller and more fragmented.

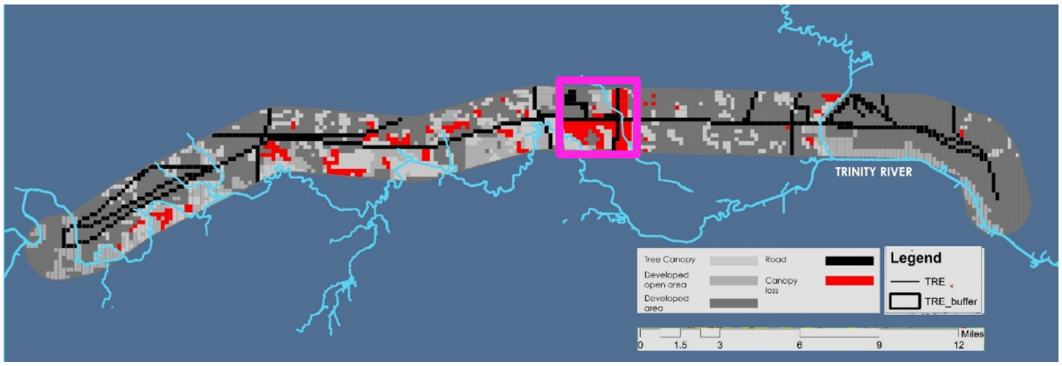


Figure 4.28 Landscape analysis, one mile buffer TRE, 2015

By looking sequence of land transformation and fragmentation in the identified area negative effects of transit infrastructure are significant over time (Fig 4.29). The Same area was selected to illustrate landscape change associated with railroad and highway transit infrastructure. In this sequence, the categorized land turns into canopy cover (light gray), developed the open area (medium gray), developed areas (dark gray), and TRE and other highways (black). Landscape formation and fragmentation started by constructing a railroad in the 1890s and landscape condition remained almost the same until 2000.

