Mobility interventions to protect supply chain workers during pandemics

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Objectives

Truck Parking (rest stop) supply

- identify long-haul HCV rest stop parking locations
- Classify HCV parking locations
- Estimate total (legal) parking supply

Connect rest stops with distribution centers

- Identify major distribution centers (DCs)
- Link observed trips between rest stops and DCs
- Prioritize rest stops for resources during a pandemic

Background

TRANSPORTATION

From closed rest areas to drive-thru testing limitations, truck drivers face rough road during coronavirus pandemic

By Mary Wisniewski
Chicago Tribune • Jun 24, 2020 at 2:10 pm

Truck driver Brenda Echols of JKC Trucking Inc. at Summit Cold Storage in Summit, May 15, 2020. Echols drives between Illinois and Texas. (Antonio Perez / Chicago Tribune)

Background

- **Fatigue** is cited as a contributing factor to freight collisions.
- **Hours of Service (HOS) Laws** have been enacted with the intent of reducing driver fatigue.

- **Electronic Logging Device** mandates:
  - The United States began mandating **ELDs** in 2017
  - Canada implemented a similar **ELD** mandate in 2021; enforcement expected in June 2022

Sources: (National Academies of Sciences, Engineering, and Medicine, 2016), (Government of Canada, 2009), (Federal Motor Carrier Safety Administration, 2016), (The American Transportation Research Institute, 2017), (Government of Canada, 2017); Image Source: https://www.garyakesslerlaw.com/auto-accidents/big-rig-truck-tractor-trailer-accidents/

Background

Caledon illegal trucking operator hit with $1M fine

PREFERRED REGION Latest News

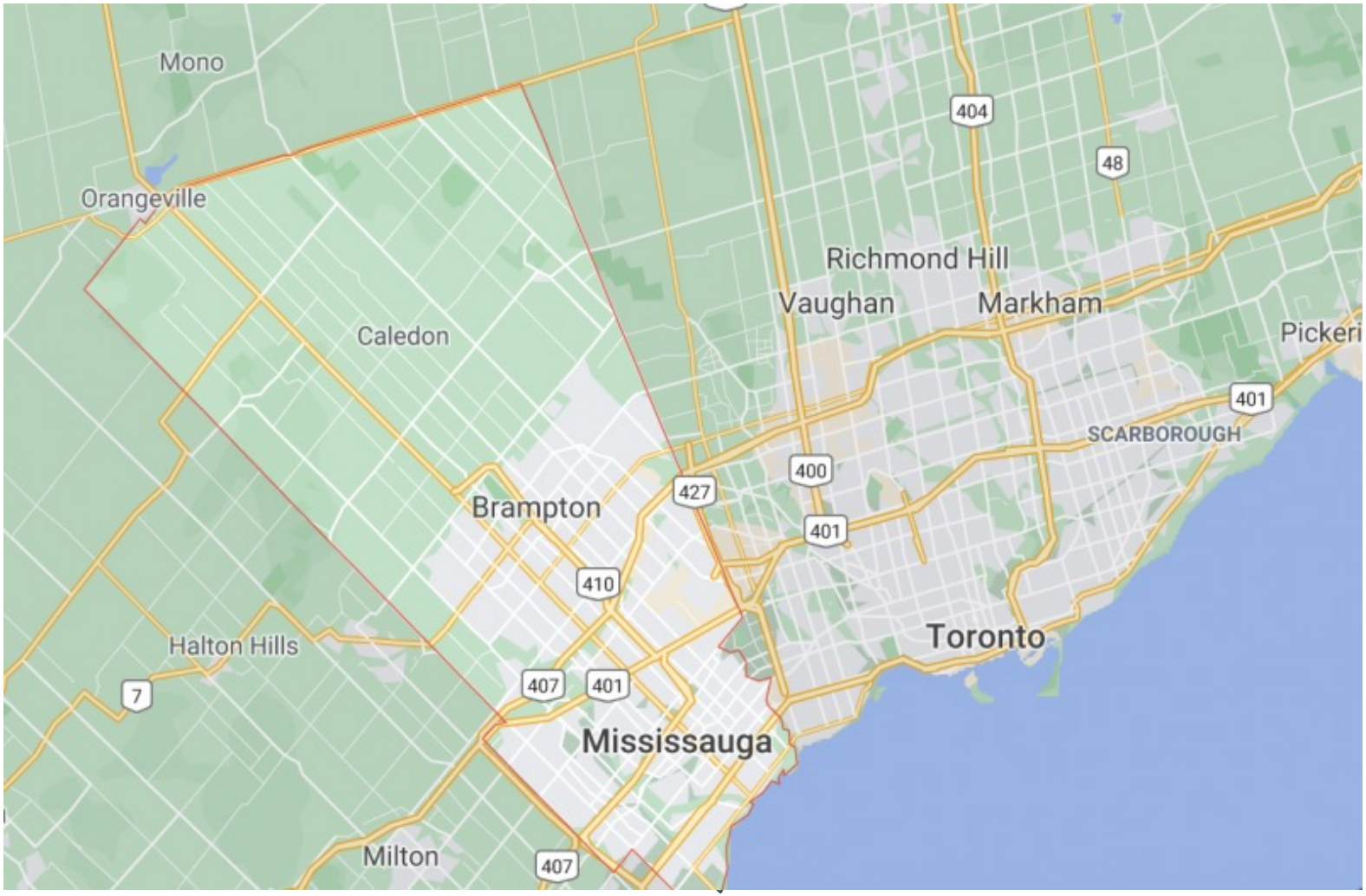
By Ryan Rumbolt
Published December 10, 2021 at 5:09 pm

