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Research Note

Population Changes, Weather, and Congestion: Exploring Declines in Use of Chicago's Elevated Trail

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Abstract

This research note examines possible explanations for declines in use of Chicago's 606 Trail between 2016, its first complete year of operation, and 2018. Hypotheses include population changes near the trail, adverse weather in 2017-2018, and congestion effects. To evaluate these hypotheses, respectively, we use Census data, traffic counts, weather data, and regression modeling; and level-of-service (LOS) grades for peak use periods. We show that population changes were unlikely to have contributed to the use reductions and that, after controlling for weather effects, daily use still was significantly lower in 2017-2018 relative to 2016. Although LOS grades of "F" characterize much of weekend daytime use in summers, use reductions also occurred during periods with better LOS. None of the hypotheses fully explains the use declines. Field surveys are needed to explore additional, potential explanations including changes in preferences and perceptions of residents in gentrifying neighborhoods and the loss of a novelty effect.

Keywords

Trail, use, demand, monitoring, weather

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Introduction

Park and recreation managers need information about demand to plan and assess investments in new facilities. Low-cost, automated sensors for measuring use are increasingly available, but deployment of these new technologies is not standard practice (English & Bowker, 2018; Jones, Yang, & Yamamoto, 2018; Snider, Hill, Simmons, & Herstine, 2018; Ziesler & Pettebone, 2018). The 606, a $95 million, 2.7-mile trail that opened in Chicago in summer 2015, is the only elevated, multiuse rail-trail in the United States. The 606 was designed to be used by neighborhood residents who, until its development, had little access to nearby public open space (Chicago Department of Transportation, 2012). The 606 has attracted millions of users and, because of its unique characteristics, cost, and location in a major city, the attention of researchers from a variety of disciplines. Researchers have shown that the race/ethnicity of users on the eastern and western sections of the trail reflects, respectively, the Anglo and Latino/a populations who reside adjacent to the trail (Harris, 2018; Kraft, Nunez, Tarlov, Slater, & Zenk, 2019); Latino/a users are less likely to use sections of The 606 in white neighborhoods (Kraft et al., 2019); the 606 may be a catalyst for gentrification and displacement (Anderson, 2016; Gomez-Feliciano, McCreary, Sadowsky, Peterson, Hernandez, McElmurry, & Park et al., 2009; Rigolon & Nemeth, 2018; Vivanco, 2016); and rates of crime in adjacent neighborhoods may have declined since its opening (Harris, 2018; Harris, Larson, & Ogletree, 2018).

We initiated monitoring of trail use with infrared sensors deployed on eastern and western segments of The 606 in late December 2015, a few months after the trail opened. We documented significant use of The 606 during 2016 (Gobster, Sachdeva, & Lindsey, 2017) and, more recently, at the sixth Fábos Conference on Landscape and Greenway Planning, reported declines in use of the trail in both 2017 and 2018 (Lindsey, Qi, Gobster, & Sachdeva, 2019). Trail traffic on the eastern (predominantly Anglo, more affluent) section of the trail declined 11.9% from 1.4 million in 2016 to 1.2 million in 2018. Declines on the western (predominantly Latino/a, less affluent) section were greater: a drop of 16.1% from 1.2 million in 2016 to a little over 1 million in 2018 (Lindsey et al., 2019). In absolute terms, the largest declines in use on the two segments have occurred in different years. On the eastern segment, the largest decline in total counts occurred between 2017 and 2018, while on the western segment, the largest decline occurred between 2016 and 2017. At the 2019 Fabos greenways conference, we speculated on possible explanations for these declines but presented no analyses of hypotheses. Specifically, we hypothesized that declines in use could be associated with changes in (1) populations of nearby residents and users; (2) weather; (3) congestion associated with high levels of use; (4) user perceptions of and preferences for the trail; and (5) the loss of a novelty effect associated with the opening of the trail (Lindsey et al. 2019).This research note builds on our Fabos conference presentation by examining the three of these hypotheses that can be analyzed with secondary data: (1) population changes in neighborhoods adjacent to The 606, (2) adverse weather in 2017 and 2018, and (3) congestion effects that diminish the recreational experience. We conclude none of these hypotheses fully explains the declines and that new field studies involving interviews with users and neighbors are needed to address other hypotheses and understand the reductions in use.

