Agricultural Growth and Development in District One and the Impacts to Transportation and Freight Logistics

FDOT District One

2017

FDOT DISTRICT 1

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION
FLP
Office of Freight, Logistics and Passenger Operations

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1. Introduction

Florida has one of the fastest growing populations in the United States with three of the fastest growing metropolitan areas in the United States located in Southwest Florida. Florida is also a key state for agriculture production in the United States. According to the Florida Department of Agriculture and Consumer Services:

"In 2015, Florida had 47,300 commercial farms and ranches, using a total of 9.45 million acres; Florida ranked second in the U.S. for value of vegetable production; first in production value for oranges, fresh market tomatoes, watermelons, grapefruit, sugarcane, fresh market snap beans and fresh market cucumbers; second in the production of greenhouse and nursery products, bell peppers, strawberries, fresh market sweet corn, spring potatoes, peanuts, tangerines and avocados; 10th in beef cows; and accounted for 56 percent of total U.S. citrus production. Florida ranked seventh in the U.S. for agricultural exports, with over $4 billion of agriculture commodities shipped in 2015."[1]

Agriculture is the #2 industry in Florida behind tourism. A large portion of the state's agriculture production is located in District One including citrus, fresh market tomatoes, watermelons, sugarcane, fresh market cucumbers, bell peppers, fresh market snap beans, and beef cattle. Consider the following example to illustrate the scale of the corporate-level agriculture production industry in Southwest Florida. In District One alone, over 496,471 truck trips are required to transport one recent year's harvest of citrus and vegetables to packing houses, production plants, markets, and return. Lining these trucks up nose to tail would cover 4-lanes of US 27 from Miami to the FDOT Headquarters building in Tallahassee…**more than 3 times**.

The population growth and urban development anticipated to occur in District One will increase the footprint of urban areas in the region and encroach upon existing agricultural land. This encroachment will cause a shift in the land use and influence property decisions for the producers of agricultural goods. This shift in production location will result in a reconfiguration of transportation and freight logistics for agricultural products within the District.

The relocation of agriculture production in District One has particular relevance to freight movements since the District is home to major agribusinesses with large-scale agricultural operations. These agribusinesses are vital suppliers of agricultural goods to large wholesale and retail grocery and other food production companies across the United States and the world. It is anticipated that such a shift of agriculture production operations of this scale will have a profound impact on some areas/counties within the District. Some of this impact may produce a reduction in agriculture-related truck traffic, but in other areas it may increase the pressure of heavy truck traffic on the surrounding area/network—particularly in areas where there may not be any state highway facilities to support such an industrial operation.

[1] Florida Agriculture Overview and Statistics, *http://www.freshfromflorida.com/Divisions-Offices/Marketing-and-Development/Education/For-Researchers/Florida-Agriculture-Overview-and-Statistics*

This report aims at identifying where the encroachment on agricultural land will likely occur in District One with particular focus on the coastal counties. It looks at where the agriculture production will likely shift to other counties in District One, and how this shift will impact the transportation network across the District. Findings focus in the areas of impact on a regional basis, impact on key corridors and state roads, impact on local roads, identification of areas for future hubs for freight activity, and how this information may be useful in other transportation planning efforts.

2. Methodology Overview

There are two basic analytical components used in this study to analyze the impact of agricultural development on the transportation network:

1. Identifying and quantifying the impact of urban development on agricultural production location for the counties in District One; and,
2. Assessing how these changes to agricultural production location change truck traffic across the main roads in the District.

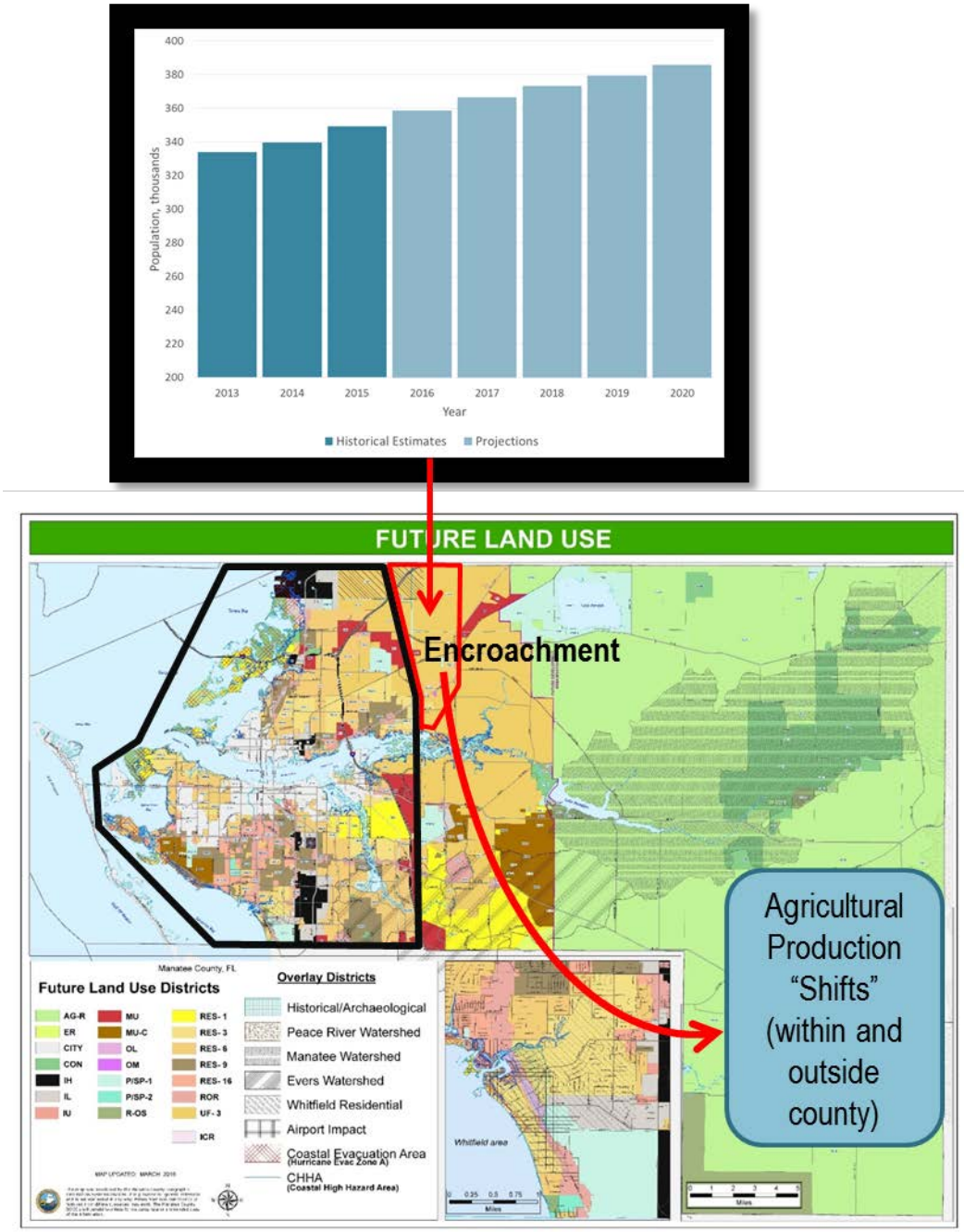
Each component is described briefly in the following subsections.

A. Impact of Urban Development on Agricultural Production Location

The basic premise used to estimate the impact of urban development on agricultural production location is that population growth in District One's urban areas will generate an increase in their urban footprint, thus leading to encroachment on land adjacent to these urban areas. Encroachment is expected to occur over several types of land uses, including agricultural land. Our analysis focuses on the impacts on agricultural land, so for the agricultural land that is anticipated to be encroached on producers have the option of either relocating their agricultural operations within the same county (subject to availability of land) or to move their operations to another county in District One. A graphical representation of this logic is presented in Figure 1.

The decision for agricultural producers to relocate within the same county or to move to a different one depends on the crop being farmed, the amount of agricultural land being encroached on, the amount of available agricultural land in the county where they are currently located, the amount of available agricultural land in the county where they could potentially move to and an anticipated pattern of agricultural production movements based on crop types and counties where the production is encroached on.

Figure 1. Graphical Illustration of Impact of Urban Development on Agricultural Production

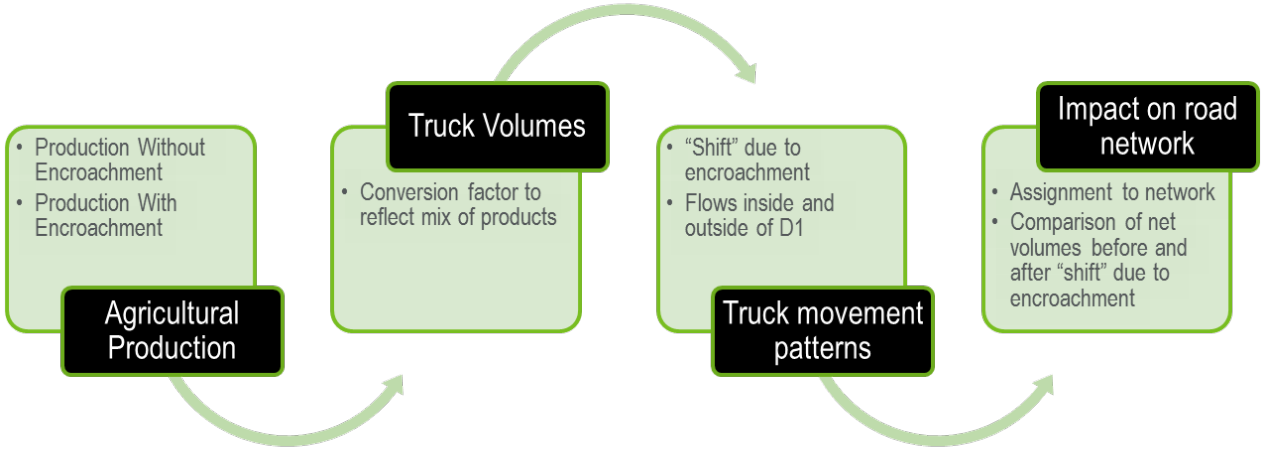


B. Changes to Truck Traffic Across Main Roads Due to Changes in Agricultural Production Location Changes

Once the locational changes to agricultural production have been identified and quantified, their impact on the road network is analyzed. To do this, a situation of "agricultural production without encroachment" is compared to a situation of "agricultural production with encroachment" in terms of truck volumes moving through the main highways and roads of District One.

The comparison of these two situations allows for the identification and quantification of shifts in truck traffic within District One's transportation network as a result of urban growth and encroachment. The shifts in truck traffic are, therefore, a reflection of the shifts in agricultural production location. A graphical representation of the logic used in this component of the study is presented in Figure 2.

Figure 2. Logic Behind Estimates for Impact on Road Network



A key element that needs to be mentioned as part of this component is that there is a significant amount of agricultural production being transported to destinations outside of District One. The study assumes that this share of agricultural production leaving the District is the same under both the "production without encroachment" and the "production with encroachment" situations. Furthermore, as part of the analysis, "exit roads" (out of the District) were assigned for these volumes based on the most-likely destination and route, taking into consideration truck traffic restrictions where applicable.

3. Assumptions and Preliminary Findings

The main assumptions as well as the preliminary findings for each analysis component of this study are presented in the appropriate subsections.

The analysis was conducted for the 2017-2035 period to coincide with available traffic and capacity forecasts for the District One road network.

A. Impact of Urban Development on Agricultural Production Location

Population growth will cause changes in population density and expand the urban footprint. As the population increases, cities will also spread out to cover a greater area. Some of this expansion will encroach on agricultural lands and could potentially cause relocation of production activities. The different steps needed to quantify the impact of urban development on agricultural production location are broken down below and their key assumptions are clearly identified.

EXPANSION OF URBAN FOOTPRINT

The first step required to conduct the analysis is to quantify the expansion of the urban footprint and the encroachment. The 2010 Census estimates provide measures for population density in urbanized areas and urban clusters. In the coastal counties (Manatee, Sarasota, Charlotte, Lee, and Collier) and Polk County, a significant portion of the population lives in urban areas.[2] The analysis assumes that the proportion of population that lives in urban areas in each county in District One remains constant across the period of analysis. This urban proportion and the urbanized area population density are then combined with the population forecasts[3] to obtain estimates of the urban footprint (in land area) in each county across the forecast period. For the more rural counties, which contain smaller urban areas (Hardee, DeSoto, Highlands, Okeechobee, Glades, and Hendry), it is assumed that the county's entire population lives in or near an "urban cluster" as defined by the U.S. Census. Thus the county's total population is used in combination with the population density for urban clusters to estimate the urban footprint in each county. In this way, the growth of the urban footprint in each county is driven directly by each county's population growth.

ENCROACHMENT ON AGRICULTURAL LAND

Urban expansion is anticipated to affect lands currently adjacent to the urban areas. Therefore, not all of the forecasted increase in urban footprints calculated in the previous step is expected to affect agricultural land. The specific impact of increases of urban footprint on agricultural land is explored through a qualitative assessment of current and future land use maps for District

[2] The Florida Department of Transportation, Office of Policy Planning provides estimates on the proportions of the population residing in urbanized areas in counties that contain urban areas.

[3] The population forecast (2017-2040) is adopted from the Demographic Estimating Conference, held by Florida's Legislative Office of Economic and Demographic Research in 2017. They use the final April 10, 2016 official state estimate as the baseline. Population projections for 2016-2040 are provided by Florida's Office of Economic and Demographic Research based on 2015 population estimates. The forecast comprises expectations of net natural increase (birth rates and death rates) and net new residents.

One counties, and a review of changes in Florida urbanized area boundaries between 2000 and 2010[4]. This assessment is included in the analysis by developing a qualitative parameter called an "encroachment factor" that applies to each county. This encroachment factor captures the extent to which urban expansion will encroach on agricultural land (versus other types of land). The specific factors (at the county level) are defined based on the geographic layout of urban areas relative to agricultural lands in the county, the location and size of other land use areas in the county (such as residential areas, mixed industrial land uses), and the extent of conservation lands. When considering encroachment, it is assumed that urban expansion will develop and urbanize industrial and/or residential areas in addition to encroaching on agricultural lands. However, it is assumed that conservation lands will not be affected by population growth.