Identify Parking Locations

- **Truck GPS data** for 2014 was used to identify long-haul HCV stop locations:
  - ~27 million stop events
  - ~3.3 million trips in North America

- Rest stops are identified when a vehicle is stopped for 2 hours or longer in the middle of a trip

Parking Activities: Region of Peel



Classification Scheme

Notable Truck Parking Characteristics:

1. **Legality** – is a parking space legal or unauthorized?
2. **Accessibility** – is a parking space open or limited access?
3. **Ownership** – is a parking space publicly or privately owned?
4. **Dedication** – is parking the dedicated function of the location?
5. **Roadside** – is the parking space a roadside?

Classification Scheme

Authorized Parking Locations

① Public Rest Areas and Gas Stations

② Weigh Stations

③ Open Access HCV Parking

④ Limited Access HCV Parking

⑤ Authorized Roadside Parking

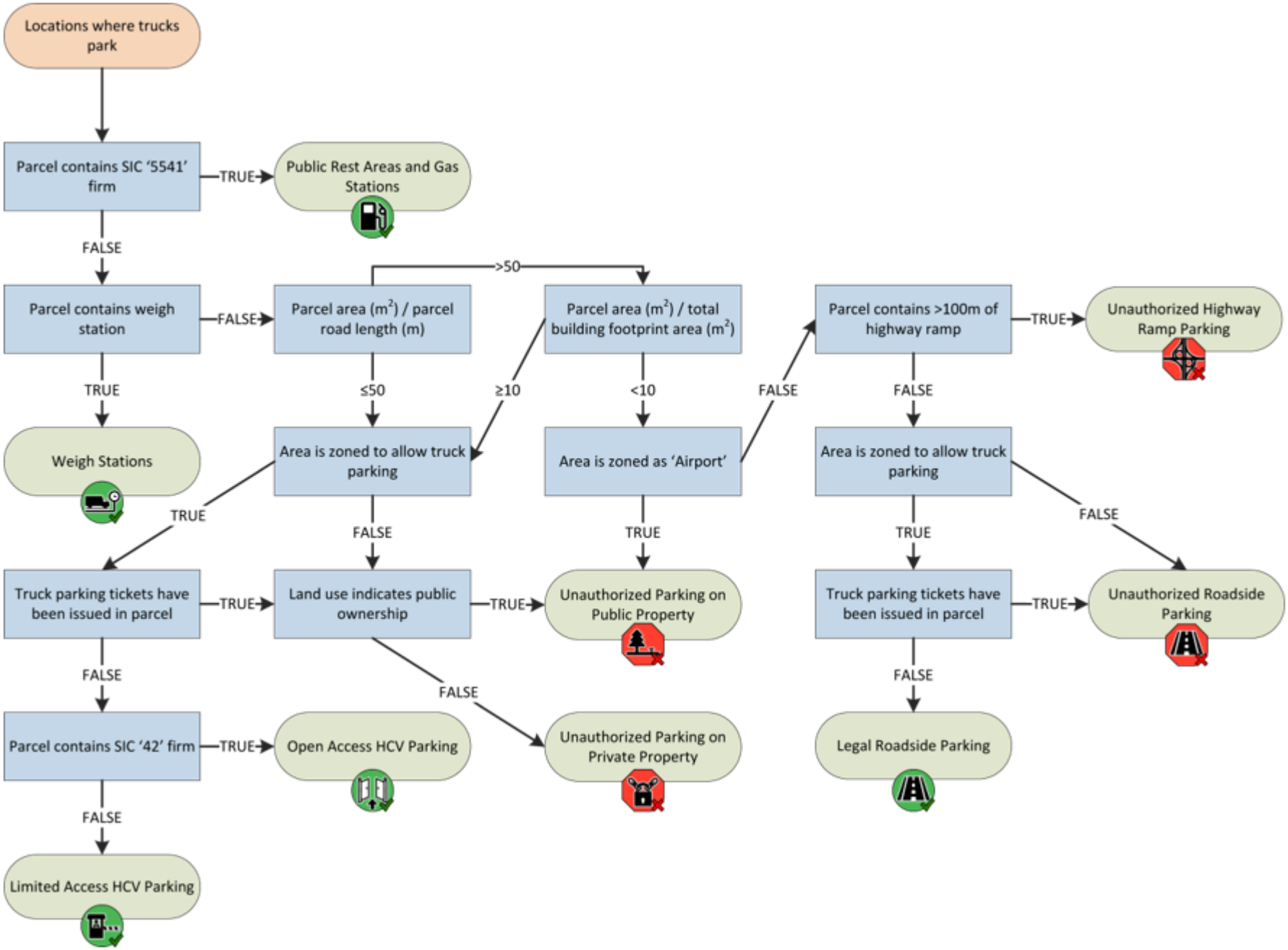
Unauthorized Parking Locations

⑥ Unauthorized Roadside Parking

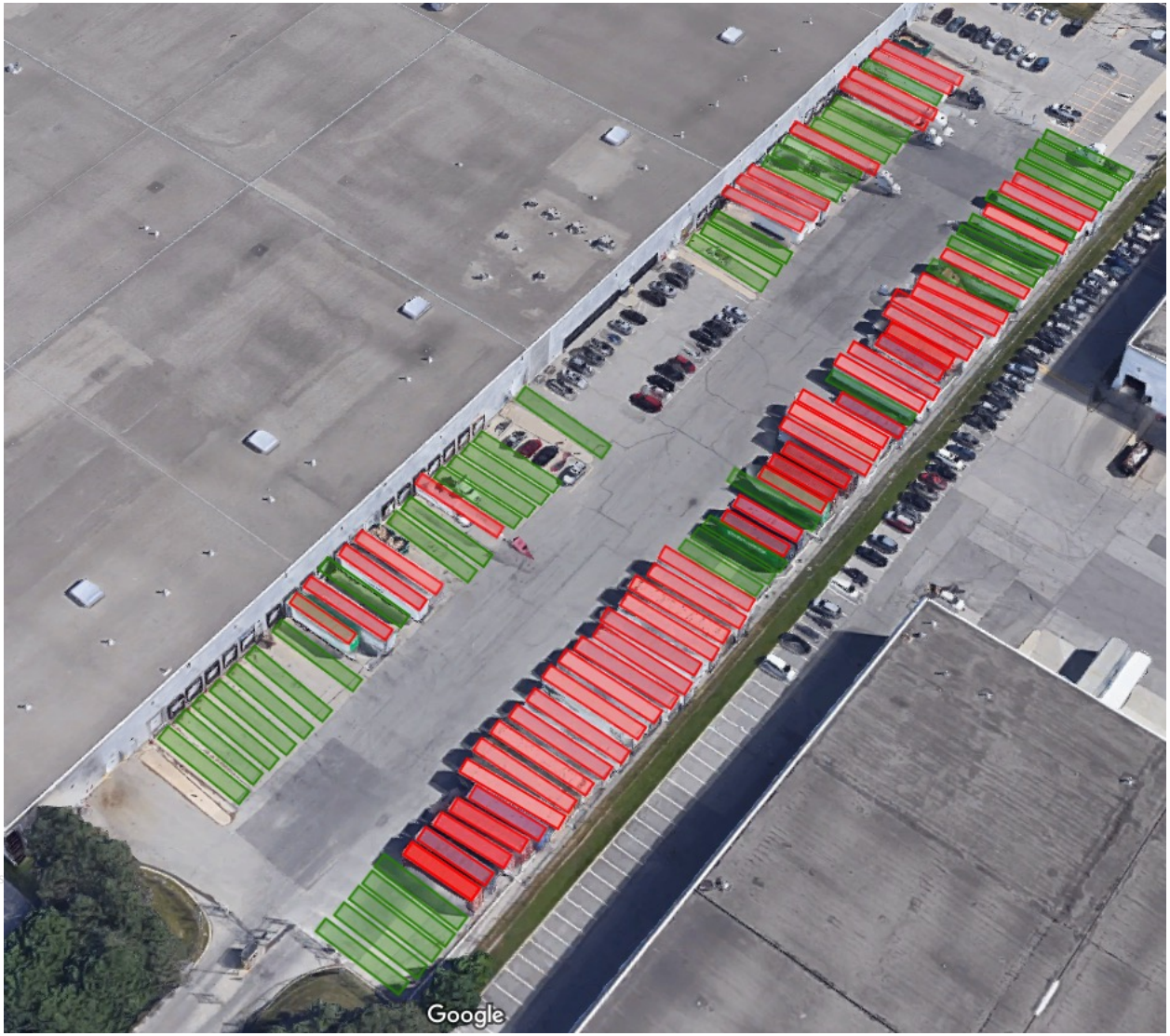
⑦ Unauthorized Highway Ramp Parking

⑧ Unauthorized Parking on Public Property

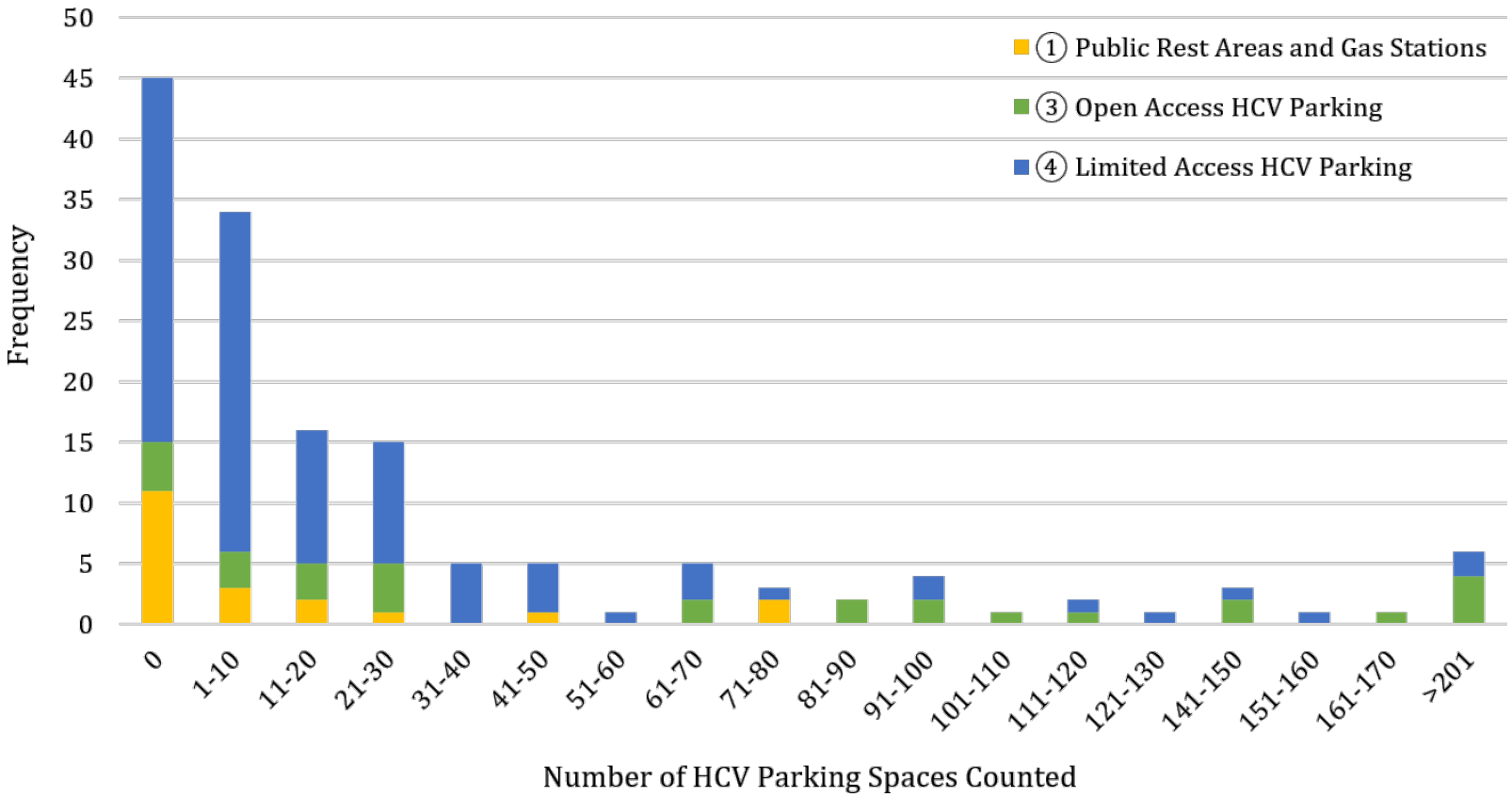
⑨ Unauthorized Parking on Private Property


Locations where trucks park
Parcel contains SIC '5541' firm
TRUE
Public Rest Areas and Gas Stations
FALSE
Parcel contains weigh station
FALSE
Parcel area (m²) / parcel road length (m)
>50
Parcel area (m²) / total building footprint area (m²)
Parcel contains >100m of highway ramp
TRUE
Unauthorized Highway Ramp Parking
TRUE
≤50
≥10
<10
FALSE
FALSE
Weigh Stations
Area is zoned to allow truck parking
Area is zoned as 'Airport'
Area is zoned to allow truck parking
TRUE
FALSE
TRUE
TRUE
FALSE
Truck parking tickets have been issued in parcel
TRUE
Land use indicates public ownership
TRUE
Unauthorized Parking on Public Property
Truck parking tickets have been issued in parcel
TRUE
Unauthorized Roadside Parking
FALSE
FALSE
FALSE
Parcel contains SIC '42' firm
TRUE
Open Access HCV Parking
Unauthorized Parking on Private Property
Legal Roadside Parking
FALSE
Limited Access HCV Parking