Methods

Methods for monitoring use on The 606 were based on methods used to monitor trail traffic in Indianapolis (Lindsey, Wilson, Rubchinskaya, Yang, & Han, 2007), Minneapolis (Wang, Lindsey, Hankey, & Hoff, 2014), and Columbus, Ohio (Wang, Hankey, Wu, & Lindsey, 2016). Infrared sensors were installed in late December 2015 at locations on the eastern and western sections of the elevated trail, respectively, above cross-streets named Honore and Spaulding (Gobster et al., 2017). These locations were chosen in consultation with trail managers and following guidance in the Federal Highway Administration's (FHWA, 2013) *Traffic Monitoring Guide*. Specifically, the locations were chosen to represent flows through the segments of the trail in the different neighborhoods which, as noted, differ sociodemographically. A limitation of measuring only flows on the main trail is that we have no information about differences in use of the different access points along the trail and cannot draw inferences about origins and destination of users.

The infrared sensors record the time a person passes by; they do not record mode-mix or different types of users (i.e., walkers, runners, cyclists; Gobster et al., 2017). The sensors systematically undercount because only one user is recorded if users pass simultaneously, a problem known as occlusion. This limitation is particularly important to address in analyses of use of The 606 because many users are Latino/a, and research has shown Latino/a users prefer to recreate in larger groups (e.g., Stodolska, Shinew, & Li, 2010). To account for occlusion, we completed field validation studies in 2016 at both monitoring locations in which we counted users, compared counts to sensor readings, and developed correction factors that subsequently were applied to each daily count. In addition, sensors may malfunction or be vandalized. Counts for missing days were imputed using weather and day-of-week regression models. Additional methodological details are described in Gobster et al. (2017) and Lindsey et al. (2019).

Our hypotheses for the declines in use can be posed as research questions:

1. Could population changes in adjacent neighborhoods account for declines in use?
2. Could adverse weather conditions in 2017 and 2018 account for declines in use?
3. Could congestion on The 606 lead to choices by users to discontinue use?

We used different approaches to address each question. First, to evaluate the population change hypothesis, we used the U.S. Census American Community Survey (ACS) 5-year Census tract population estimates for 2011-2015 and 2013-2017 and compared percentage changes for contiguous tracts and for all tracts at least partially within ½-mile of the trail to the percentage changes in trail traffic. We examined changes in total population, income, and ethnicity separately for the two segments of The 606 and for the trail overall.

Second, daily trail use has been shown to be highly correlated with daily weather and day of week; daily demand models that control for these effects explain as much as 75% of variation in daily use (Ermagun, Lindsey, & Loh, 2018; Lindsey et al., 2007; Wang et al., 2014; Wang et al., 2016; Gobster et al., 2017; Lindsey et al., 2019). To evaluate the weather hypothesis, we compiled daily high temperature (degrees Fahrenheit), rain (inches), snow (inches), wind speed (miles per hour), average sky (cloud) cover (%), and visibility (miles) for each day from January 1, 2016 through December 31,

2018 and completed three analyses. We first compared descriptive statistics for numbers of adverse weather days in each year (i.e., days with high temperatures over 85 degrees or under 32 degrees Fahrenheit; days with more than 0.098 inches of rain or snow. We then estimated two weather-based regression models to control for the effects of weather and temporal changes. In one model, we used binary (0-1) variables for each year (i.e., 2017, 2018); in the second model, we dropped the binary year variables and included a trend variable, days since opened, to capture temporal trends. The third analysis was a counterfactual analysis: we estimated a weather-based regression for 2016 each monitoring location and used each model to predict daily use in 2017 and 2018 (using daily weather measurements for each day in those years). This procedure provides an estimate of what trail traffic would have been had users responded to weather in 2017 and 2018 as in 2016. We then compared our counterfactual, predicted estimates, to actual volumes for 2017 and 2018. We also analyzed residuals to assess the patterns of errors.

Third, to address the congestion hypothesis, we examined the distribution of daily traffic volumes, specifically mean and median traffic volumes, by decile for each year. We reasoned that if congestion was the principal factor resulting in declining use, the differences in use should occur primarily in the upper halves of the distributions. We then used Federal Highway Administration (Patten, Schneider, Toole, Hummer, & Rouphail, 2006) procedures for computing level-of-service (LOS) for shared-use paths. In this approach, measures of trail width, user flows, mode-mix, user speed, and directional flow are combined to produce grades (i.e., A through F) that reflect congestion and are believed to represent quality or LOS. Because volume thresholds for grades of LOS depend on mode-mix and mode-mix varies by time-of-day and day-of-week, thresholds vary throughout a day. We used estimates of mode-mix obtained in our 2016 field count validations as inputs to the LOS analyses. These analyses were limited to weekday a.m. high-use periods (i.e., 7:00 a.m. – 9:00 a.m.), weekday late-afternoon, early evening high-use periods (4:00 p.m. – 8:00 p.m.), and weekend high use periods (10:00 a.m. – 5:00 p.m.). The thresholds for grades of F (failing) for hourly traffic on weekday mornings, weekday afternoons, and weekend high use periods, respectively were 520, 484, and 356. A limitation of this analysis is that we relied on 2016 mode-mix data, and it is likely that use has evolved differentially among modes over time. Despite this limitation, we believe the results generally capture the effects of congestion over time.