Additionally, the analysis also considers the existence of agricultural land in each county that is currently not actively farmed, either due to rotation practices or lacking the necessity to utilize all available land. This concept is referred to as "inactive land" in this study. A ratio of active to inactive land is developed for each county using USDA data on total agricultural land and total acres harvested. As urban expansion occurs, inactive land can be developed into populated areas (residential, urban, etc.) or can accommodate "intra-county" agricultural movements, when farming operations decide to relocate within the same county in response to urban expansion. In some counties, urban expansion eventually will force farmers to relocate to another county within the District (called "inter-county" agricultural production movements). Through this analysis, it is assumed that some portion of the original agricultural production remains in the county where the production currently occurs. For the purposes of this analysis, this portion is assumed to be equal to the portion of inactive land available before the beginning of the forecast period (i.e., during the year 2016). Finally, we assume that District One retains all of the agricultural production currently located within District One (that is, movements modeled in this report only occur between counties within District One and do not include any additional production volume that may shift to District One from the East Coast counties, where similar encroachment will occur).[5,6]

AGRICULTURAL PRODUCTION RELOCATION

Urban expansion is translated into acres of encroachment on agricultural land through the encroachment factor described above and then encroached agricultural land is translated into "intra-county" or "inter-county" movements of agricultural production by accounting for inactive land in each county. The "inter-county" movements are also called "outbound" agricultural movements (since they move out of a particular county) and are estimated in the analysis in

[4] Land use maps were obtained through individual county websites. Information on Florida Urbanized Areas is available on the Florida Metropolitan Planning Organization Advisory Council website (www.mpoac.org).
[5] This is due to the large availability of agricultural land in District One's Inland counties, which is assumed to discourage the movement of agricultural producers to places further away from their current location.
[6] The same type of encroachment on agricultural land is occurring in the East Coast of Florida, pushing agricultural production to the Inland counties. Therefore, this assumption is considered to be appropriate to represent the reality in the region.

terms of area (acres) at the agricultural commodity (or crop) level for the main three agricultural goods produced in the District: vegetables, citrus, and sugarcane.[7] The total agricultural production of each county, as well as the shares of each crop is determined from county-level USDA data.

The analysis estimates positive outbound movements of agricultural production originating in the most highly populated and urbanized counties in the District, with the exception of Collier. Four out of the five of the counties with forecasted acres of outbound agricultural production movements are coastal (Manatee, Sarasota, Charlotte and Lee). This is in line with expectations since urban areas in coastal counties are large and have less area to expand into, making them more likely to encroach on agricultural land. Polk County, the only inland county with outbound movements, is another county expected to generate outbound movements of agricultural production because it holds portions of three separate urbanized areas recognized by the Census Bureau, and has one of the highest projected population growth rates in the District.

Most of the other counties in the District are more rural; they encounter less urban expansion due to smaller populations and have more inactive land to provide for intra-county movements in agricultural production, so the analysis does not predict outbound movements for them. Collier is the exception. It is coastal and contains an urbanized area and a significant amount of conservation land, which limits the area to which the urban footprint can expand. However, it also has enough inactive land to accommodate intra-county agricultural movements and some acres of production moving from other counties (i.e., inter-county movements).

The number of outbound acres that a county is forecasted to have is allocated across the rest of the counties in the District by crop/commodity type through weight matrices, developed through conversations with FDOT experts on likely movements of citrus and vegetable production.[8] Multiple movement scenarios were modeled to validate the results. In general, citrus farms move north to south, and vegetable operations move west to east. Movements are designated "inbound" for the receiving counties and "outbound" for the county where the movement originates. For example, some citrus and vegetable production is pushed out of Lee County (as an outbound movement). All the citrus groves are relocated to Hendry County (as an inbound movement), and the vegetable production may be split between locations in Hendry and Collier counties (also as inbound movements). Movements are constrained by the remaining available inactive land in each receiving county, so that no county can receive more agricultural production in acres than the land allows.

[7] It is assumed that total agricultural production volumes in District One are represented by vegetables, citrus fruits and sugarcane. As part of this analysis, data by county on these commodities was gathered from the USDA to represent all agricultural production and acreage.
[8] The direction of the movements for citrus and vegetables was validated with some major growers through informal discussions. Our analysis did not identify outbound movements for sugarcane since this crop is produced primarily in the Inland Counties of District One.

Finally, it is assumed that land productivity is constant across the forecast period, but unique to each county.[9] The effect of urban encroachment on agriculture for District One is summarized for all commodities in short tons by applying land productivity estimates by county. The effects are negative numbers for counties that experience net losses in agricultural production due to urban expansion (Polk, Lee, Sarasota, Manatee, and Charlotte), and are positive numbers for counties that experienced net gains in production due to urban expansion (Hendry, Glades, Collier, Hardee, DeSoto, Highlands, and Okeechobee). A table with the number of accumulated acres of agricultural production that relocate between District One counties is presented in Table 1 for years 2017, 2020, 2025, 2030 and 2035. Notice that positive numbers represent counties that receive acres of agricultural production from other counties, while negative numbers represent counties that have their agricultural acreage production reduced due to encroachment.[10]

Table 1. Cumulative Net Impacts on Agricultural Production Land due to Encroachment (in acres)

County	*2012 Production Acreage**	2017	2020	2025	2030	2035
Charlotte	*16,513*	0	0	-562	-1,914	-3,063
Collier	*44,661*	56	598	1,164	1,832	2,438
DeSoto	*65,463*	247	2,395	4,611	7,323	9,794
Glades	*33,349*	227	1,887	3,565	5,747	7,753
Hardee	*47,887*	134	1,367	2,647	4,186	5,584
Hendry	*137,626*	672	5,408	10,173	16,454	22,238
Highlands	*61,525*	21	340	683	1,049	1,375
Lee	*15,541*	-673	-10,658	-15,541	-15,541	-15,541
Manatee	*52,972*	0	0	-2,634	-7,638	-12,102
Okeechobee	*10,554*	0	0	0	0	0
Polk	*83,730*	0	0	-2,770	-10,163	-17,140
Sarasota	*1,336*	-686	-1,336	-1,336	-1,336	-1,336

** Represents number of acres that produced agricultural goods in 2012 (source: USDA and FDACS)*

Notice that Okeechobee is not anticipated to generate any outbound or receive any inbound movement of acres as a result of growth in District One's urban areas. However, encroachment already occurring in urban areas on the East Coast of Florida is creating a shift of agricultural

[9] Land productivity is estimated as agricultural production per acre with production and acreage data on citrus, sugarcane, and vegetables from the USDA 2011/2012 by county in Florida.

[10] It is worth noting that the shift in acres between counties may not be one-for-one. For example, in some cases the acres that are lost by a county may not convert to the same kind of growing in the receiving county. Therefore, the receiving county may not require as many acres as the ones being shifted away. However, the result captured in this analysis is that these shifts, even if they may not materialize as one-for-one relocations in terms of acres, represent little change in the volume of agricultural production being shifted. This result was validated with growers through informal discussions.

production to Okeechobee. The analysis of encroachment generated by urban growth in the East Coast of Florida cannot be denied, but its quantification is outside of the scope of this White Paper.

When the number of acres relocated among the different counties in the District is transformed into production volumes (i.e., short tons), the result is that presented in Table 2. The process to estimate such volumes for outbound shifts consists of breaking down the number of outbound acres generated in a particular county into the main crop types analyzed in this study using the current shares of agricultural production for that particular county. Once this is done, the number of outbound acres for each crop type is multiplied by the productivity of land (short-tons per acre) for those particular crops in that particular county. Similarly, for inbound shifts the number of acres shifting inbound at any particular county is assigned to the main crop types using current shares of crop production in the receiving county. Once this is complete, the number of acres for each crop type is multiplied by the productivity of land (short-tons per acre) for those particular crops in that particular county.

Table 2. Cumulative Net Impacts on Agricultural Production Land Due to Encroachment (in short tons)

County	*2012 Production Tonnage**	2017	2020	2025	2030	2035
Charlotte	*201,206*	0	0	-6,853	-23,322	-37,318
Collier	*632,117*	796	8,696	16,966	26,673	35,460
DeSoto	*853,073*	3,291	32,288	62,276	98,783	132,012
Glades	*1,050,400*	3,392	27,962	52,777	85,138	114,891
Hardee	*635,287*	1,842	19,081	37,024	58,456	77,907
Hendry	*3,264,462*	9,296	73,591	138,109	223,783	302,755
Highlands	*1,066,140*	298	4,716	9,487	14,569	19,093
Lee	*196,666*	-8,516	-134,876	-196,666	-196,666	-196,666
Manatee	*793,212*	0	0	-39,441	-114,367	-181,211
Okeechobee	*134,827*	0	0	0	0	0
Polk	*1,418,384*	0	0	-46,921	-172,168	-290,355
Sarasota	*15,480*	-7,946	-15,480	-15,480	-15,480	-15,480

** Represents short tons of agricultural goods produced in 2012 (source: USDA)*

AGRICULTURAL PRODUCTION FORECASTS

Two agricultural production forecasts are generated as part of this analysis in order to isolate the impact of urban development on the movement of agricultural operations. The baseline forecast consists of the forecast of agricultural production in District One assuming that urban expansion generates no encroachment on agricultural land and therefore does not generate a

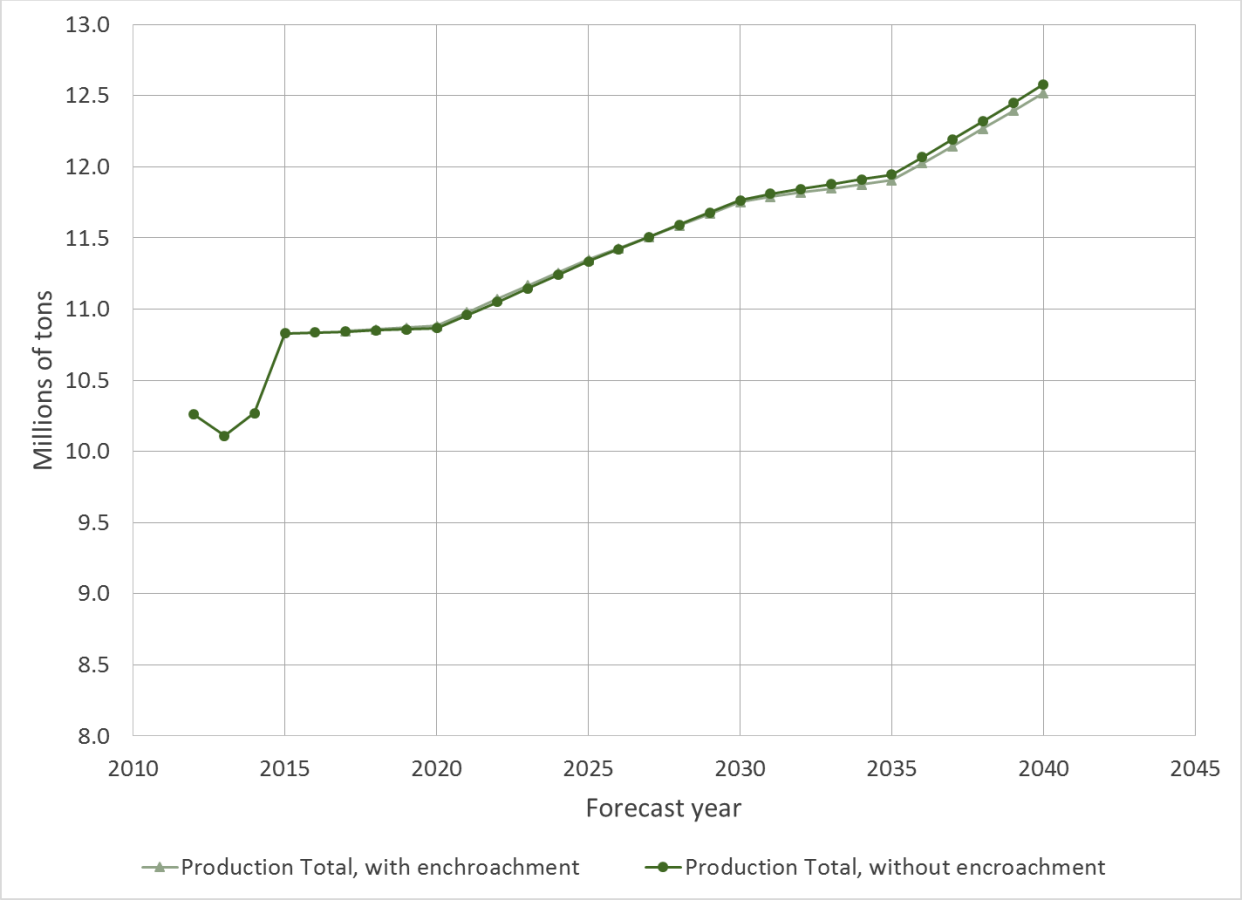
shift of agriculture production.[11] The alternative forecast consists of the forecast of agricultural production in District One where urban expansion generates encroachment on agricultural lands, generating a shift of production facilities away from growing urban areas.

The baseline scenario uses growth rates from the Freight Analysis Framework (FAF) data on agricultural products[12] and applies them to current District One agricultural production volumes to generate future estimates of agricultural production.[13] Since FAF provides an unconstrained forecast, a constraint on agricultural production relative to the agricultural land available in each county is applied, to ensure that the analysis does not forecast production levels beyond a county's available land resources. This baseline forecast is then modified with changes due to encroachment (which represent agricultural production movements between District One counties in short tons) to create a production forecast by county that reflects the effects of encroachment.

Figure 3 illustrates the difference in total agricultural production volumes at the District level between a situation where urban growth does not generate encroachment and a situation where urban growth generates encroachment. In this case, the difference in total production is negligible.