HCV Parking Supply



Parking Supply – Manual Counting



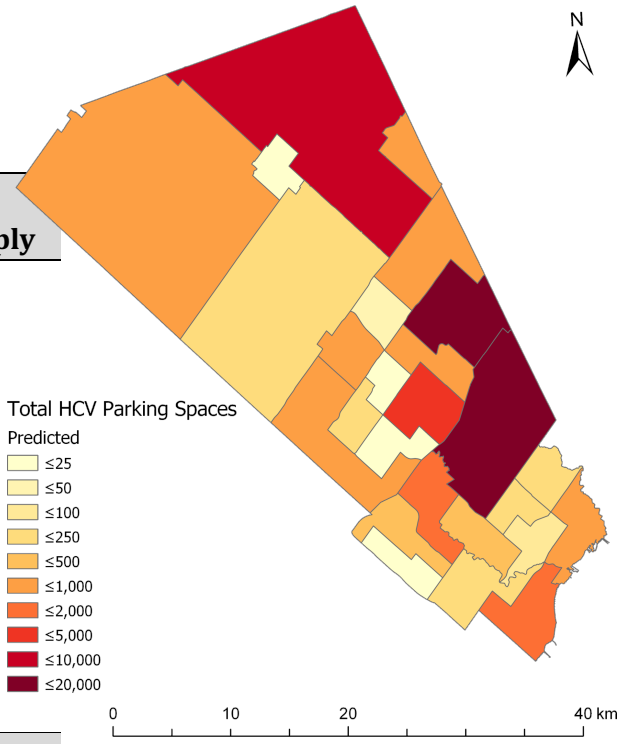
Parking Supply – Model Results

Variable	Negative Binomial						Zero-Inflated Negative Binomial					
	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	β	p	β	p	β	p	β	p	β	p	β	p
Intercept	1.49	<0.001***	2.27	<0.001***	0.89	0.014**	2.07	<0.001***	2.76	<0.001***	1.77	<0.001***
$Perimeter_i$	1.96	<0.001***			2.19	<0.001***	1.56	<0.001***			1.62	<0.001***
$Rural_i$			1.48	0.051**	−0.35	0.659			2.25	<0.001***	0.87	<0.001***
$Perimeter_i \times Rural_i$	−2.63	0.001***					−1.91	<0.001***				
$Area_{paved,i}$			53.04	<0.001***	82.90	0.005***			38.25	<0.001***	40.32	<0.001***
$Perimeter_i \times Area_{paved,i}$					−49.46	0.025**					−20.67	<0.001***
$Class_{open,i}$	1.02	0.006***	0.57	0.139	0.60	0.111	0.97	<0.001***	0.54	<0.001***	0.67	<0.001***
$Class_{rest,i}$	−0.12	0.781	−0.44	0.322			0.50	<0.001***	0.10	0.184		
$IND_{59,i}$	−2.13	0.007***	−2.17	0.006**	−2.04	0.009***	−1.80	<0.001***	−2.17	<0.001***	−1.98	<0.001***
Zero-Inflated Variables												
Intercept							0.14	0.664	0.32	0.923	0.11	0.744
$Area_{paved,i}$							−163.07	0.003***	−124.72	0.005***	−156.99	0.004***
$Perimeter_i \times Area_{paved,i}$							68.40	0.051*	69.31	0.024*	37.76	0.055*
Data												
Removed Outliers	3		1		2		3		1		2	
n	127		129		128		127		129		128	
k	5		5		6		5 + 2		5 + 2		6 + 2	
df	121		123		121		118		120		118	

(***), (**), (*) represent statistical significance to 99%, 95%, or 90% respectively

Parking Supply – Model Estimates

City of Mississauga		City of Brampton		Town of Caledon	
TAZ	Estimated Supply	TAZ	Estimated Supply	TAZ	Estimated Supply
1	736	1	16	1	523
2	1,242	2	792	2	216
3	187	3	3,931	3	0
4	165	4	0	4	7,423
5	19,588	5	195	5	886
6	259	6	939		
7	90	7	973		
8	136	8	10,067		
9	449	9	37		
10	0	10	645		
11	1,206				
Total	**24,058**	**Total**	**17,594**	**Total**	**9,049**
Region of Peel Total: 50,701					