Results

Population Changes

Figure 1 maps changes in the population of residents in the Census tracts contiguous to and at least partially within 1/2-mile of The 606 between the 2011-2015 (2015) and 2013-2017 (2017) ACS sampling periods. These changes are summarized in Table 1. In the contiguous tracts (n=20; 2015 population = 37,648), the population is estimated to have increased by 155 individuals, or 0.41%. In all tracts at least partially within 1/2-mile of The 606 (n = 45, 2015 population = 122,570), the population is estimated to have decreased by 23 individuals (-0.02%). The magnitude of these population changes differed among neighborhoods. In the contiguous tracts, the population along the eastern segment increased by 1.6%, while the population along the western

segment decreased (-0.37%). In all tracts at least partially within 1/2-mile of the trail, the total population changes along the eastern and western segments were, respectively, -1.90% and 1.07%. Consistent with previous studies of gentrification (Rigolon & Németh, 2018), rates of population change differed by race and ethnicity, and household incomes increased (Table 1). In contiguous tracts, the Latino/a and Black populations declined by 2.62% and 4.15%, while the white population increased 2.56%. In all tracts at least partially within 1/2-mile, the Latino/a and Black populations declined by 3.48% and 7.49%, respectively, while the white population increased 3.8%.

All else equal, if population changes alone were responsible for declines in use, we would expect changes—declines—in population the same order of magnitude of changes in traffic (i.e., -12% to -16%). Given that the estimated population changes are small relative to changes in use (and positive in the contiguous tracts), we conclude changes in total population alone cannot account for the declines in use. However, given Kraft et al.'s (2019) finding that Latino/a individuals are less likely to use sections of the trail in white neighborhoods, it is possible that perceptions of these changes could be associated with some of the decline in use. A general limitation of this assessment, which is unavoidable when using ACS estimates, is that the margin of error associated with these estimated changes is quite high.