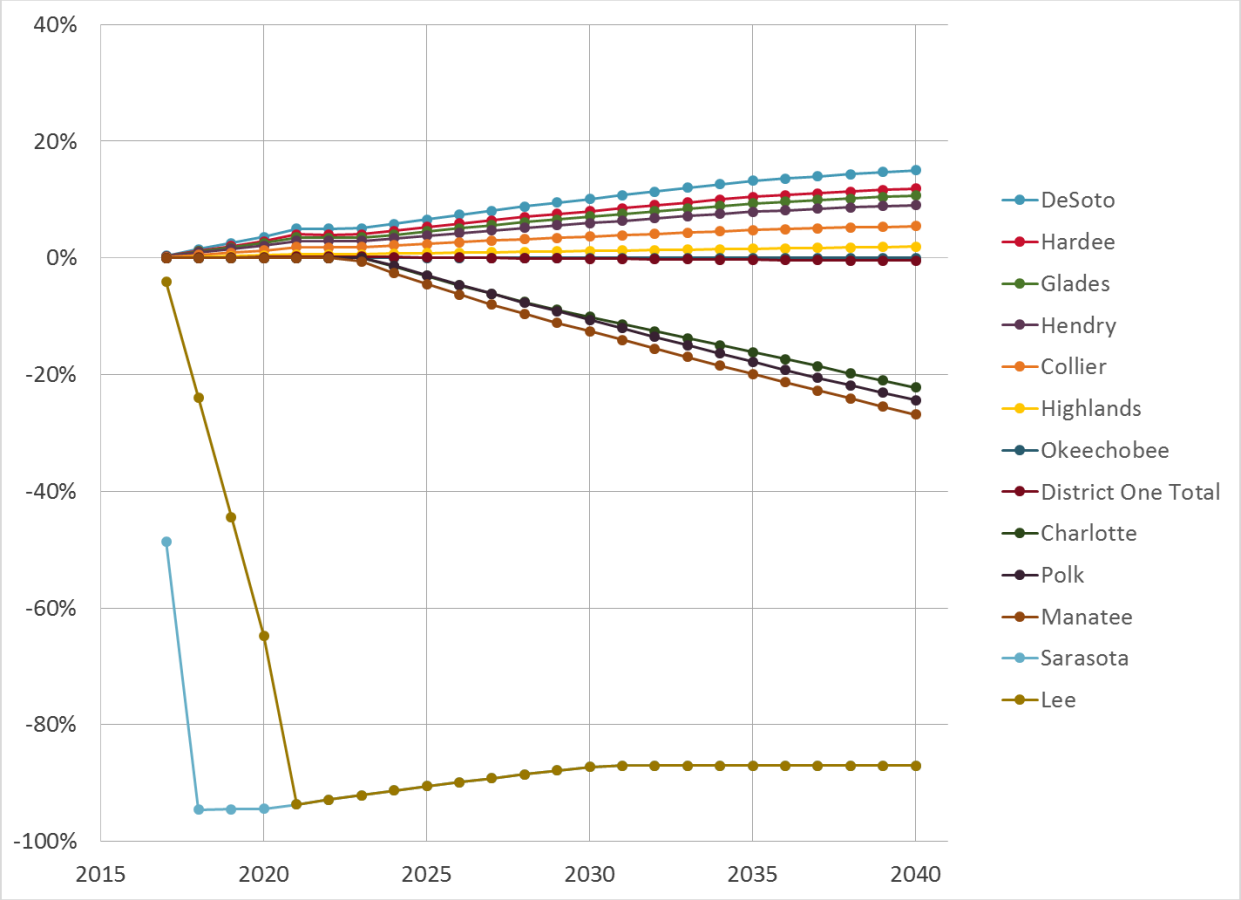
[11] This is equivalent to saying that urban growth will not encroach on agricultural land, either because only other land use types are affected or, more likely in reality, because the density of the urban areas increases as population increases, leaving the urban footprint unchanged.
[12] The underlying assumption is that the growth in production of agricultural goods in District One is comparable to growth in production in other Florida regions. The FAF growth rate used corresponds to that of freight movement data on the "other agricultural products" FAF category. When compiling a growth rate estimate for production to apply across District One, the Orlando CMA, Jacksonville MSA, and Tampa MSA were excluded based on the definition of FAF regions.
[13] This can be interpreted as assuming that the growth rates obtained from FAF generally represent steady increases in the production rate due to more efficient farming practices and improvements in technology and farming inputs.

Figure 3. Comparison of Forecasted Agricultural Production, With and Without Encroachment (in short tons)



However, despite the fact that production at the District level remains practically unchanged, the impact of encroachment on the agricultural production of individual counties varies greatly. In general, Inland counties receive the acres that are being reduced in the coastal counties. Sarasota and Lee reduce their agricultural production acres to their minimum levels due to significant urban growth and therefore are anticipated to produce agricultural goods in the future using only land that is currently classified as inactive land (but that will become active in the future as urban areas in these counties grow). Figure 4 provides a graphical representation of the counties that reduce their acres of agricultural land (and the relative magnitude) as well as those that receive it when a situation with encroachment is compared to a situation without encroachment.

Figure 4. Percentage Change in Forecasted Agricultural Production Resulting from Encroachment (in short tons) at the County Level



The breakdown of counties that are net generators of outbound agricultural production movements and those that are net receivers of agricultural production movements is provided in Table 3. In general, coastal counties are net originators of outbound movement of agricultural production acres while inland counties are net receivers of inbound movement of agricultural production acres.[14]

[14] As stated before, even though the one-for-one shift in acres is an oversimplification of our analysis, it yields the desired result that these shifts represent small changes to the volume of agricultural production.

Table 3. Net Generators and Net Receivers of Agricultural Production Movements (in acres)

Percent of Total Outbound Acreage, by County	
Total Outbound Acreage	**-60,864**
Charlotte	6.9%
Lee	25.5%
Manatee	26.9%
Polk	38.5%
Sarasota	2.2%

Percent of Total Inbound Acreage, by County	
Total Inbound Acreage	**60,864**
Collier	2.8%
DeSoto	19.9%
Glades	15.8%
Hardee	11.3%
Hendry	47.5%
Highlands	2.8%
Okeechobee	0.0%

The previous table shows that, by year 2035, a little less than 61,000 acres of agricultural production will move between counties in District One. The counties of Polk, Manatee and Lee (in that order) are the main originators of these movements. The primary locations showing an increase in production acres as a result of this shift are Hendry, DeSoto, Glades and Hardee counties.

In summary, the key findings from this component of the study are the following:

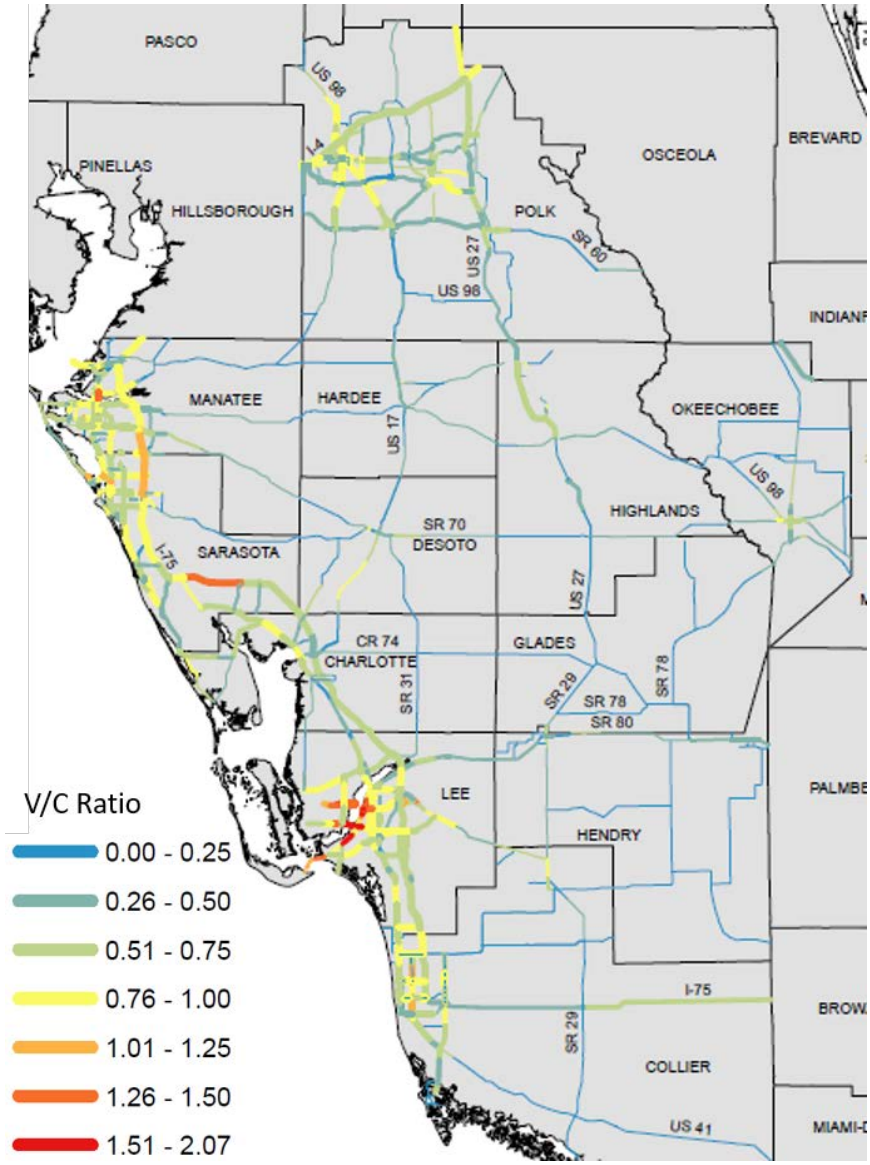
1. Encroachment is anticipated to have a small impact on total volume of agricultural goods produced in District One due to internal shifts to other District One counties. In particular, the analysis found a reduction in total agricultural production across District One of less than 1 percent compared to the non-encroachment scenario.
2. Urban areas in Sarasota and Lee counties are forecasted to encroach on all currently-used agricultural land due to the existence of large urban areas and relatively small amount of remaining agricultural production acreage. This means that future agricultural production in these counties can only be performed on currently-inactive land that turns active as urban areas grow.
3. Different counties have different rates of impact on their agricultural production. Coastal counties are commonly net generators of outbound shift agricultural movements to other District One counties while inland counties are net recipients of outbound shift movements of agricultural production.

B. Changes to Truck Traffic Across Main Roads Due to Changes in Agricultural Production Location

The agricultural production for both scenarios defined above (without and with encroachment) was used as the basis for the analysis of changes in truck traffic across District One. In order to provide a comparison point for the impact created by changes in truck volumes due to agricultural shifts, data depicting current and future level of service for the road network was taken from the FDOT District One Freight Mobility and Trade Study. In particular, this Freight

Mobility and Trade Study included information on AADT, road capacity, and volume over capacity (V/C) ratios for the main freight corridors in the District for the years 2013 and 2035.

Figure 5. V/C Ratios for Main Freight Network in District One in 2013, Before Impacts of Encroachment

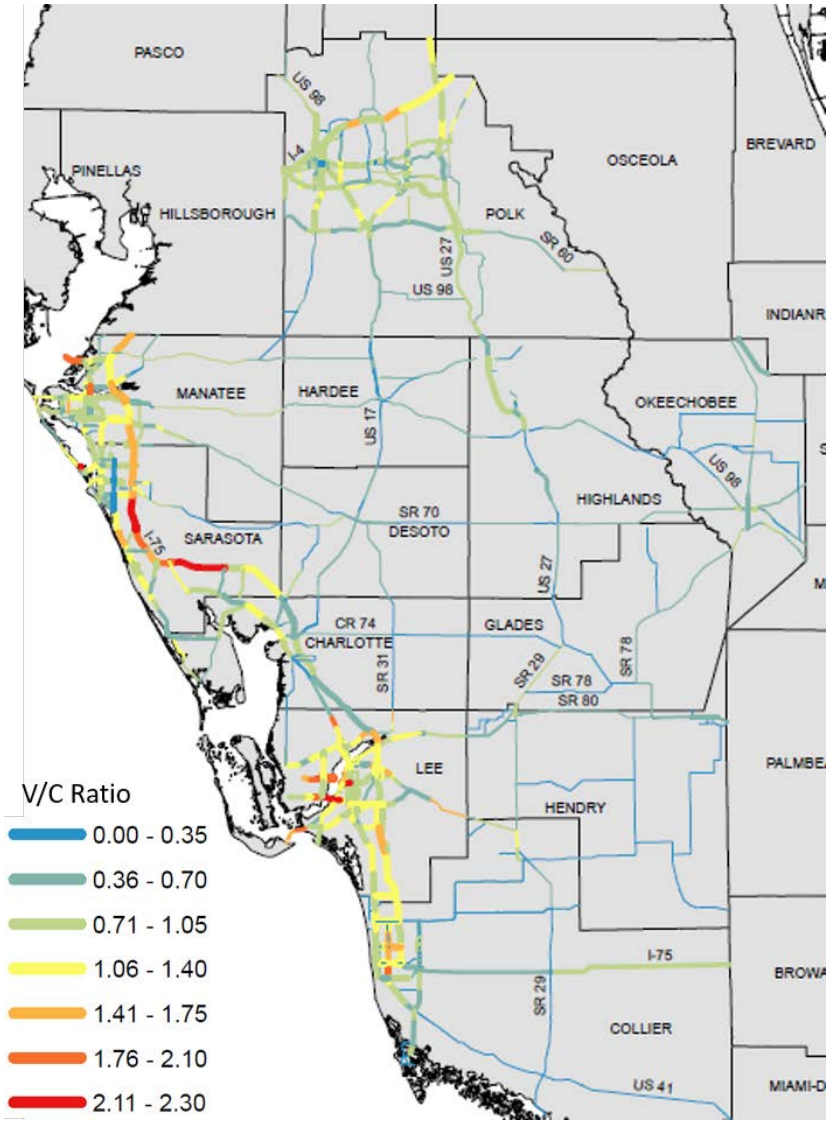


Note: Line thickness depicts 2013 AADT levels, an indication of current road conditions for all vehicle traffic. The thickness of the line is not related to the color displayed on the roads.

A map with the V/C ratios reported for year 2013 in District One's Freight Mobility and Trade Study is presented in Figure 5 and a similar map for year 2035 is presented in Figure 6.[15] For the purposes of this study, these measures represent the V/C ratios for the transportation network before taking into account the impacts of encroachment.

[15] The information on road capacity for year 2035 only exists for a subset of District One's road network and therefore the map depicting the V/C ratios is less dense than the map representing the changes in truck volumes of agricultural products.