Prioritization of Rest Stops

- GPS data is used next to identify trips between overnight rest stops and distribution centers (DCs)

GPS Data Statistics

- GPS Data in the Region of Peel
  - obtained from Transport Canada and the Smart Freight Centre

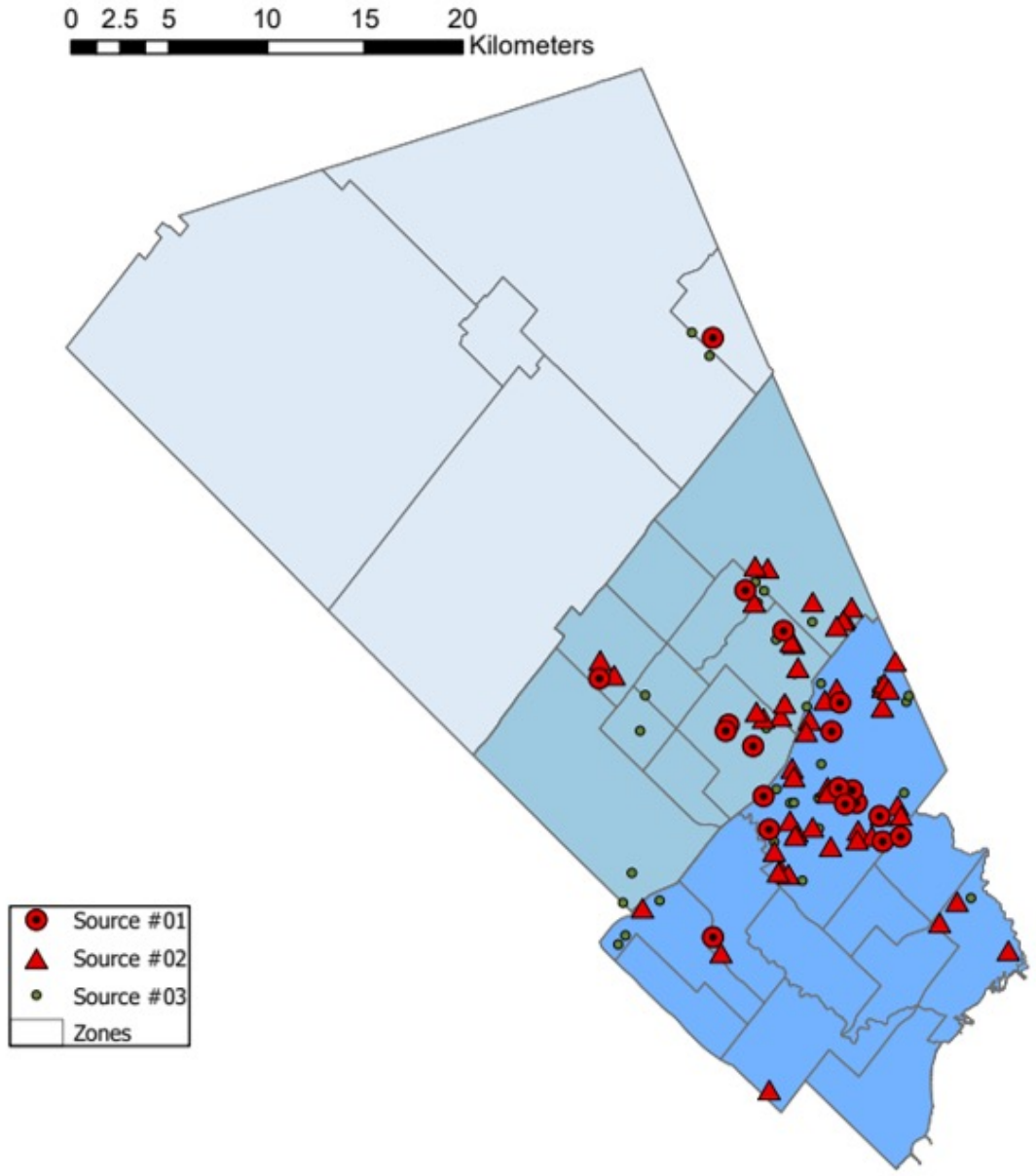
Description	1st dataset received	2nd dataset received
Time Frame	February 1, 2020 to July 31, 2020	January 1, 2019 to Dec 31, 2019
Raw data file size	109,372,246 data records	50,415,327
Data fields	Truck ID, date/time, latitude, longitude	Truck ID, date/time, latitude, longitude
Study Area	Region of Peel	Region of Peel
Number of unique trucks (based on power ID)	117,537	43,736

- Trips identified for trucks:
  - resting overnight for at least 2 hours: 9 pm to 6 am period
  - Traveling to a distribution center (DC) in the morning

Identifying Distribution Centres (DCs)

Source	Name	Description
1	McMaster Institute of Transportation & Logistics report (MITL, 2014)	A list of firms that attract or generated significant freight activity in the Greater Toronto-Hamilton Area.
2	DMTI Enhanced Points of Interest	Businesses filtered by Standard Industrial Classification (SIC) codes using SIC4225 (i.e., warehouses).
3	ATRI GPS data	Locations with a high concentration of parking were individually verified.