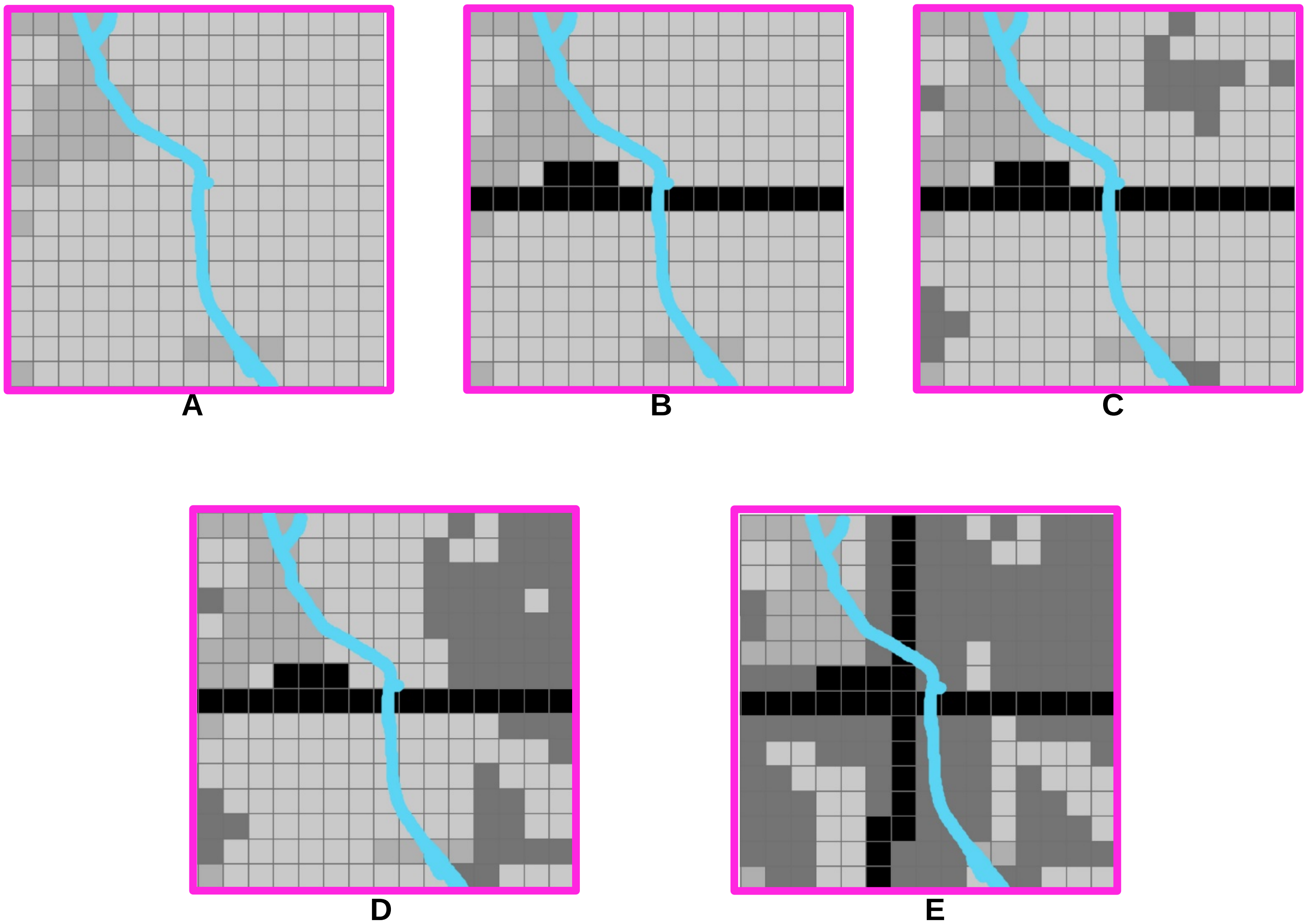


Figure 4.29 Landscape transformation associated with transit infrastructure development (1950-2015)

Then from 2005-2015 tree canopy and open areas patches were destroyed aggressively by constructing a new highway over TRE (E). This sequence clearly shows higher direct effects of highway on habitat fragmentation and habitat loss than the railroad. Same as other example patch sizes decreased significantly and background matrix changed from forested to the developed urban area.

4.2.3.3 IH-30 versus TRE

Habitat fragmentation and land transformation level were analyzed by comparing Mean Patch size area within one mile buffer of IH 30 and TRE from 2000 to 2015. Hence, the Mean Patch size model, is the area recorded in the number of grid cells instead of areal units (Leitao et al, 2012). So each cell within one mile buffer of IH 30 and TRE was analyzed and categorized in canopy cover, developed open area and developed urban areas. Then each cell was identified and mean patch size was calculated with spatial analysis method in ArcGIS.

Charts 4.20 and 4.21 shows patch numbers within one buffer of IH 30 and TRE respectively. By comparing 2 charts, urban patch numbers within one mile buffer of TRE is higher than IH 30. On the other hand, tree canopy and open area patch numbers are higher within one mile buffer of IH30. It is important to know that a landscape with more patches is not necessarily more desirable or ecologically rigorous than one with fewer patches. Another factor we need to consider for assessing fragmentation level is Mean patch size. Connectivity and stability are higher with patches that have higher patch size. Thus, Mean Patch size was analyzed within one mile buffer of IH30 and TRE (Chart 4.22 and 4.23).