Figure 6. V/C Ratios for Main Freight Network in District One, Before Impacts of Encroachment, 2035



Note: Line thickness depicts 2013 AADT levels, an indication of current road conditions for all vehicle traffic. The thickness of the line is not related to the color displayed on the roads.

It is not surprising to observe in Figure 6 that higher V/C ratios are located along the Coastal Counties and Polk, since these locations currently have a freight transportation network with high V/C ratios (see Figure 5 for a map displaying recent V/C ratios[16]).

In order to estimate the change in truck volumes generated by agricultural shifts, forecasted agricultural production levels at the county level for each scenario were transformed into the number of equivalent truckloads and then were assigned to destination counties based on available information on agricultural production's origins and destinations for District One. Next,

[16] The 2035 transportation network forecasted for use in the Freight Mobility and Trade Study for District One indicates that the capacity for a few roads is expected to increase between 2013 and 2035.

the truck volumes at the origin and destination county were linked through the most-likely path to develop the assignment of trucks to District One's road network under each scenario, taking into consideration restrictions to truck traffic on certain roads. Finally, the differences in truck volumes between the two scenarios were calculated for a selected number of years (2017, 2020, 2025, 2030 and 2035) to estimate the impact of encroachment on the main roads of the District for each one of those years. Using the changes in the number of truckloads that result from shifting agricultural production together with current and forecasted traffic conditions on the District's road network, we derive future traffic conditions for the network that take into consideration the locational changes of agricultural production.

AGRICULTURAL PRODUCTION AND TRUCK VOLUMES

The agricultural production forecasts in each scenario were transformed into freight movement forecasts to identify the effect of urban encroachment on the transportation system in District One's road network. It is assumed that the amount of agriculture moved by freight rail is negligible, so all agricultural production was converted from short tons to truck trips using a weight per truckload of 23 short tons per truck.[17] These forecasted truck volumes represent the number of loaded trucks required to move agricultural production originating in each county since they are derived using the agricultural production volumes estimated in the previous section.

However, the previous forecast must be adjusted upwards to include additional empty truck movements required to transport agricultural goods. In particular, this adjustment must be made to capture the truck trips needed to position the trucks into the farms and groves so they can be loaded with agricultural goods as well as the repositioning of trailers after they unload their cargo. As a result, the forecast of loaded trucks derived using the agricultural production volumes is multiplied by two in order to generate the total number of truck trips related to agricultural goods movements.[18] This total number of truck trips is used in the following subsections to estimate the impact of agricultural shifts on the transportation network.

IDENTIFICATION OF ORIGINS AND DESTINATIONS

From freight flow data on farm products in the FDOT District One Freight Mobility and Trade Study, Technical Memo 2, it is known that more agricultural production volumes are destined for markets and processing plants outside of District One than those that remain within the District. Therefore, it is necessary to delineate and quantify representations of three types of freight flows as part of this analysis:

1. Agricultural products freighted within a county (intra-county freight flows);
2. Agricultural products shipped to another county in District One (inter-county, intra-district freight flows); and,
3. Agricultural product shipments with a final destination outside District One.

[17] Based on HDR's experience and FDOT District One personnel insight.
[18] A factor of two is considered to be a conservative adjustment, since the movement of citrus in the District, for example, is likely to require more than two empty truck movements for each loaded truck movement.

The second and third types of freight flows account for the majority of agricultural truck trips in the District, so these trips will comprise a majority of the impacts on the transportation system based on the forecasted shift of agricultural movements instigated by urban expansion.

The data on truck tonnage of farm products by county from data tables in the FDOT District One Freight Mobility and Trade Study, Technical Memo 2, provide a distribution for agricultural produce that originates in and is destined for the same county (called the "Remains In" category in that study). The amounts listed there correspond to the volumes of agricultural products freighted within a county (#1 in list above). That memo also has data on produce that originates in one county and is destined for another county within the district (called the "Destined For" without the "Remains In" value in that study).[19] These amounts correspond to the volumes of agricultural products shipped to another county in District One (#2 in list above). Using this information, a partial origin-destination matrix that represents the number of truck trips of agricultural products between origin and destination counties in District One was built by transforming the number of tons moving between each origin-destination pair into the number of truck trips needed to transport them. An example of this partial origin-destination matrix is presented in Table 4 (note that the same 12 counties are both origins and destinations).[20]

Table 4. Illustration of Partial Origin-Destination Matrix for Intra- and Inter-County Agricultural Freight Flows (in number of truck trips)

O (row) / D (col)	Charlotte	Collier	DeSoto	Glades	Hardee	Hendry	Highlands	Lee	Manatee	Okeechobee	Polk	Sarasota	TOTAL
Charlotte	6	92	46	7	25	50	49	133	154	21	872	48	1,501
Collier	124	66	147	22	80	162	156	427	495	68	2,807	153	4,707
DeSoto	166	395	94	30	107	218	210	573	664	91	3,769	206	6,523
Glades	204	486	243	0	131	267	258	705	817	112	4,632	253	8,107
Hardee	124	294	147	22	8	162	156	427	495	68	2,806	153	4,862
Hendry	637	1,517	759	114	410	39	804	2,200	2,549	349	14,461	789	24,628
Highlands	204	486	243	36	131	267	28	704	816	112	4,628	253	7,907
Lee	38	90	45	7	24	50	48	46	151	21	858	47	1,423
Manatee	152	362	181	27	98	199	192	525	383	83	3,449	188	5,839
Okeechobee	26	62	31	5	17	34	33	91	105	6	595	32	1,038
Polk	296	706	353	53	191	388	374	1,023	1,186	162	462	367	5,561
Sarasota	3	7	4	1	2	4	4	10	12	2	67	3	117
TOTAL	1,980	4,564	2,293	323	1,222	1,840	2,310	6,864	7,826	1,094	39,407	2,491	

[19] See, for example, Table 4.1 on page 4 of the FDOT District One Freight Mobility and Trade Study, Technical Memo 2 for data on truck tonnage moved between origins and destinations.
[20] See Appendix for a larger depiction of this partial origin-destination matrix.

Notice this matrix only accounts for intra- and inter-county agricultural freight flows within District One and therefore is only a partial origin-destination matrix for agricultural products moved by truck.[21]

For the remaining freight flow type (#3 in the list above), it is assumed that agricultural goods produced in District One will exit the region in one of three general directions in pre-determined proportions: agricultural products will be freighted toward Tampa, toward Southeast Florida (Miami/Fort Lauderdale), or toward Northeast Florida (Orlando or Jacksonville).[22] Depending on the county from which the agricultural production originates, an "exit county" is assigned based on proximity to the assumed destination and a second partial origin-destination matrix representing truck trips with a final destination outside District One is created (see Appendix for an example of this partial origin-destination matrix that captures out-of-District truck flows).[23] When the estimates from the matrix capturing flow #3 are combined with the matrix that captures flows #1 and #2 from the above list, the result is an integrated origin-destination matrix that accounts for all the truck trips related to the movement of agricultural goods produced in the District whose destination is either within or outside of the District.

IDENTIFICATION OF TRUCK MOVEMENT PATTERNS

Once the identification of origin-destination are made for all three types of agricultural freight flows the number of trucks that travel between each origin-destination pair is assigned to the road network.[24] The assignment methodology is the following:

- For freight flows that originate and terminate in the same county, the number of truck trips is simply allocated entirely to the county in which they originate;
- For freight flows that originate in one county and terminate in another, the number of truck trips is allocated to the road network assuming that the trucks take an optimal path between origin and destination counties, represented by the shortest route in the transportation network, but taking into consideration bridge and weight restrictions;[25]
- For truckloads leaving District One for a destination outside of the District, an exit roadway is chosen for each exit county and truck volumes exiting the District in this

[21] For example, from the FDOT Memo freight data it was determined that less than 1% of all agricultural production that originates in Charlotte County stays in Charlotte County, and 16% of Charlotte County agricultural produce is distributed to other counties in the District. These shares are numerically derived based on FDOT Memo freight data tables.
[22] Even though their final destinations may not be these particular locations these particular destinations were used only to identify "exit counties."
[23] To continue the example from the previous footnote, the remaining 84% of Charlotte County agricultural production exits the District: 17 percent of that total exiting toward Tampa through Manatee, 25 percent leaving for Miami through Collier, and the remaining 42 percent traveling through Polk toward Jacksonville.
[24] ArcGIS Network Analyst was used to determine optimal paths and assign truck volumes to roads within the counties and on the optimal path between each county, according to the origins and destinations for select years in forecast period.
[25] This is done identifying the shortest route using ArcGIS Network Analyst software and manually adjusting the volumes to account for the main bridge restrictions (such as the bridge restriction on SR 29).

direction are assigned to this road, accounting for restrictions on the type of truck.[26] These exit roadways usually comprise the major interstate or state highway within the county leading out of District One, and represent a "most likely" scenario for trucks leaving the District;

- Finally, because it is impossible to know the actual locations in each county of agricultural production farms/groves, processing plants, or market locations, truck trips in counties where flows originate and terminate are loaded to all roads in the network within these counties[27].

CHANGES IN TRUCK MOVEMENT PATTERNS ACROSS MAIN ROADS IN DISTRICT ONE

The assignments that result from applying the previous steps to each scenario represent the estimated changes in truck volumes for the main roads in the District's network. These changes embody the effect of urban expansion on the dispersion of agriculture and farming operations throughout District One and the subsequent impact on the transportation network due to necessary changes in logistics.

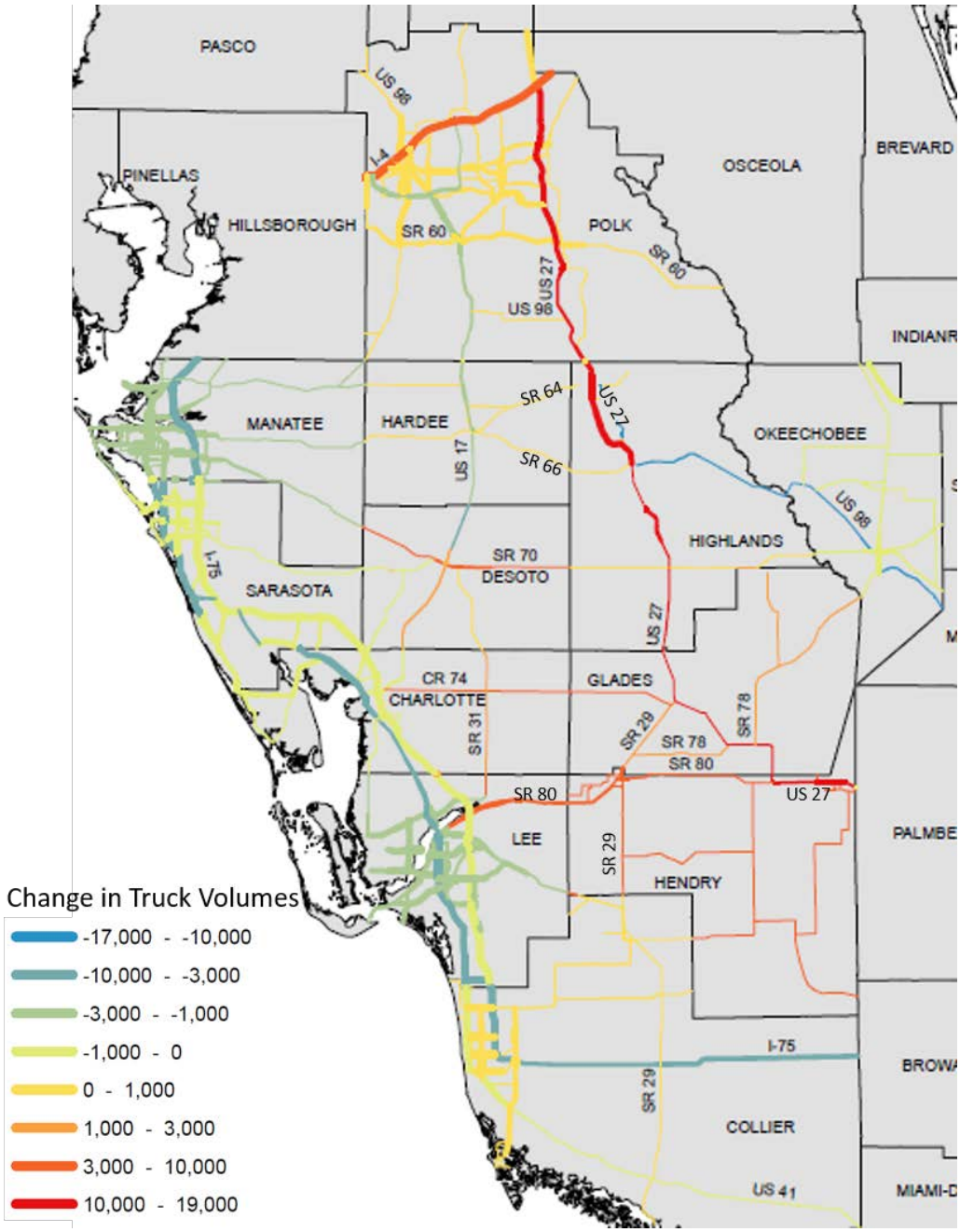
The change in truck volumes for a specific road as a result of encroachment is combined with forecasted traffic volumes and data on the capacity of the roadway to determine forecasted levels of service (LOS) for each road across the network at specific points in the future. The measure used to represent LOS in this study is the volume over capacity (V/C) ratio, defined as the quotient of a road's total traffic volume (including passenger vehicles and trucks) over its design capacity. Information on forecasted traffic volumes and road capacity was obtained from FDOT District One's Freight Mobility and Trade Study (as presented in Figure 5 and Figure 6).

The changes in truck volumes as a result of encroachment are represented at the road level. Figure 7 represents those changes for the year 2035, expressed in number of trucks (notice that the thickness of a line in the map is proportional to the 2013 AADT for the road it represents). Additional maps for other years of analysis are provided in the Appendix.