DC Locations



Optimization

- P-Median used to determine impact of available open/closed rest stops
- Assign closest open rest stop to the DC for each trip
- Travel cost based on AM morning travel times
- Demand based on observed trips to DCs

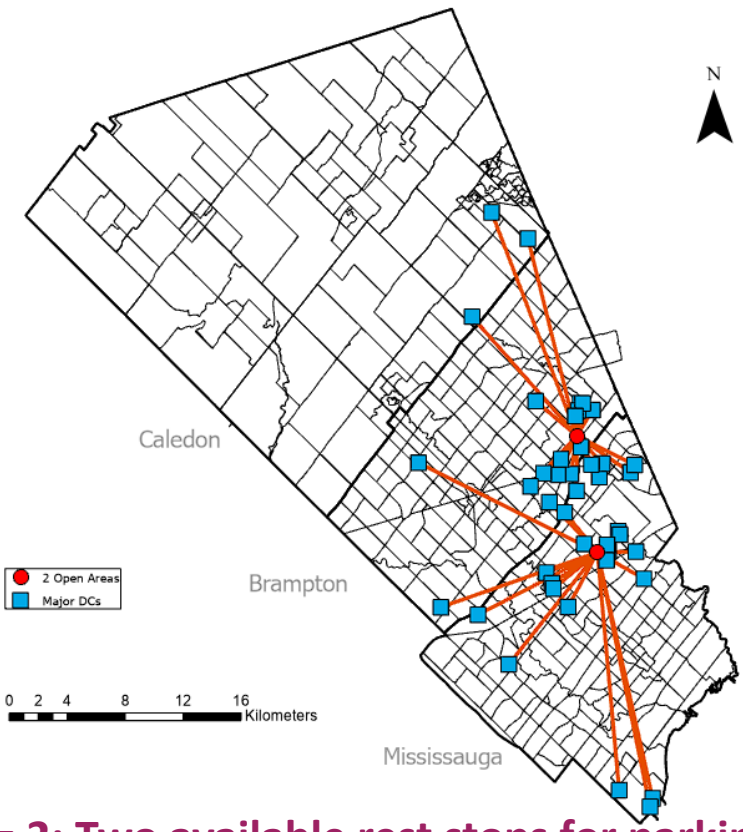
$$\textit{Minimize } \sum_i \sum_j D_j \, c_{ij} x_{ij}$$

Subject to:

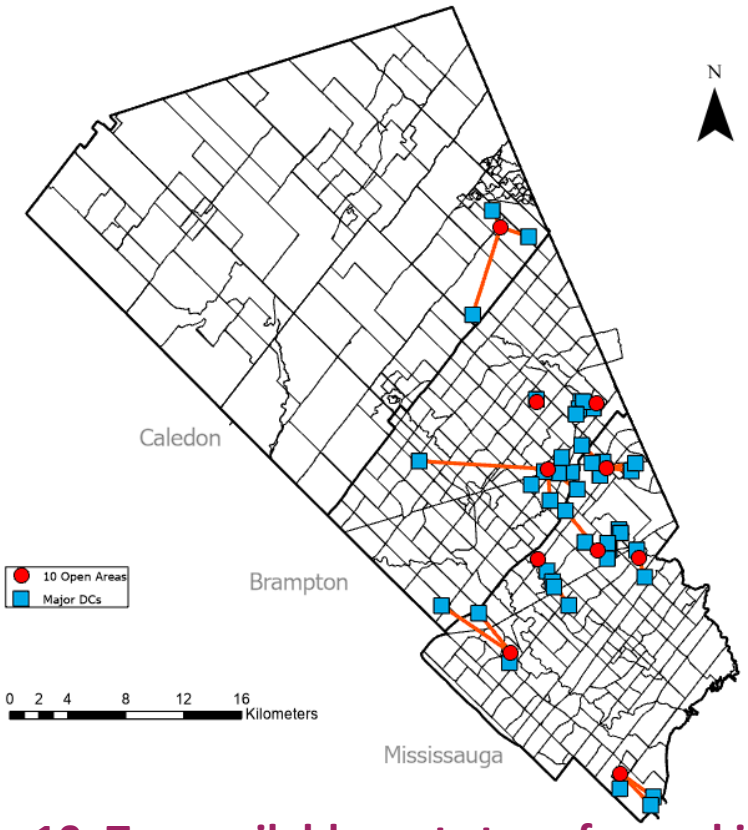
- $\sum_i x_{ij} = 1 \qquad \forall\, j$
- $\sum_i Y_i = p$
- $x_{ij} \leq Y_i \qquad \forall\, i,j$
- $x_{ij} \in \{0,1\} \qquad \forall\, i,j$
- $Y_i \in \{0,1\} \qquad \forall\, i,j$

Trip Rest Stops to DCs

- How does opening more rest areas help change travel time between major freight facilities?