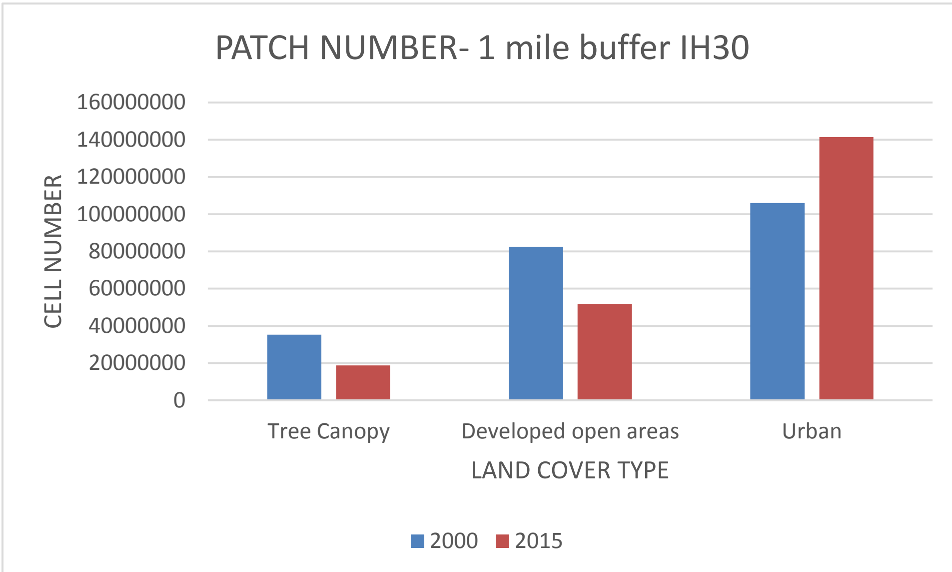


Chart 4.20 Patch numbers within IH 30 one mile buffer, 2000-2015

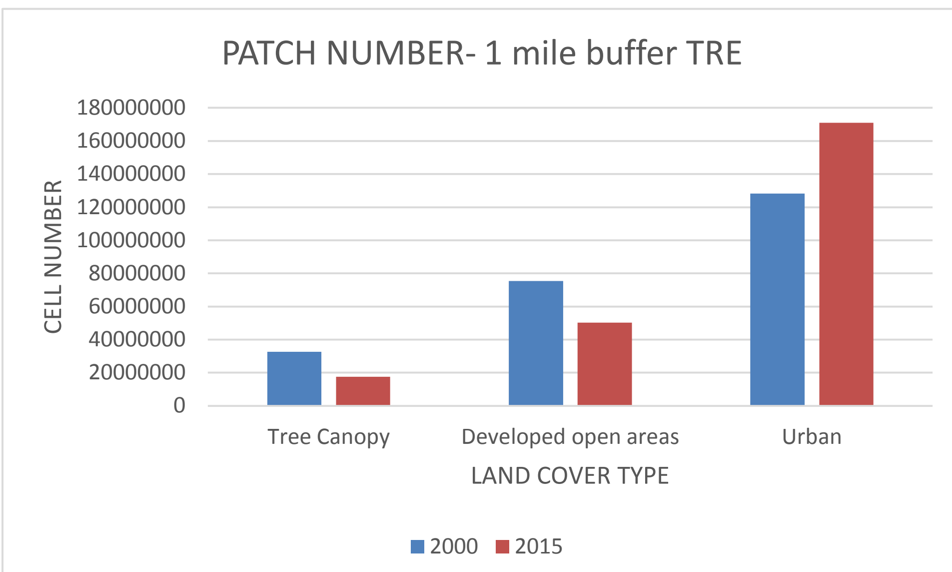


Chart 4.21 Patch numbers within TRE 30 one mile buffer, 2000-2015

By comparing 4.22 and 4.23 charts, on the whole, mean patch sizes are higher within one mile buffer of TRE than IH 30. However, both landscapes are highly fragmented, but connectivity is higher within the one miller buffer of TRE.