Those roads in Figure 7 that feature a combination of an orange or red color and a thin line are those on which the impact of encroachment is more significant. This is due to the fact that they represent roads that currently have low traffic volumes but that in the future get a significant amount of truck traffic added as a result of the shifts in agricultural production. In most cases they are county roads that are not prepared for heavy truck traffic and therefore are expected to deteriorate quickly. Furthermore, these roads are expected to feature higher congestion levels due to a combination of low capacity and a significant increase in truck traffic.[28]

[26] In particular, we account for the restriction of trucks with open beds carrying divisible loads on the interstates.
[27] This uniform dispersion of truck volumes creates roads with traffic conditions that appear to abruptly change at county lines. Ideally, with a more sophisticated model, the colors along a single road would form a gradient, representing a reality of gradual changes in traffic conditions across county lines.
[28] This reasoning also applies to the maps shown in the Appendix.

Figure 7. Forecasted Changes in Truck Volumes in Year 2035 Due to Urban Growth and Encroachment (in number of trucks)



Note: Line thickness depicts 2013 AADT levels, an indication of current road conditions for all vehicle traffic. The thickness of the line is not related to the color displayed on the roads

It is worth noting the difference in truck volumes for some of the key roadways in the District. For example, urban growth is anticipated to result in I-75 handling less truck volumes due to agricultural production moving from the Coastal counties to the inland ones, therefore shifting agricultural production traffic to other roads such as US-17 or US-27. I-4 is anticipated to increase its truck traffic volumes as a result of encroachment by virtue of being the “exit route” for agricultural production heading towards Jacksonville and beyond. US-27 increases its

volume of truck traffic due to encroachment while traffic on US-17 overall decreases due to agricultural production moving eastward from the Coastal counties to Glades and Hendry. The primary processing plants and packing houses are assumed to remain in Polk County.

Of similar relevance is the anticipated increase in truck volumes on the local roads in Hendry, Glades, and to a lesser degree, DeSoto, due to the relocation of agricultural production to these counties. Production will need to be transported from the farms and production sites to the main roads in the counties before making their way to their final destinations, thus putting increased pressure on the capacity of local roads.

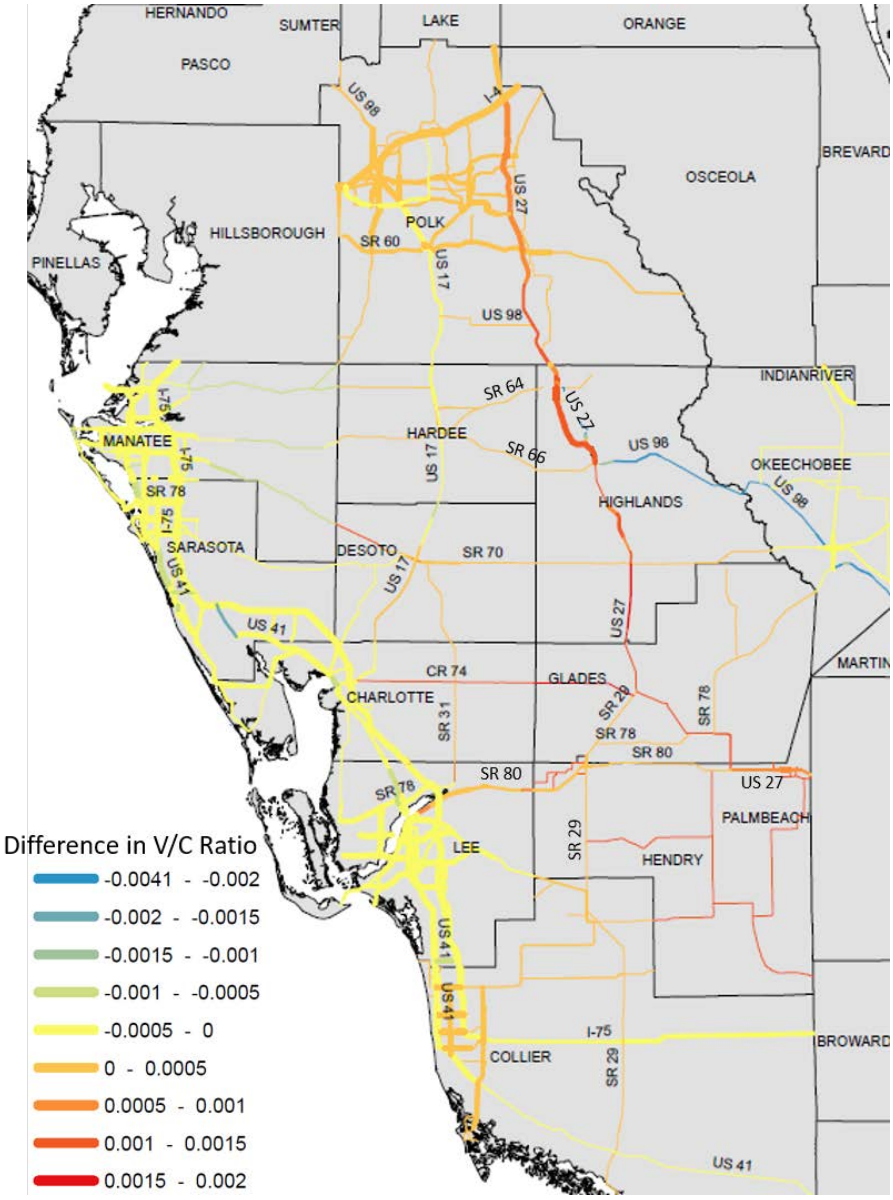
In order to transform the changes in truck volumes due to urban growth and encroachment into LOS metrics, the study relied on current and future Average Annual Daily Traffic (AADT) and capacity indicators for roads in the District One transportation network estimated as part of District One's Freight Mobility and Trade Study.

In order to develop the impact of encroachment on V/C ratios for the transportation network of the District, the changes in truck volumes related to agricultural production shifts are transformed into daily averages and combined with the AADT numbers for year 2035 at the road level, and the resulting AADT is divided by the capacity listed under each corresponding road for 2035. The changes to V/C ratios due to encroachment are presented in Figure 8 (in this map the thickness of a road is also representative of the 2013 AADT).

Similar to Figure 7, where the changes in truck volumes due to encroachment were presented, Figure 8 shows that increases in V/C ratios in year 2035 (represented by the colors of the roads) will be observed predominantly along US-27 for north-south traffic and along many west-east roads including, but not limited to, CR-74, SR-60, SR-70, and SR-80 for west-east movements. Furthermore, the reduction in truck volumes carrying agricultural products shown in Figure 7 that will occur along the roads in the Coastal counties are also reflected in Figure 8 as reduction in the V/C ratio for those same roads.[29] The following section looks at these potential impacts in more detail.

[29] For the same reasons explained in the paragraphs preceding Figure 7, the roads in Figure 8 that feature a combination of an orange or red color and a thin line are those on which the impact of encroachment is more significant.

Figure 8. Difference in V/C Ratios in Year 2035 Due to Urban Growth and Encroachment



Note: Line thickness depicts 2013 AADT levels, an indication of current road conditions for all vehicle traffic. The thickness of the line is not related to the color displayed on the roads

4. Summary of Findings

A. Impact of Agricultural Shifts and Freight Movement Patterns on a Regional and County Basis

The study found that urban development and encroachment generate different impacts across different counties in the District. In particular, three overarching findings can be reported:

1. Lee, Charlotte, Manatee, Okeechobee and Sarasota experience reductions in truck volumes of agricultural products due to the relocation of agricultural production to Inland counties resulting from encroachment. The impacts range from a 49 percent (in Lee) to an 8 percent (in Manatee) decrease in the future anticipated truck volumes of agricultural products compared to a situation without encroachment, representing a total reduction across all four counties of more than 49,000 truck trips by year 2035.
2. Hardee, DeSoto, Glades and Hendry experience increases in truck volumes for agricultural products since production relocates to these counties due to encroachment. The impacts range from a 12 percent (in DeSoto) to an 8 percent (in Hendry) increase in the future anticipated truck volumes of agricultural products compared to a situation without encroachment, representing an increase of more than 57,000 truck trips across these counties by year 2035. This significant increase in truck traffic is anticipated to circulate on a local transportation network that is unprepared for heavy truck traffic, especially in Hendry County, potentially resulting in county roads deteriorating quickly.
3. Polk has a combination of impacts since some production relocates to other counties as a result of encroachment, but that production still needs to be processed at the facilities in this county. The net impact is a reduction of 3 percent in the anticipated truck volumes of agricultural products, representing a reduction of almost 15,000 truck trips, compared to a situation without encroachment. This translates to a heavy dependence on US 27 and its roadway arteries to transport the agriculture of Southwest Florida.

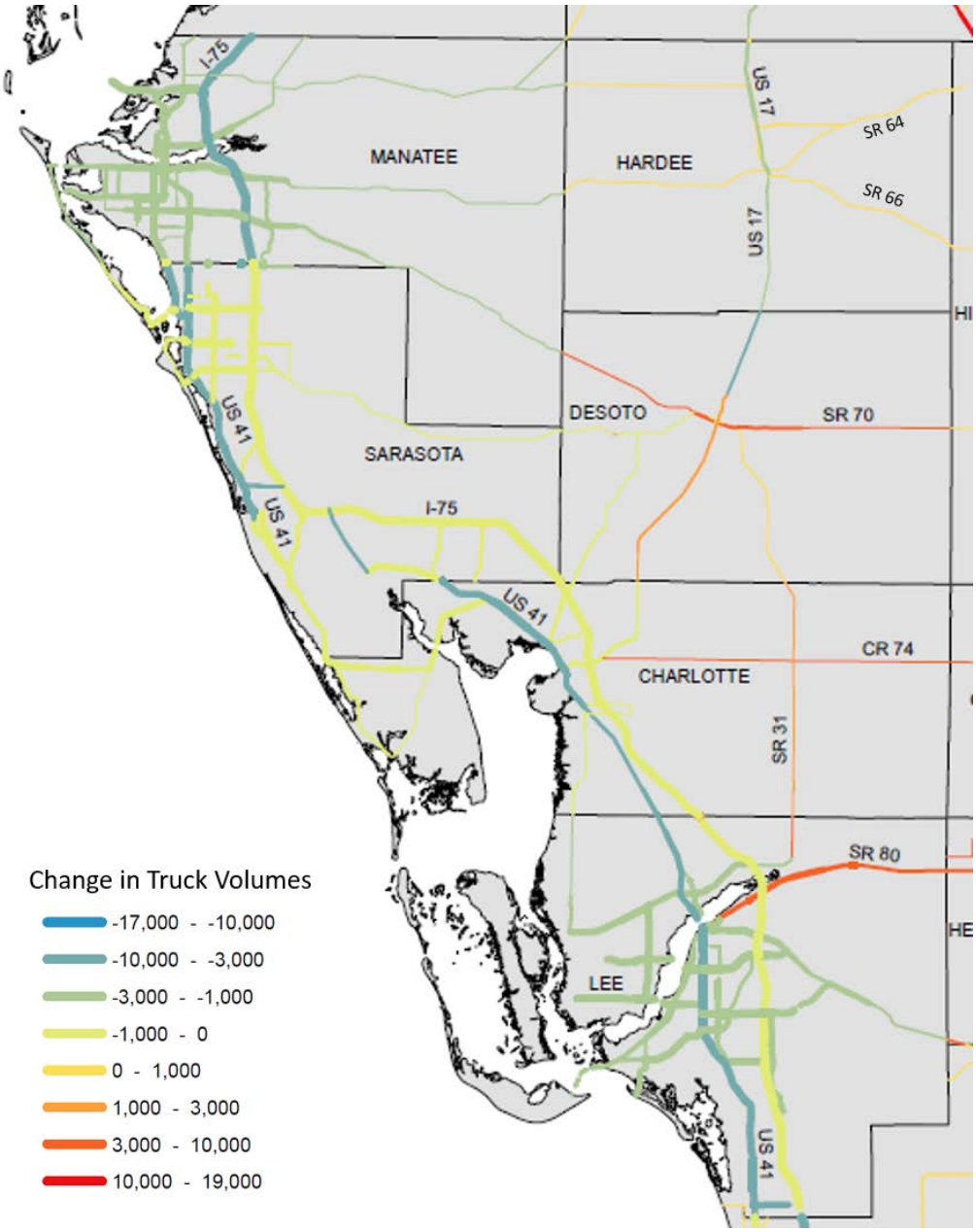
When the counties in District One are categorized into regions, a more granular perspective of the findings is shown. In particular, this perspective allows the identification of impacts of urban development on a set of counties and, in some cases, on individual counties. Some general findings identified by regions within District One include the following:

Coastal Counties (Manatee, Sarasota, Charlotte, Lee; see Figure 9 for the anticipated impacts in year 2035):

- Coastal counties are anticipated to experience less congested networks from agriculture-related traffic due to the movement of agricultural production towards Inland counties.
- West-east roads are anticipated to experience increased volumes since the existing processing plants for agricultural products and the ports in the Coastal counties are not expected to relocate, while the production of agricultural goods will move from the Coastal counties to the Inland counties.

- The road networks in Sarasota and Lee County are anticipated to experience less volumes of trucks carrying agricultural products due to the fact that the counties' agricultural production will be significantly reduced as a result of urban growth.