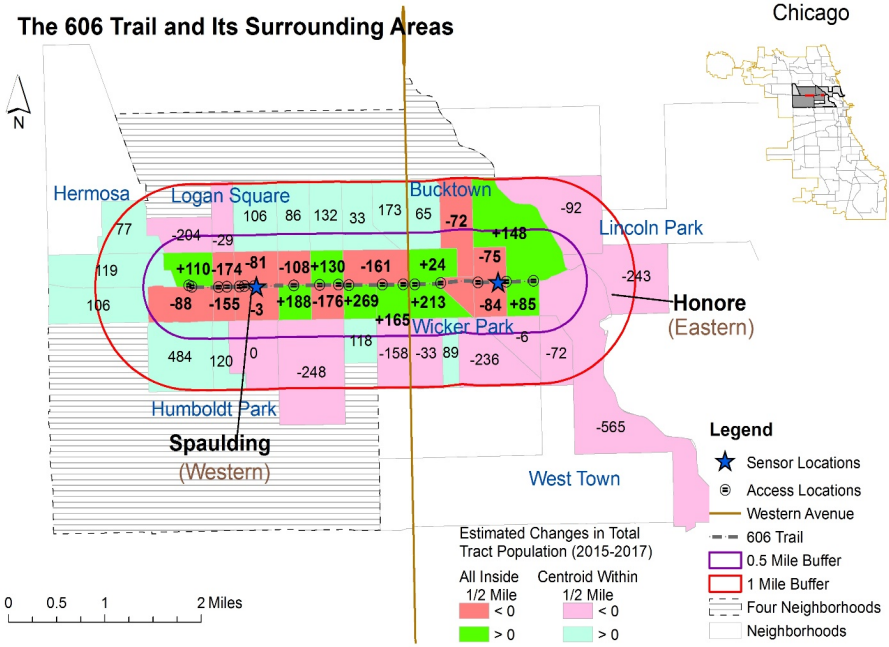

Figure 1. Estimated changes in Census tract populations near The 606, 2015-2017

Table 1
Population Changes in Census Tracts Near The 606

Contiguous Tracts	Total (20 tracts)				East (7 tracts)				West (13 tracts)			
	2015	2017	Change	Change%	2015	2017	Change	Change%	2,015	2017	Change	Change%
Total Population	37,648	37,803	155	0.41%	14,738	14,977	239	1.62%	22,910	22,826	-84	-0.37%
White (Non-Hispanic)	17,388	17,833	445	2.56%	11,179	11,010	-169	-1.51%	6,209	6,823	614	9.89%
Latino/Latina	15,705	15,294	-411	-2.62%	1,818	2,066	248	13.64%	13,887	13,228	-659	-4.75%
Black (Non-Hispanic)	2,312	2,216	-96	-4.15%	317	362	45	14.20%	1,995	1,854	-141	-7.07%
Average Median Household Income	$ 73,331	$ 81,829	$ 8,498	11.59%	$ 115,244	$ 124,717	$ 9,473	8.22%	$ 50,763	$ 58,735	$ 7,973	15.71%
% of Bicycle in All Commuting Trips	4.02%	4.35%	0.33%	8.17%	2.15%	3.01%	0.86%	40.00%	5.69%	5.50%	-0.19%	-3.32%
% of Walk in All Commuting Trips	3.19%	3.21%	0.02%	0.63%	2.35%	3.20%	0.85%	36.17%	3.94%	3.23%	-0.71%	-18.08%
Tracts within ½ mile	**Total (45 tracts)**				**East (16 tracts)**				**West (29 tracts)**			
	2015	2017	Change	Change%	2015	2017	Change	Change%	2015	2017	Change	Change%
Total Population	122,570	122,547	-23	-0.02%	44,924	44,070	-854	-1.90%	77,646	78,477	831	1.07%
White (Non-Hispanic)	51,230	53,175	1,945	3.80%	32,643	32,285	-358	-1.10%	18,587	20,890	2,303	12.39%
Latino/Latina	55,990	54,044	-1,946	-3.48%	6,346	6,225	-121	-1.91%	49,644	47,819	-1,825	-3.68%
Black (Non-Hispanic)	8,958	8,287	-671	-7.49%	2,161	1,646	-515	-23.83%	6,797	6,641	-156	-2.30%
Average Median Household Income	$ 67,484	$ 78,082	$ 10,598	15.70%	$ 104,340	$ 119,280	$ 14,940	14.32%	$ 47,150	$ 55,352	$ 8,202	17.40%
% of Bicycle in All Commuting Trips	4.08%	4.30%	0.22%	5.36%	3.56%	3.06%	-0.50%	-14.04%	4.49%	5.22%	0.73%	16.26%
% of Walk in All Commuting Trips	4.53%	4.06%	-0.47%	-10.46%	4.60%	4.21%	-0.39%	-8.48%	4.48%	3.94%	-0.54%	-12.05%

Weather Effects

Mean daily high temperatures in Chicago in 2016, 2017, and 2018 were 60.8 °F, 61.2 °F, and 59.2 °F, respectively. Mean daily precipitation volumes in 2016, 2018, and 2018 were 0.10 in, 0.12 in, and 0.14 in, respectively. These gross measures mask differences in frequencies of days with extreme temperatures and rainfall events associated with reductions in use. The number of days that high temperatures exceeded 85°F was 50 in 2016, 43, in 2017, but 65 in 2018, the year with lowest total use. Daily use on these hot weekdays and weekends at the Honore site in 2016 averaged 5,586 and 5,720, respectively. In 2018, the comparable weekday and weekend mean daily measures were 5,176 and 5,295, respectively, reflecting a large drop in average use along with the increase in number of hot days. At Spaulding, the drop in average daily use on those hot days was much greater on weekdays than weekends. On hot weekdays, use declined from 5,741 in 2016 to 4,705 in 2018. On weekends, the decline in average daily use on hot days was proportionately smaller: from 5,031 in 2016 to 4,916 in 2018.

Conversely, there were 40 days with daily high temperatures that remained below freezing (32°F) in 2016, but only 32 in 2018. Daily use on the coldest weekdays and weekend days at the Honore site in 2016 averaged 584 and 888, respectively. In 2018, the comparable weekday and weekend average user counts were remarkably similar: 590 and 889, respectively. At Spaulding, average daily use on the coldest days in 2016 was 496 on weekdays and 677 on weekends. The comparable values in 2018 were slightly lower: 488 and 654, respectively. The number of days with rain or snow increased from 2016 to 2018, respectively, from 73 to 86 and 54 to 59. Overall, there were more days in 2018 not conducive to trail use than in 2016; while mean use on the hottest days was lower, mean use on the coldest days remained stable.