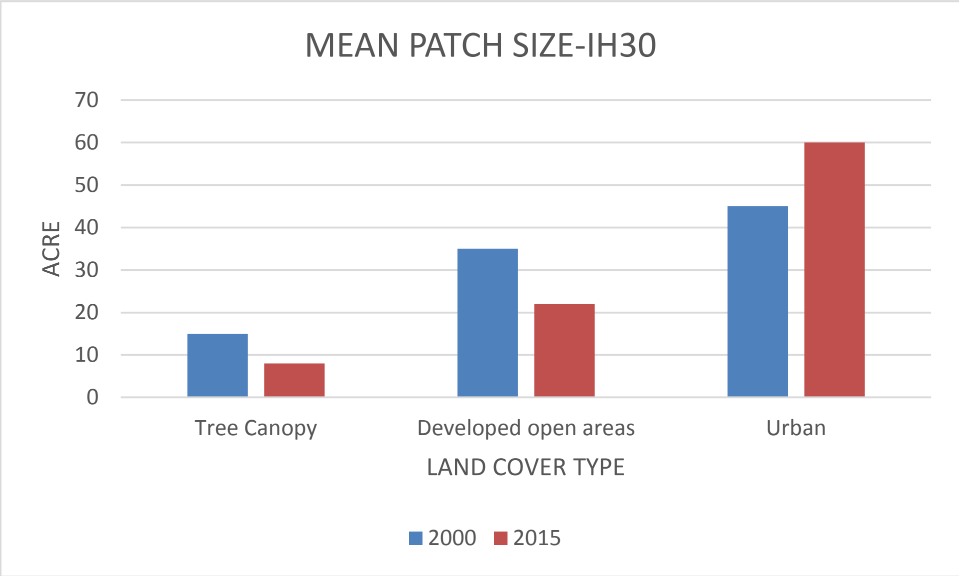


Chart 4.22 Mean patch within IH 30 one mile buffer, 2000-2015

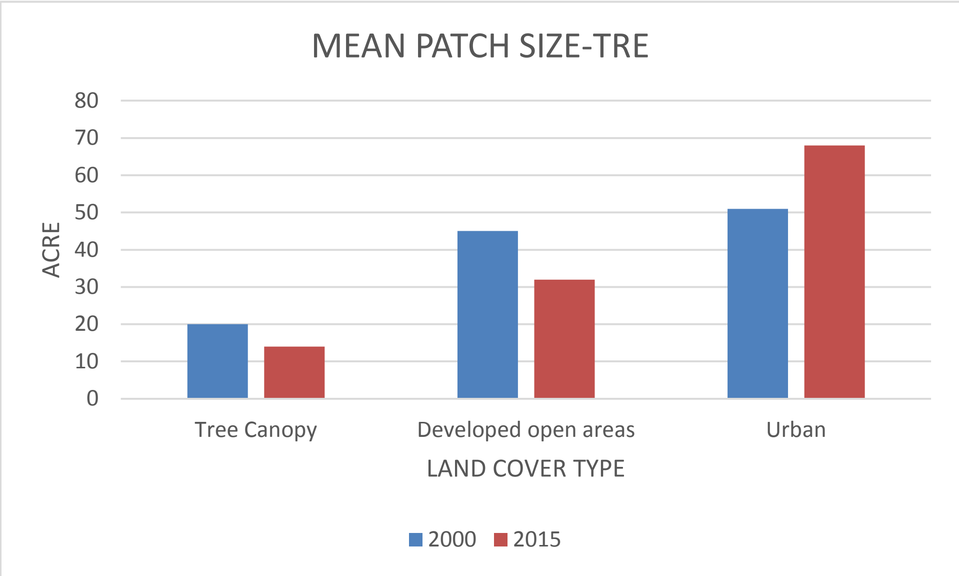


Chart 4.23 Mean patch within TRE one mile buffer, 2000-2015

On the other hand, patches are more isolated within one mile buffer of IH 30. For comparing levels of fragmentation more accurately, mean patch size of tree canopy land cover should be considered. Mean patch size of tree canopy cover is higher within the one-mile buffer of TRE than IH 30 in both 2000 and 2015.

In summary, although both IH 30 and TRE are highly fragmented, fragmentation level is higher within the one-mile buffer of IH 30 than TRE. In fact, the expansion of IH 30, roads density and urban development especially residential development are the main causes of a higher amount of fragmentation within one mile buffer of IH30.

Habitat mortality due to vehicle crashes is one of the major causes of habitat fragmentation. Fig 30 and 31 shows habitat and vehicles crash point locations and crash density within one-mile buffer of IH 30 and TRE. There is an obvious relevance between habitat and vehicle crash density with areas that have higher fragmentation and isolation. For instance, the density of crashes within one mile buffer of IH 30 is higher closer to Dallas and areas with higher density of roads and lower closer to Fort Worth and areas with higher mean patch size area. On the other hand, within one mile buffer of TRE, animal and vehicle crash has almost the same density through the whole area. Therefore, a higher amount of crashes within one mile buffer of

IH 30 than TRE shows that animals tend to move to other patches more often. Other reason can be higher traffic volume in highways as well.

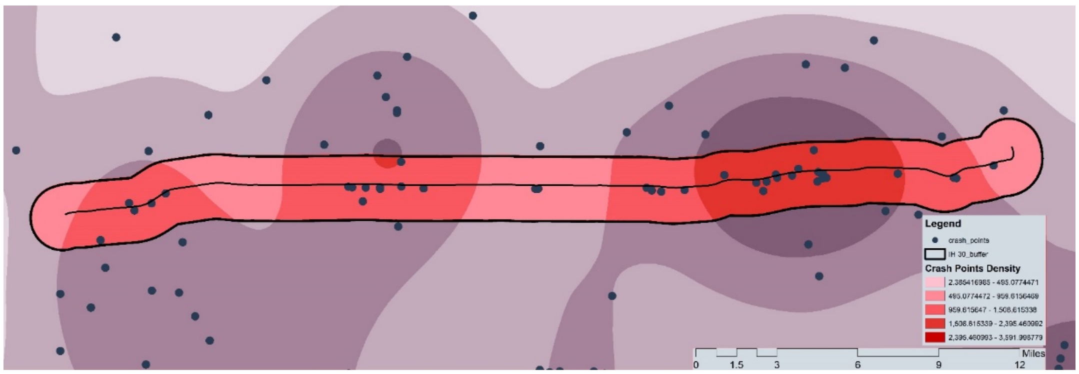


Figure 4.30 Habitat and vehicle crash points and density, IH 30 one mile buffer, 2007-2017