Figure 9. Changes in Truck Volumes in Year 2035 at Coastal Counties Due to Urban Growth and Encroachment

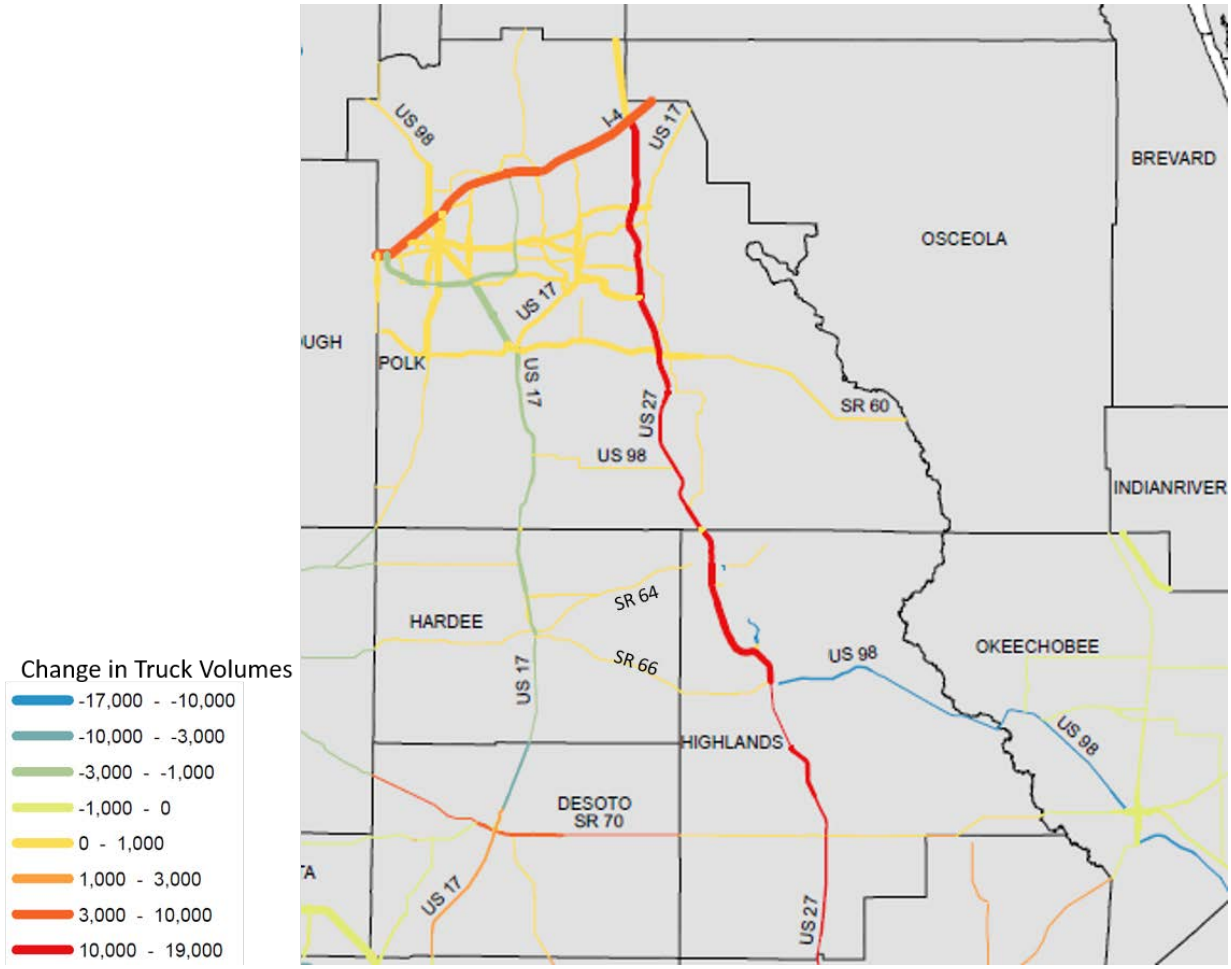


Note: Line thickness depicts 2013 AADT levels, an indication of current road conditions for all vehicle traffic. The thickness of the line is not related to the color displayed on the roads

Northern Inland Counties (Polk, Hardee, DeSoto, Highlands, Okeechobee; see Figure 10 for the forecasted impacts in year 2035):

- There is an anticipated shift of truck traffic related to agricultural products from US-17 to US-27. This change is related to north-south movements of agricultural products destined for the processing plants in Polk County. Since agricultural production will move from Coastal to Inland counties, US-27 represents a more direct route to Polk compared to US-17.
- Little change in truck volumes of agricultural products is forecasted for Okeechobee County since this county is not expected to be a net originator of outbound movements of agricultural production acres nor a net receiver of inbound movements from District One counties.[30]

Figure 10. Changes in Truck Volumes in Year 2035 at Northern Inland Counties Due to Urban Growth and Encroachment



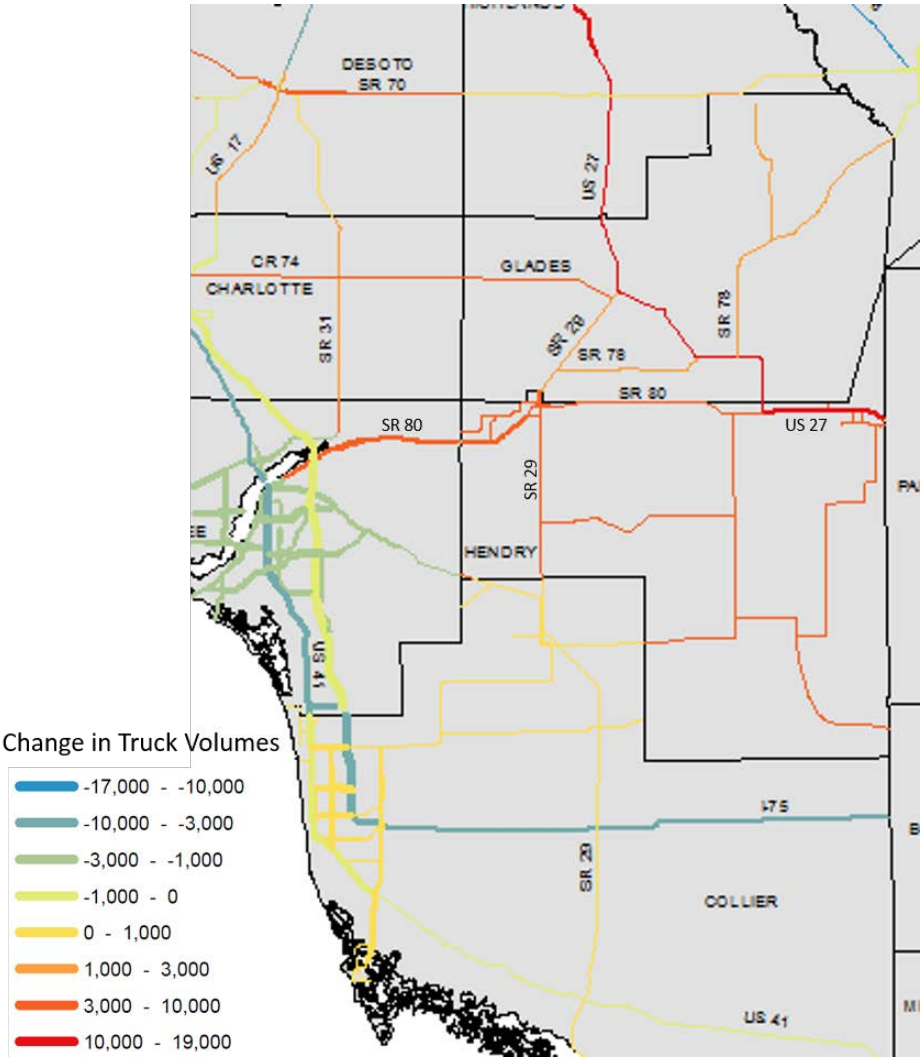
Note: Line thickness depicts 2013 AADT levels, an indication of current road conditions for all vehicle traffic. The thickness of the line is not related to the color displayed on the roads

[30] However, as stated before, agricultural production in Okeechobee is anticipated to increase due to shifts generated by encroachment from urban areas in the East Coast of Florida, but the quantification of these impacts is not part of the scope of this analysis.

Southern Inland Counties (Glades, Hendry, Collier[31]; see Figure 11 for the anticipated impacts in year 2035):

- Most of the agricultural production shifts that result from encroachment are destined for Hendry, so the local road network in that county is anticipated to be impacted with higher truck volumes for agricultural products.
- Collier County is anticipated to be the recipient of some shifted agricultural production from other counties, but its truck volumes are primarily anticipated to decrease slightly due to a net reduction in agricultural production as a result of urban growth in the county.

Figure 11. Changes in Truck Volumes in Year 2035 at Southern Inland Counties Due to Urban Growth and Encroachment



Note: Line thickness depicts 2013 AADT levels, an indication of current road conditions for all vehicle traffic. The thickness of the line is not related to the color displayed on the roads

[31] Note that Collier County fits into the classification of both Coastal and Inland Counties, but it has been placed under the Inland Counties for the purposes of this grouping.

B. Impact of Agricultural Freight Movements on Key SIS Corridors, Connectors and State Roads

The Strategic Intermodal System (SIS) Corridors bear much of the transportation movements through Florida. Table 5 displays SIS roads that may observe large increases in truck volumes somewhere along the roadway due to agricultural shifts. Listed are the estimated increases in truck volumes from changes in agricultural freight movements for year 2035, current truck traffic projections for 2035, and the percent increase in truck traffic from agricultural freight movements.

Table 5. Largest Increases in Heavy Truck Traffic on SIS Corridors from Agricultural Shifts in District One[32]

Road	Counties	Increase in Trucks in Year 2035 from Ag. Freight Shifts	Truck Traffic Projections for Year 2035 Without Ag. Shifts	Percent Increase in 2035 Truck Traffic from Ag. Freight Shifts
US 27	Highlands, Polk, Glades, Hendry	18,442	1,085,092	1.7%
SR 70	DeSoto, Highlands (east of Arcadia)	4,444	180,190	2.5%
SR 80	Hendry, Lee	4,103	200,152	2.0%

Values listed represent annual volumes. Truck traffic projections for year 2035 are interpolated from current 2017 and 2040 truck volume forecasts corresponding to a scenario without agricultural shifts.

The percentage increases reported in the last column of Table 5 are in addition to the underlying growth in truck volumes anticipated for these roads between the years 2013 and 2035. In particular, US 27 is anticipated to increase its traffic by 174 percent, SR 70 by 69 percent and SR 80 by 117 percent during that timeframe. Therefore, these corridors may become more congested from expected agricultural shifts as they continue to serve as the foundation of freight movements in the area.

- As previously mentioned, inland movements will cause a significant amount of truck traffic to move from US 17 to US 27 as their major route north and south. Consequently, more congestion can be expected at intersections along US 27, such as with SR 60 through Lake Wales, SR 64 through Avon Park, SR 66/US 98 in Sebring, SR 70 through Lake Placid, and SR 29 in Glades County.
- In the southwest part of District One, SR 80 runs east-west along the Caloosahatchee River through Hendry County and then Lee County. It connects SR 29 and US 27 in the east to US 41 and I-75 in the west. Southward and inland movements of agriculture will make SR 80 one of the major east-west connecting corridors in the middle of District One. It is one of the largest routes out of Hendry County, and will receive much of the

[32] Roads listed were identified because the analysis yields a relatively large difference in V/C ratios and a large difference in truck volumes for these roads. We consider a large increase as one that comprises part of the top 20% of increases observed. While these roads may be impacted the most by projected shifts in agriculture and freight movement, they may not be the only roads that deteriorate from heavy truck traffic due to agricultural shifts.

freight movements of shifted agriculture in Hendry County. SR 80 also runs just south of the Caloosahatchee River, and serves as the main route for heavy weight trucks to travel around the Caloosahatchee River to a bridge that is appropriate for their size and weight.[33]

- SR 70, the other major east-west connecting corridor, is also expected to experience significant increases in truck traffic. SR 70 spans the width of Florida in the center of District One from Bradenton through Arcadia and Okeechobee, crossing I-75, US 17, US 27, and US 98. Only SR 70 east of Arcadia is currently designated as an SIS corridor.

US 98 is mentioned above in relation to other SIS corridors (though it is not in the SIS), but it is not identified in the data as having large increases in truck traffic. This is due to the scope of this paper, as we did not consider agricultural shifts from counties outside of District One. Coastal counties east of Okeechobee are likely to see inward shifts in agriculture similar to what is projected for coastal District One counties. In this case, forecasted increases in truck traffic on US 98 as well as SR 70, US 441, and SR 78 are likely underestimated. As a result of these agricultural shifts originating in the east of Florida, these roads may become major facility corridors in the transportation network and for the movement of agriculture.

"Emerging SIS corridors" act as major facility connectors, serving connections to larger highways like US 27, US 17, and SR 80.[34] Table 6 displays emerging SIS roads with the largest forecasted increases in truck volumes due to agricultural freight movements (somewhere along its length), with the current truck traffic forecast for 2035 and the percent increase in truck traffic due to agricultural freight shifts corresponding to the road segment(s) with the largest truck volume increase.

Table 6. Largest Increases in Heavy Truck Traffic on Potential Facility Connectors from Agriculture Shifts[35]

Road	Counties	Increase in Trucks in Year 2035 from Ag. Freight Shifts	Truck Traffic Projections for Year 2035 Without Ag. Shifts	Percent Increase in 2035 Truck Traffic from Ag. Freight Shifts
SR 70	DeSoto (west of Arcadia)	6,061	171,152	3.5%
SR 29	Hendry, Glades, Collier	4,175	331,772	1.3%
SR 78	Hendry, Glades	1,705	209,120	0.8%

[33] Notice that our analysis includes some restrictions to truck traffic due to weight limitations, but a more thorough exercise is needed to refine the analysis to a corridor segment level. Additionally, the model used for this analysis did not consider the fastest routes for freight shipping routes, it used a shortest-distance-method. If truck volumes are allocated to small local roads that are semi-parallel to more cost-efficient SIS corridors, the impact of encroachment may be underestimated for SIS corridors.
[34] As identified in FDOT's Freight Mobility & Trade Plan 2016.
[35] Roads listed were identified because the analysis yields a relatively large difference in V/C ratios and a large difference in truck volumes for these roads. While these roads may be impacted the most by projected shifts in agriculture and freight movement, they may not be the only roads that deteriorate from heavy truck traffic due to agricultural shifts.

Values listed represent annual volumes. Truck traffic projections for year 2035 are interpolated from current 2017 and 2040 truck volume forecasts corresponding to a scenario without agricultural shifts.

As in the previous case, the percentage increases reported in the last column of Table 6 are in addition to the underlying growth in truck volumes anticipated for these roads between the years 2013 and 2035. In particular, SR 70 is anticipated to increase its traffic by 46 percent, SR 29 by 294 percent and SR 78 by 169 percent during that timeframe.

The following roads, also described in Table 6, are potential facility connectors that may experience large increases in truck movements from future agriculture shifts:

- SR 70 west of Arcadia, while not yet designated as an SIS corridor, has the potential to be more affected by the shifts in production than the SIS designated portion of SR 70.
- SR 29, south of LaBelle, will act as a facility connector, joining US 27 and SR 80 with I-75 in Collier. It also connects the large farmers market in Immokalee with future agricultural production sites in Hendry and Glades Counties.
- In the southeast part of District One, SR 78 runs along Lake Okeechobee, connecting US 27 and SR 29 in Glades County to SR 70 and US 441 in Okeechobee County. As mentioned above, increases in truck traffic on this portion of SR 78 could be underestimated because of agricultural shifts from the eastern coastal counties of Florida that are not accounted for in this study.