We generally followed procedures used previously to estimate daily demand or use as a function of daily weather and day-of-week (Gobster et al., 2017; Lindsey et al., 2019). We used generalized least squares models rather than negative binomial count models because analyses of residuals indicated the models had better fit throughout the distribution of counts. Table 2 presents six daily demand models; we present the marginal effects for each independent variable rather than coefficients to better illustrate the magnitude of effects.

a. Honore daily demand model, 2016-2018; binary variables: 2017, 2018
b. Spaulding daily demand model, 2016-2018; binary variables: 2017, 2018
c. Honore daily demand model, 2016-2018; trend variable: days since opened
d. Spaulding daily demand model, 2016-2018; trend variable: days since opened
e. Honore daily demand model, 2016
f. Spaulding daily demand model, 2016

Each of the models has good fit. As expected, the weather and day-of-week variables mostly are statistically significant and have effects in the expected direction. In models (a) and (b), the yearly binary variables, 2017 and 2018, are negative and statistically significant, indicating that after controlling for variation in weather and day-of-week, daily volumes in each year were lower relative to 2016. For example, the estimated reductions in daily traffic between 2016 and 2017 were 154 and 417, respectively, at Honore and Spaulding. Similarly, in models (c) and (d), the trend variable, days since

Table 2
Marginal Effects of Weather Conditions and Day-of-week on The 606 Daily Traffic Volumes

Marginal effects on Daily Traffic Volume (GLM model with power = 0.5)	(a) Honore 2016 – 2018	(b) Spaulding 2016 – 2018	(c) Honore 2016 – 2018	(d) Spaulding 2016 – 2018	(e) Honore 2016	(f) Spaulding 2016
Weekend (=1)	994.5***	592.4***	994.8***	591.0***	1230.4***	746.7***
Holidays (=1)	572.9**	426.2**	605.8***	461.9***	761.8*	525.0
Days since the trail opened			- 0.74***	- 0.89***		
Year = 2017	- 154.4*	- 416.8***				
Year = 2018	- 387.5***	- 511.4***				
Highest temperature	81.0***	79.6***	81.5***	80.1***	81.8***	89.3***
Highest temperature deviation from average (1981 - 2010)	- 22.3***	- 30.8***	- 23.1***	- 31.8***	- 8.2	- 28.8***
Moderate rain or heavier (=1)	- 1169.8***	- 961.6***	- 1146.4***	- 928.6***	- 1088.5***	- 1015.1***
Snow (=1)	- 958.7***	- 677.9***	- 964.5***	- 665.3***	- 1000.1**	- 704.0*
Wind (Beauford wind force level)	- 27.3**	- 23.5**	- 29.3**	- 28.1***	- 26.2	- 18.0
Visibility	118.5***	99.8***	129.4***	113.0***	152.4***	107.9**
R^2 (Zheng & Agresti, 2000)	**0.773**	**0.816**	**0.779**	**0.822**	**0.793**	**0.823**

* p-value $\leqslant$ 0.05; ** p-value $\leq$ 0.01; *** p-value $\leq$ 0.001

opened, is negative and statistically significant, indicating steady declines in use at each location over the three-year period.

When we use our 2016 demand models (e and f) to predict daily traffic in 2017 and 2018 at each location, we find our estimates are on average higher than the actual daily totals that occurred (Table 3). For example, our predicted annual average daily traffic (AADT) volumes at Honore in 2017 and 2018 were, respectively, 3,835 and 3,682. Actual AADT volumes were 3,653 and 3,332 in 2017 and 2018, respectively. Similarly, at the Spaulding site, predicted AADT volumes in 2017 and 2018 were 3,423 and 3,300; actual volumes were 3,028 and 2,846. When we examine the residuals from predicting 2017 and 2018 volumes with the 2016 models for each site, we see that the observations are systematically below zero and that they become larger over time (Figure 2). These results suggest over-prediction of daily traffic after controlling for weather and day-of-week and indicate the drop is not fully attributable to changes in weather.