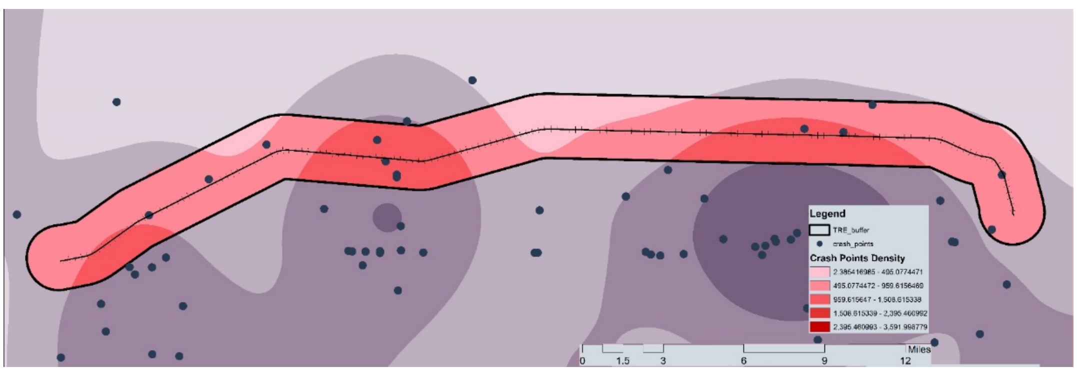


Figure 4.31 Habitat and vehicle crash points and density, TRE one mile buffer, 2007-2017

Thus, by comparing all the discussed variables, despite the fact that both areas are highly fragmented, but fragmentation level due to the direct effect of roads within one mile buffer of IH 30 is higher than TRE. The analysis results prove that in 15 years period area within one mile buffer of IH 30 became more fragmented than TRE.

5 Chapter 5: Summary and Conclusion

This chapter includes a summary of findings and list of recommendations based on analysis results in order to apply them in the future studies and projects. The analysis focused on the land use change, habitat fragmentation, and land formation located within one mile buffer of Interstate Highway 30 from downtown Dallas to Fort Worth and one mile buffer of Trinity Railway Express.

5.1 Findings

Based on analysis results, I found that the negative impacts of Interstate Highway 30 and Trinity Railway Express on land use and land cover change, habitat fragmentation, and habitat loss are unquestionable. Findings and analysis results of this study emphasize the previous findings of negative impacts of transit infrastructure network especially highway systems on human, habitat, environment, and ecology.

Analysis verified that land use has been changing aggressively within IH 30 and TRE one-mile buffer over past 25 years. Open area had the highest decrease and residential and commercial land uses increased the most among other land uses. Land use changed more drastically within one mile buffer of IH 30 because of population growth, IH 30 expansion from 6 lanes to 16 lanes, and adding new highway connection to IH 30. On the other hand, land use changes within the one-mile buffer of TRE were not as aggressive as IH 30. Another factor to take into consideration is that IH 30 was built around 60 years ago but TRE was built in the 1980s. Thus, the direct effect of IH 30 on land use change and land transformation is significant compared to TRE.

The same situation applies to other land use and land cover types. Moving into a deep investigation the tree canopy loss, negative effects of both IH 30 and TRE on destroying tree canopy are significant throughout the past 60 years. However, in the past 20 years, tree canopy decrease rate is slightly higher within the one-mile buffer of IH 30. The expansion of IH 30 and aggressive suburbanization and, development are the main causes of tree canopy loss.

Based on the literature, habitat fragmentation is one of the consequences of tree canopy loss. Although, both one-mile buffers of IH 30 and TRE are highly fragmented and isolated, analysis results show that IH 30's one-mile buffer became more fragmented within the past 20 years. Fragmentation level was analyzed based on Mean Patch size model. Mean patch sizes of tree canopy covers within the one-mile buffer of TRE are higher, which means connectivity among the patches are higher and less isolated. Similar to land use and tree canopy loss change, the main reason is IH 30 expansion. Over the past 20 years, IH 30 required a significant amount of land acquisition and almost all of it acquired from open area and tree canopy lands. On the contray, after construction TRE never expanded and remained the same 2 lanes of rail. Another factor that proofs the negative impact of IH 30 is more than TRE on habitat fragmentation is habitat mortality and loss. Results of crash point's density show that there are more crashes within the one-mile buffer of IH 30 than TRE. Even though the main reason for habitat and vehicle crashes is habitat fragmentation, smaller patch sizes, and isolation, other factors like traffic volume and changing habitat behavior are considerable.