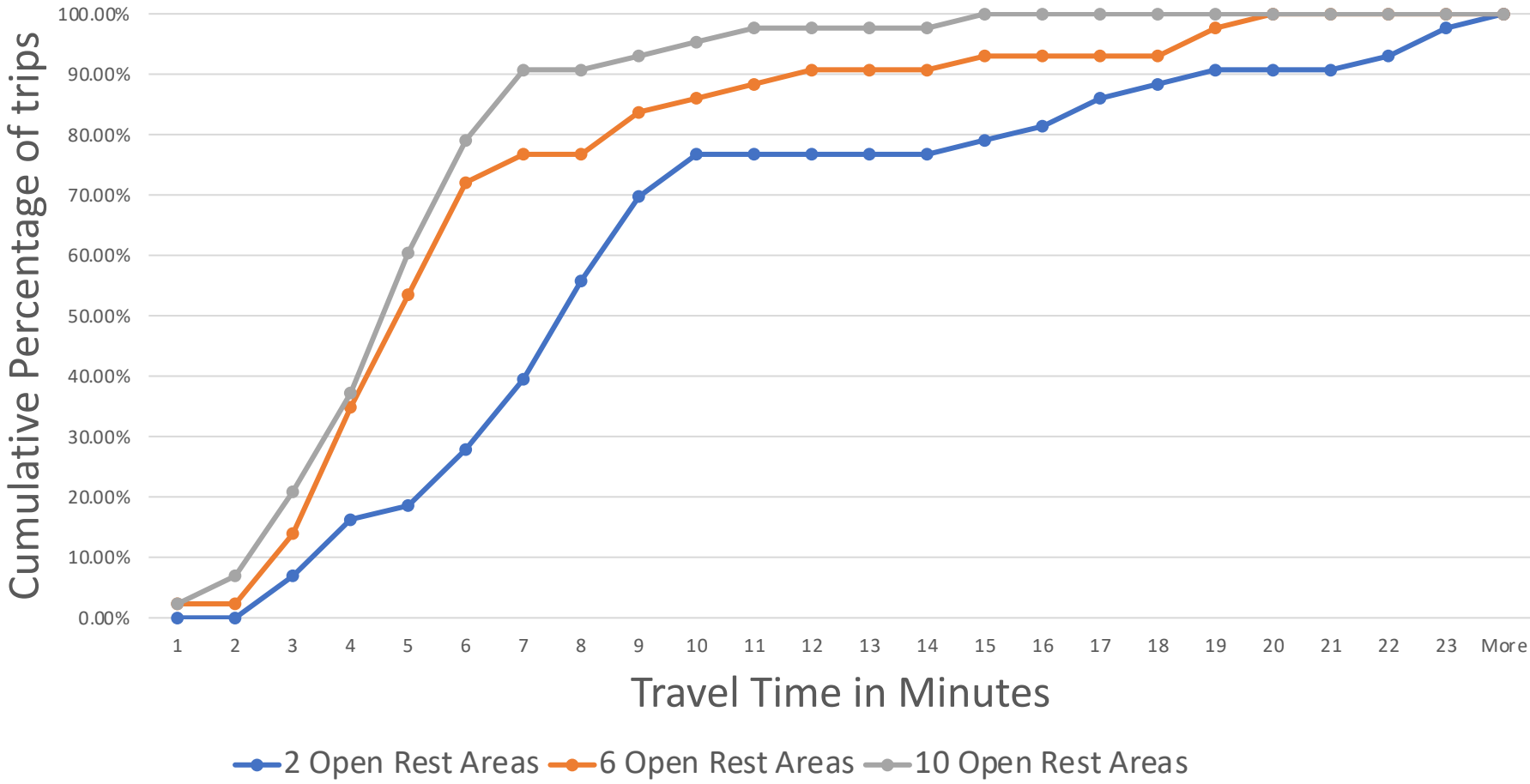


P = 2; Two available rest stops for parking



P = 10; Ten available rest stops for parking

Travel Time Results



Conclusions – Next Steps

- Optimization testing is still in progress
- Optimization can benefit from:
  - Expanded data beyond sample values
  - Capacity constraints based on parking supply
  - Substitution patterns with other potential parking locations
- Further research expected on illegal truck parking

Acknowledgements

- NSERC
- Region of Peel
- Transport Canada
- Additional data providers