C. Impact of Agricultural Freight Movements on Local Roads

With the shifts in agriculture estimated in this study, smaller county roads will serve to connect major facilities as the flow of freight movement changes. It is anticipated that county roads will experience more heavy truck traffic, leading to congestion and road deterioration, which will put pressure on the transportation of agriculture through Southwest Florida. Table 7 displays local roads with the largest forecasted increases in truck volumes due to changes in freight movements. The percent increase in daily truck traffic due to agricultural shifts and current forecasts of 2035 truck volumes are also listed.

Table 7. Largest Increases in Heavy Truck Traffic on Local and County Roads from Agriculture Shifts[36]

Road(s)	Counties	Increase in Trucks in Year 2035 from Ag. Freight Shifts	Truck Traffic Projections for Year 2035 Without Ag. Shifts	Percent Increase in 2035 Truck Traffic from Ag. Freight Shifts
CR 74	Glades, Charlotte	6,242	108,293	5.8%
CRs 832, 833, 835, 846*	Hendry	3,922	74,167	5.3%

[36] Roads listed were identified because the analysis yields a relatively large difference in VC ratios and a large difference in truck volumes for these roads. While these roads may be impacted the most by projected shifts in agriculture and freight movement, they may not be the only roads that deteriorate from heavy truck traffic due to agricultural shifts.

CR 721	Glades	1,741	39,440	4.4%

**Each county road listed may individually experience the listed increase in truck volume. Values listed represent annual volumes. Truck traffic projections for year 2035 are interpolated from current 2017 and 2040 truck volume forecasts corresponding to a scenario without agricultural shifts.*

Again, the percentage increases reported in the last column of Table 7 are in addition to the underlying growth in truck volumes anticipated for these roads between the years 2013 and 2035. In particular, CR 74 is anticipated to increase its traffic by 50 percent and CR 721 by 50 percent during that timeframe. CRs 832, 833, 835 and 846 did not handle truck traffic in 2013 and therefore an estimation of percentage growth is not applicable.

Several county roads in Glades and Hendry are expected to see significant increases in truck volumes due to the shifts in agriculture. Since there is a limited state transportation network in these counties, the burden falls on the local and county roads to accommodate the influx of agriculture and heavy freight truck movements.

- County Road 74 runs east-west from Charlotte County to Glades County, connecting US 17 and US 27. With expected agriculture shifts inland and south, this road may provide another necessary west-east artery, connecting suppliers with the processing and packaging plants that remain along the coast. It could become a significant SIS facility connector through the District as it accommodates new truck routes for shifted agriculture.
- CR 833, 835, 846, and 832 generally run through the center of Hendry County in various directions. They connect potential agricultural sites in Hendry to US 27, SR 80, and SR 29, providing the first link in the transportation network chain, and all are expected to experience considerable increases in heavy truck traffic. County Roads 833 and 846 are positioned particularly well for becoming facility connectors, because CR 833 runs generally north-south from US 27 to I-75, and CR 846 runs from the center of Hendry to Immokalee in Collier County.
- In Glades County, County Road 721 runs north-south through the Brighton Reservation from SR 70 to SR 78, and will serve future potential agricultural sites that may locate in Glades County.

Since these roads are maintained by local county crews and are not built to accommodate significant heavy truck traffic, we can expect that all these roads will deteriorate faster than usual due to the increased heavy truck traffic volumes.

D. Potential Future Hubs for Freight Movement

The data produced by the analysis shows that there is significant freight movement through Hendry County (among others), as agriculture moves south and inland. Most notably, it appears that truck traffic on US 17 shifts to US 27 with agriculture shifts inland. Towns like LaBelle in the north part of Hendry and Moore Haven in Glades, and towns along US 27 north of Palmdale near the major state highway interchanges will be the focus on this ongoing shift. These towns will be prime sites for future processing plants, packaging houses, or other agricultural production development to streamline the supply chain process through Southwest Florida.

Immokalee on SR 29 in Collier County is already a functioning hub for agriculture with a large farmers' market attracting many suppliers. Based on the analysis of agricultural shifts and possible main truck routes, Immokalee is likely to grow into an even larger freight distribution and processing hub for Southwest Florida as agricultural production shifts due to expanding urban footprints.

E. Bridge Restrictions and Routing of Freight Movements

This study acknowledged that bridges are a potential bottleneck for agricultural freight movements. A cursory analysis of restricted bridges on the State Highway System in District One was performed to demonstrate future possible limitations and constraints on freight movements, especially in the case of county roads. There are many bridges not built to handle overweight freight trucks, and freight approved bridges crossing the Caloosahatchee River (I-75 in Fort Myers and US 27 in Moore Haven) and other waterways in Hendry, Collier and Glades County may experience more congestion due to the higher volume of freight traveling to and from Hendry and Collier counties. The state designates and publishes weight restrictions for bridges on state-owned roads. Such restricted bridges include, but are not limited to[37]:

- US 27 bridge over Fish Eating Creek, near Palmdale, just north of the connection between SR 29 and US 27 (restricted bridge number 050046).
- SR 31 bridge (Wilson Pigott Bridge) across the Caloosahatchee River, connecting SR 80 and SR 78 in Lee County (restricted bridge number 120064).
- SR 80 bridge across Billy's creek in Fort Myers, Lee County, east of the intersection with US 41 (restricted bridge number 120001).
- SR 29/Bridge Street in LaBelle across the Caloosahatchee River in Hendry County (restricted bridge number 070033).
- US 98 across the Kissimmee River at the border of Highlands and Okeechobee County (restricted bridge number 090016).
- US 41 across Faka Union Canal in Collier County west of the intersection of SR 29 (restricted bridge numbers 030062 and 030063).

This is not a comprehensive list of bridge restrictions in the District,[38] but identifies the bridges that may be problematic for agricultural freight movements. Detours around these bridges may be costly and operationally inefficient. There are very few bridges capable of handling overweight loads; therefore, bottle necks may occur along these routes. All the bridges west of the Wilson Pigott Bridge on SR 31 in Lee County have various restrictions from operational to physical, and therefore are impractical for use by trucks hauling agriculture loads. All the bridges over the Caloosahatchee River are currently restricted to overweight loads with the exception of the US 27 Bridge in Moore Haven. The SR 29 Bridge in LaBelle is currently scheduled for a maintenance upgrade to increase the load rating capacity of that bridge in the spring/summer of

[37] See http://www.fdot.gov/maintenance/STR/OWODP/Weight%20Restrictions%20Charts%20(2016-11-10).pdf for more details on bridge restrictions.
[38] For a complete list of bridge restrictions on state-owned roads, refer to http://www.fdot.gov/maintenance/OWODPermits.shtm.

2018. The bridge over the Kissimmee River on US 98 in Okeechobee County and many bridges crossing the canals in eastern Collier County all require even longer detours than the ones noted above.

Further, county roads incorporate several bridges that span waterways, ditches, and canals. As agriculture moves inland, these roads will serve an increasing level of truck traffic, while potentially being ill-equipped for it. There is no readily available inventory for bridge restrictions on county-maintained roads in Glades, Collier (in particular on the eastern portions of the county) Charlotte, nor Hendry. Additionally, bridge weight restrictions may not be posted on the roads themselves. This becomes a risk for freight shippers, as truck drivers are left to make decisions on acceptable freight routes on a case-by-case basis with inadequate information to do so. It is anticipated that the county bridges may be especially susceptible to wear from future increases in heavy truck traffic, because they were not initially constructed to withstand high levels of such traffic. As agriculture shifts occur, more official assessment of the weight and capacity limits of roads and bridges at the county level is warranted.

F. Usefulness of Study in Other Freight Planning Efforts

A final consideration of this study is its potential usefulness for other freight planning activities in the District. In particular, the incorporation of changes to land use and travel forecasts in the region is considered through a high-level review of the District's Travel Demand Model.

The Travel Demand Model for District One has a Heavy Truck Traffic (HTT) component to predict truck traffic flows for the regional road network. The HTT component for District One is derived from the Statewide HTT Model and actually mimics the volumes found at the statewide level. In other words, the HTT component for D1 is a pre-load of the origin-destination volumes generated by the Statewide HTT Model and therefore consists of static assignments that are added to the volumes generated by other vehicle types in D1's Travel Demand Model to generate total traffic moving through the network.

By virtue of being a pre-load, D1's HTT component does not take into account changes to land use to generate future truck volumes. Therefore, the information generated in this study (in particular the O-D matrices for future years) could be used to adjust the pre-loaded future truck volumes to reflect the changes related to shifts in agricultural production location due to encroachment. However, further refinements outside of the scope of this study would need to be made to identify the specific traffic analysis zones (TAZs) within each county to which the changes to truck volumes should be applied. This is a result of the fact that our analysis used information at the county-level on origins and destinations of truck traffic while the HTT component requires more specific locations within each county to make the appropriate traffic assignments.

Finally, an updated version of the HTT component is under development and therefore the information generated by our analysis could be considered as a way to introduce (at a very high level and for a very specific type of commodity) the impact of changes in land use on the transportation network.

5. Conclusion

As a result of the analysis conducted in this study, the following conclusions were reached:

- Coastal counties are projected to experience significant population growth, and some of the agriculture currently located there will shift south and inland. Polk will likely remain a large hub for distribution and agricultural production.
- Inland and southward shifts in agriculture will translate to shifts of truck traffic from US 17 to US 27 as the main north-south corridor, and will lead to a higher dependence on east-west corridors and facility connectors, linking new agriculture production locations to distribution centers, processing plants, and markets in and beyond Polk County and the coastal counties.
- County roads in Hendry and Glades Counties (and potentially in Collier and Okeechobee as well) will serve to connect major facilities as the flow of freight movement changes. This analysis projects that county roads will experience more heavy truck traffic, leading to congestion and road deterioration, which could be an obstacle to the efficient transportation of agricultural goods through Southwest Florida.
- With the changes in freight movement patterns, it is likely that local towns along the new routes will grow to match the new freight activity and traffic levels. Areas along US 27 in Glades and Highlands, and towns in the north of Hendry County have the potential to develop large distribution centers and processing plants. Immokalee, already a center for agriculture, will continue to grow into a significant hub of agricultural freight movement in Southwest Florida.
- Agricultural shifts will transfer a majority of freight movements from major roads in the northern and coastal counties of District One to the southern and inland counties, where county roads are less equipped to handle the heavy truck traffic. Specifically, weight restrictions on county road bridges in these areas will constrain freight shipments and affect the routing of agricultural goods movements. This may exacerbate the deterioration of the weaker components of the transportation network in District One.
- The results of this analysis could be included in future updates of the Statewide Heavy Truck Traffic (HTT) Model to account for the impact on the transportation network from changes in land use across the State in response to population growth. Once those changes are made at the statewide level, they would “flow down” to the District One level since the District’s Travel Demand Model consists of a pre-load of future truck volumes generated by the Statewide Model. Further analysis would be required for proper assignment of the impacts to the corresponding geographical levels within D1, specifically concerning the identification of areas (TAZs) within counties where truck volumes should be applied. Though this information is only useful for agricultural goods, the impact on the overall network may still prove significant.

Appendix

A. Additional Information for Tables 5, 6, 7: Truck Traffic Volumes for Year 2035

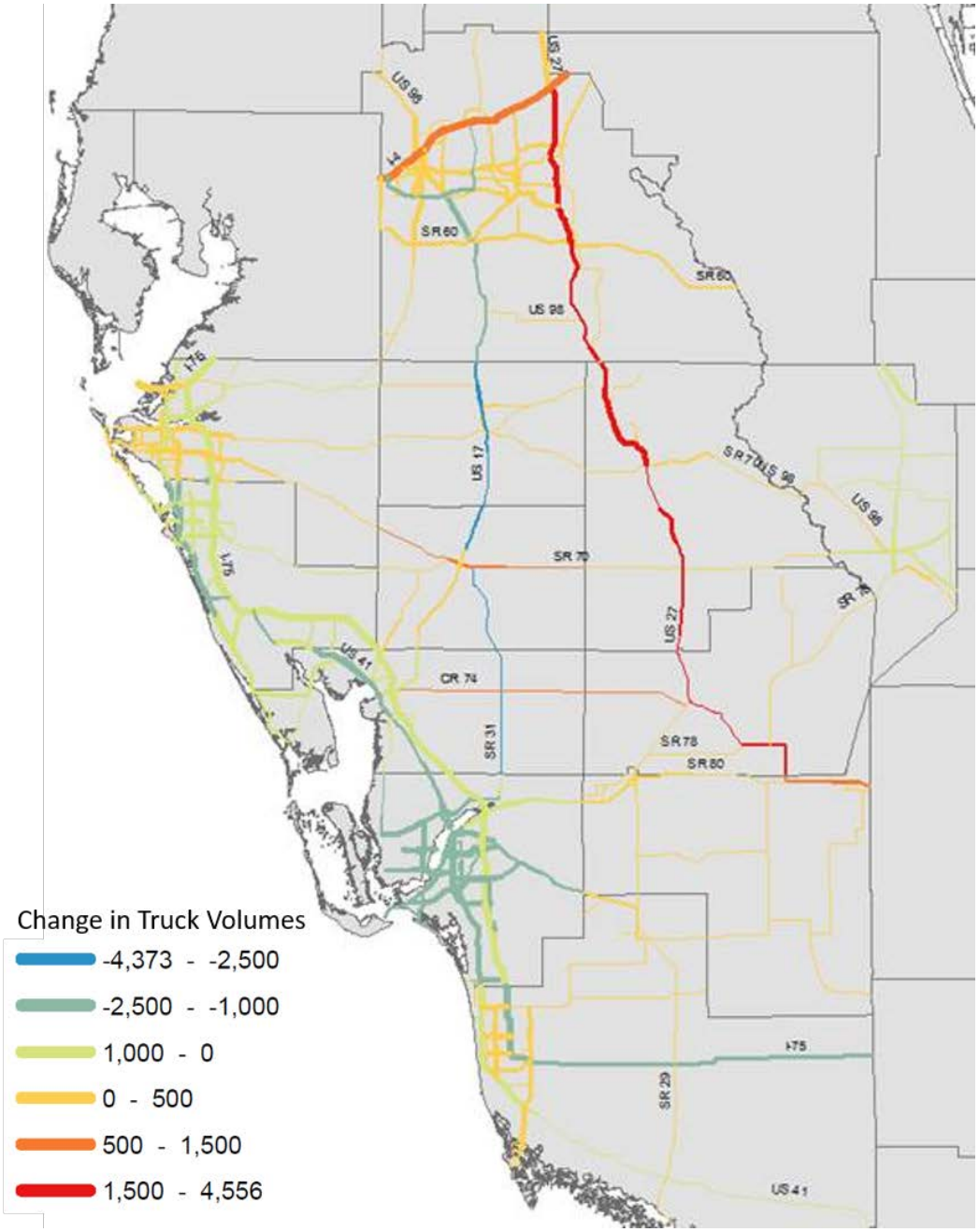
The analysis conducted as part of this study estimates increases in traffic volumes for key roads of the District One transportation network at the segment level. However, the values displayed in Tables 5, 6, and 7 only represent a handful of the segments on any given road. The roads presented in these summary tables were selected because somewhere along their length one or more segments displayed a significant increase in truck volumes resulting from shifts in agricultural freight movements. The definition of “significant increase” means that the listed segment was in the top 20% of all segments after all segments were sorted by truck traffic growth. In some cases, information that combines several segments of a single road are presented in Tables 5, 6 or 7, so the values presented there should be taken only as an indication of the increases that may be experienced along the particular road listed. Results for the entire length of the roads listed in these tables would require combining the information produced in this study with a travel demand model for the District, which is outside of the scope of this study.