In conclusion, the effects of IH 30 and TRE on land use change, land transformation and fragmentation are undeniable. Direct and indirect effects of each are different. Direct negative effects of IH 30 during construction, short-term, and long-term is way higher than TRE. Contrarily, the indirect effect of both types of transportation modes are obvious, especially with population growth and housing and commercial developments throughout the time along highways and commuter rail lines.

5.2 Recommendations

Based on analysis results and findings of negative impacts of IH 30 and TRE on land use change, land transformation and habitat fragmentation and loss, we are recommending some new approaches such as:

- Ecological and environmental impact assessment: Preparing this kind of studies in earlier phases of planning and designing a new or expansion of highway and railroads helps planners, designers, and decision makers to be aware of negative effects a new highway or railroad during construction in short-term and long-term.
- Design with nature capacity: Nature and environment have a certain capacity tolerance for accepting negative effects. Planners, designers, landscape architects, decision-makers and politicians have to always keep nature and ecology in mind. Aggressive expansion of IH 30 from 6 lanes to 16 lanes in 20 years without investing in public transportation is a true example of making a decision without considering and thinking about environment and nature capacity.
- Access to public transportation: The access to transportation for people living in the suburb of Dallas and Fort Worth is very limited. Improving accessibility and investing in public transportation especially light rail and high-tech commuter rails can decrease the need of expanding highways.
- Increase gas price: Increase gas price and put a higher tax on gas can encourage people to drive their cars less and use more public transportation. On the other hand, the government can use gas taxes on

improving access to public transportation, introducing cutting-edge transportation, and for revitalizing damaged and fragmented landscape.

- Conserve land: Conserving land for habitats and next generation is very important. By investing more in expanding light rail and commuter railroads and less on highways, a significant amount of land can be saved. As stated before, expanding an existing highway or constructing a new highway requires an enormous amount of land acquisition.
- Revitalizing damaged habitat: Revitalizing a highly fragmented urban area such as Dallas Fort Worth metropolitan area shoulb be consider before all the habitat become disappear.Neglecting a habitat can lead wildlife to extinction and reduce patch sizes. Reconnecting habitats can increase habitat connectivity and decrease chances of extinction. Habitat connectors can be designed as habitat bridges or underground connectors. Providing foods and shelters for animals in hot spots for migrating bird species can increase biodiversity in the region as well.
- Raise public awareness about habitat fragmentation, land transformation, and land use change can encourage the car consumers to drive their cars less and use more car sharing programs and public transportation alternatives.

5.3 Importance of this study to the landscape architetcure profession

This research is a valuable topic in landscape research as it expands the body of knowledge in negative effects of highway and rail systems on land use change and landscape fragmentation in a highly developing area. While other studies have been conducted on health, stormwater management's issues, and economic benefits, only a few have been carried out the impacts of transit systems on land use changes and habitat fragmentation.

From planning, site selections, and site design to remediation and landscape restoration, landscape architects can play a significant role by becoming involved as planners, designers, and consultants to engineering and transportation planning firms as well as to local and regional governmental sectors. By involving landscape architects and landscape planners in early phases, certain impacts can be reduced. Landscape architects can contribute to transportation planning and design, construction, the selective removal of plants, and to minimizing infrastructure development. In addition, after completion of a highway or railroad landscape architects can lead in habitat restoration and landscape management.

Habitat restoration is one of the ways to soften human impacts on the natural ecosystem. Habitat restoration and revitalizing damaged landscapes can be defined as the decisive gathering of native plants and animal communities with the aim of reconstructing a sustainable ecosystem that functions similarly to its original condition (Robertson 2008). Landscape architects can engage in the implementation of best management practices and the preservation and conservation of remaining living habitats in their original area.

5.4 Future Research

- Impact assessment of road networks can be done for whole Dallas Fort Worth region.
- This study includes land use change and fragmentation by IH 30 and TRE. The future study could consist of the land use change and fragmentation caused by other types of human developments such as residential, agricultural, industrialization, and recreational.
- The future study could assess impacts of drive fewer cars and new transit modes on habitat fragmentations and land use change.
- Future studies can assess negative impacts of highway and railroad networks on other variables such as stormwater management, permeability, and urban heat island effect.
- Future studies could suggest innovative ways of restoring fragmented habitats in highly fragmented and developing areas.

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