The increases in truck volumes due to freight movement shifts presented in these tables are compared to estimates of forecasted 2035 truck traffic that do not consider land use changes and agricultural shifts. In particular, the numbers presented under the “Truck Traffic Projections for Year 2035 Without Ag Shifts” column in Tables 5, 6, and 7 represent truck volumes for 2035 (truck AADT) developed using a high-level analysis of the latest forecast from the Florida Statewide Model (FLSWM). The forecast of truck volume data for year 2040 (from the FLSWM) and current 2017 truck AADT were used to extrapolate 2035 truck traffic levels. The 2040 forecast from the FLSWM is representative of truck traffic in the “current status-quo” situation. In other words, it accounts for future additions and improvements to the transportation network and population growth in terms of number of vehicles on the network rather than the expansion of urban footprints and encroachment on agriculture that this study addresses. Finally, a factor of 250 was used to scale AADT (daily traffic) up to annual levels.

B. Modeled Changes in Truck Volumes from Agricultural Freight Movements

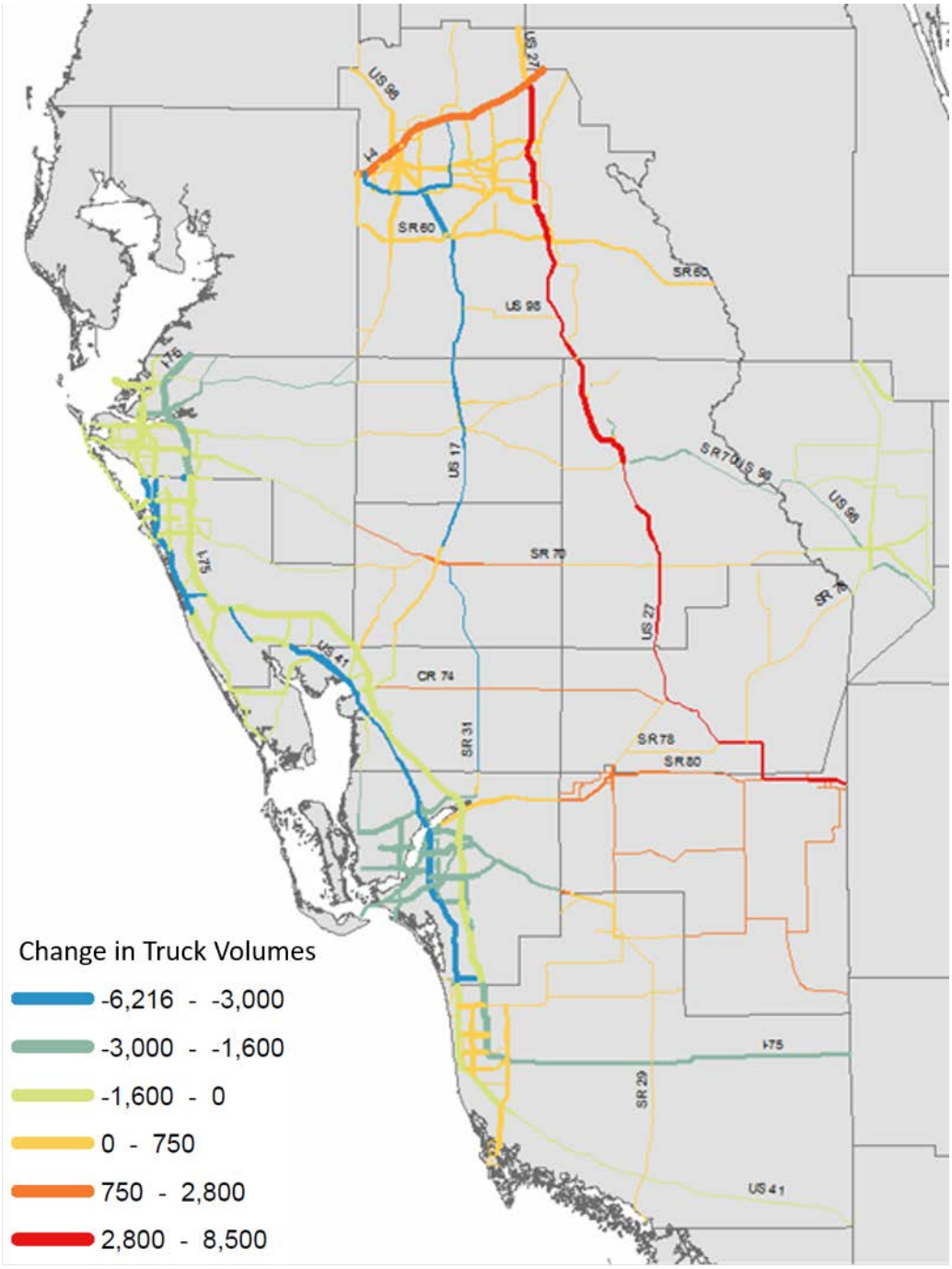
All the line thicknesses displayed below represent 2013 AADT for the corresponding road segment. Also, the thickness of the line is not related to the color displayed on the roads.

Figure 12. Forecasted Changes in Truck Volumes in Year 2020 Due to Urban Growth and Encroachment (in number of trucks)



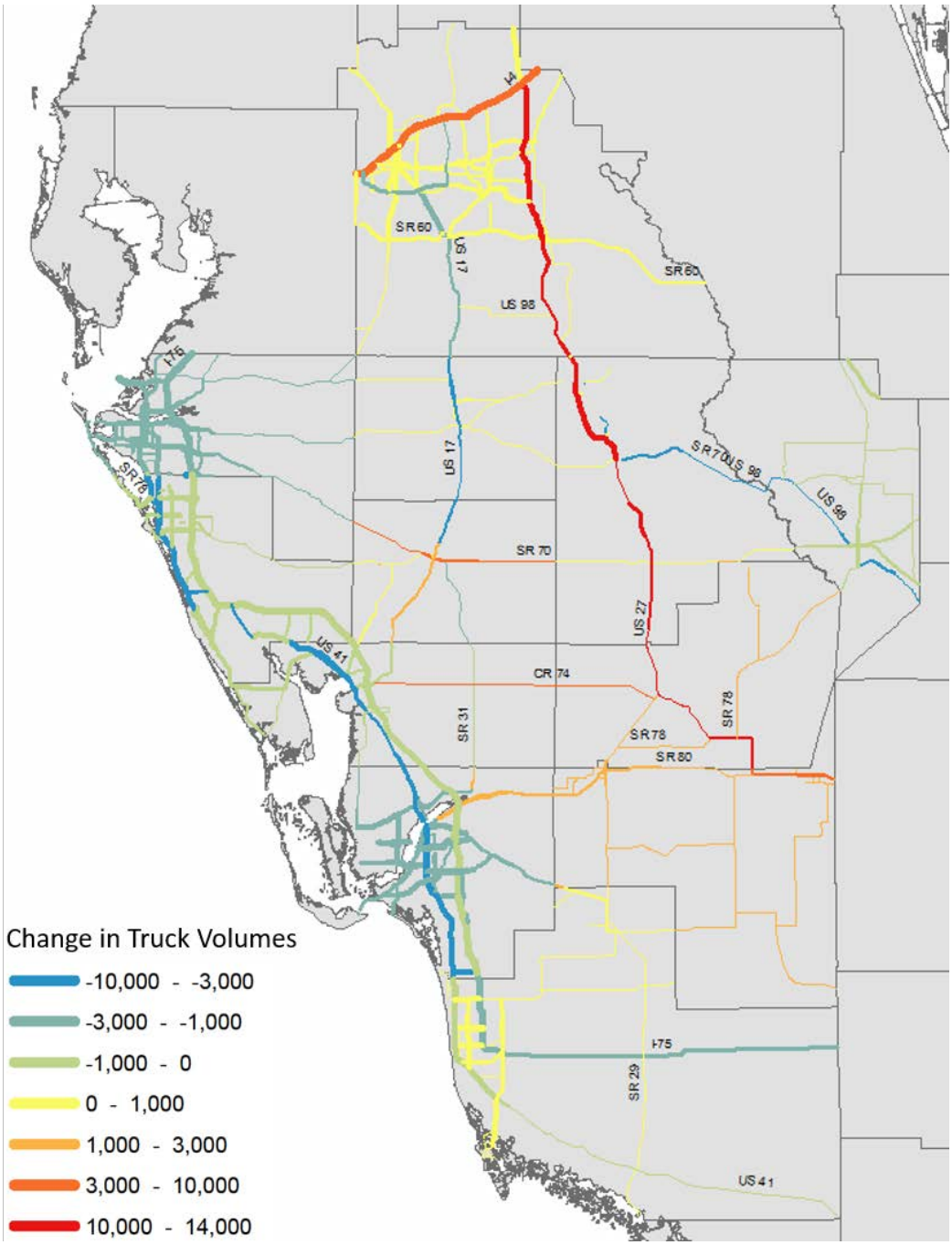
Note: Line thickness depicts 2013 AADT levels, an indication of current road conditions for all vehicle traffic. The thickness of the line is not related to the color displayed on the roads

Figure 13. Forecasted Changes in Truck Volumes in Year 2025 Due to Urban Growth and Encroachment (in number of trucks)



Note: Line thickness depicts 2013 AADT levels, an indication of current road conditions for all vehicle traffic. The thickness of the line is not related to the color displayed on the roads

Figure 14. Forecasted Changes in Truck Volumes in Year 2030 Due to Urban Growth and Encroachment (in number of trucks)



Note: Line thickness depicts 2013 AADT levels, an indication of current road conditions for all vehicle traffic. The thickness of the line is not related to the color displayed on the roads

Table 8. Partial O-D Matrix Representing Agricultural Goods Movement Within D1 Counties Only, 2035 (in number of truck trips)

O (row) / D (col)	Charlotte	Collier	DeSoto	Glades	Hardee	Hendry	Highlands	Lee	Manatee	Okeechobee	Polk	Sarasota	TOTAL
Charlotte	6	92	46	7	25	50	49	133	154	21	872	48	1,501
Collier	124	66	147	22	80	162	156	427	495	68	2,807	153	4,707
DeSoto	166	395	94	30	107	218	210	573	664	91	3,769	206	6,523
Glades	204	486	243	0	131	267	258	705	817	112	4,632	253	8,107
Hardee	124	294	147	22	8	162	156	427	495	68	2,806	153	4,862
Hendry	637	1,517	759	114	410	39	804	2,200	2,549	349	14,461	789	24,628
Highlands	204	486	243	36	131	267	28	704	816	112	4,628	253	7,907
Lee	38	90	45	7	24	50	48	46	151	21	858	47	1,423
Manatee	152	362	181	27	98	199	192	525	383	83	3,449	188	5,839
Okeechobee	26	62	31	5	17	34	33	91	105	6	595	32	1,038
Polk	296	706	353	53	191	388	374	1,023	1,186	162	462	367	5,561
Sarasota	3	7	4	1	2	4	4	10	12	2	67	3	117
TOTAL	1,980	4,564	2,293	323	1,222	1,840	2,310	6,864	7,826	1,094	39,407	2,491	

Table 9. Partial O-D Matrix Representing Agricultural Goods Movement Outside of D1 Counties Only (by County of Exit), 2035 (in number of truck trips)

O (row) / D (col)	Charlotte	Collier	DeSoto	Glades	Hardee	Hendry	Highlands	Lee	Manatee	Okeechobee	Polk	Sarasota	TOTAL
Charlotte	0	2,287	0	0	0	0	0	0	1,525	0	3,812	0	7,624
Collier	0	7,360	0	0	0	0	0	0	4,907	0	12,267	0	24,535
DeSoto	0	9,881	0	0	0	0	0	0	6,587	0	16,468	0	32,935
Glades	0	0	0	0	0	12,143	0	0	0	0	28,334	0	40,478
Hardee	0	7,357	0	0	0	0	0	0	0	0	17,166	0	24,522
Hendry	0	0	0	0	0	37,911	0	0	25,274	0	63,185	0	126,369
Highlands	0	0	0	0	0	0	0	0	0	32,356	8,089	0	40,445
Lee	0	2,249	0	0	0	0	0	0	1,499	0	3,749	0	7,497
Manatee	0	9,043	0	0	0	0	0	0	6,028	0	15,071	0	30,142
Okeechobee	0	0	0	0	0	0	0	0	0	4,159	1,040	0	5,199
Polk	0	0	0	0	0	0	0	0	0	47,018	11,754	0	58,772
Sarasota	0	176	0	0	0	0	0	0	117	0	293	0	585
TOTAL	0	38,352	0	0	0	50,054	0	0	45,938	83,533	181,227	0	