Table 3

Observed and Predicted Annual and Daily Traffic Volumes on The 606

		Annual Traffic Volume		Daily Traffic Volume		
	Year	Observed Traffic	Predicted	Observed Traffic	Predicted	Over-prediction (%)
Honore	2016	1,380,300	1,381,394	3,771	3,774	0.08%
	2017	1,333,229	1,399,903	3,653	3,835	4.76%
	2018	1,216,152	1,344,082	3,332	3,682	9.52%
Spaulding	2016	1,237,829	1,239,048	3,382	3,385	0.10%
	2017	1,105,069	1,249,245	3,028	3,423	11.54%
	2018	1,038,904	1,204,487	2,846	3,300	13.75%

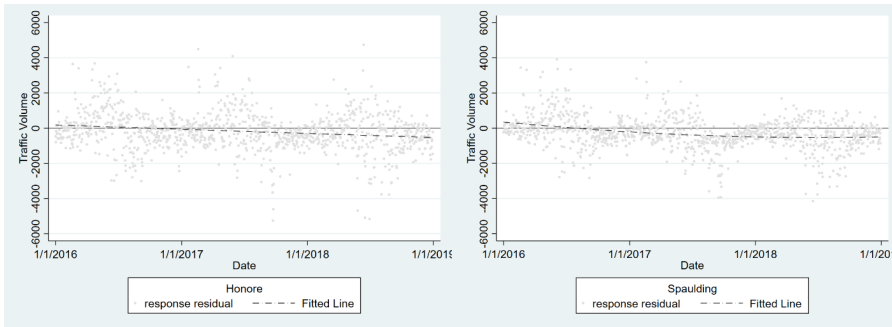

Figure 2. Regression and prediction residuals across 2016–2018 (Models e & f)

Congestion Effects

Our analyses of the deciles of the distributions of daily traffic counts each year show that means (medians) within the lower five deciles when congestion is relatively low declined in both 2017 and 2018 at each location. At Honore, the declines were from 1,728 (1,610) in 2016 to 1,663 (1,487) in 2017 and 1,493 (1,421) in 2018. At Spaulding, the declines were from 1,437 (1,280) in 2016 to 1,354 (1231) in 2017 and 1,220 (1,166) in 2018 at Spaulding. The fact that declines in use are not limited to the upper end of the distribution when congestion is greatest implies that the declines are not solely because of congestion.

The LOS analysis, however, shows that congestion sometimes is a problem, especially on weekends in summer months. Figure 3 presents the percentage of time for each level of service (A-F) by each season for each site for 2016, 2017, and 2018. In summertime weekday morning high-use periods at both Honore and Spaulding, LOS most often is C, which FHWA characterizes as fair. However, in summertime weekday late afternoon, early evening high-use periods, LOS is F (i.e., failing) approximately 40% of the time at Honore and between 30% and 40% at Spaulding. On summertime weekends, LOS is F the majority of hours during high use periods. At Honore, during summertime weekend high-use periods, LOS was F for 77.4% of the hours in 2016, 89.4% of the hours in 2017, but only 68.3% of the hours in 2018. At Spaulding during summertime weekend high-use periods, LOS is failing less of the time: 65.9% of the hours in 2016, 59.6% of the hours in 2017, but only 51.4% of the hours in 2018. To the extent that the FHWA LOS grades are valid measures of congestion and, by implication, conflicts and reductions in quality of experience, congestion is sometimes a problem on The 606, especially on summer weekends. Thus, there is potential that congestion has been a factor in the decisions of individuals to reduce or curtail use of The 606. However, as noted, reductions in use have occurred in other seasons when LOS grades are fair to good, indicating that congestion is likely not the sole factor in declines in use.

Discussion and Conclusion

Use of The 606 declined substantially between 2016 and 2018. The declines were greater on the western section of the trail in predominantly Latino/a neighborhoods (Gomez-Feliciano et al., 2009). The declines were not expected and warrant further investigation, especially as other major cities are exploring comparable major investments in new facilities to redress long-standing inequities in access to open space.

We showed that the population in Census tracts adjacent to the trail increased while the total population in tracts within 1/2 mile decreased slightly. Overall, consistent with previous reports of gentrification, the White populations increased while Latino/a and Black populations decreased. These changes were small relative to the measured declines in use, indicating other factors likely are affecting use.

After controlling for the effects of weather on daily use, we showed that trail use was significantly lower in 2017 and 2018 relative to 2016. Our counterfactual analysis indicates that other factors besides weather likely are responsible for these declines. Although LOS grades of F characterize much of weekend daytime use in summers, reductions of use also occurred during periods with good LOS.

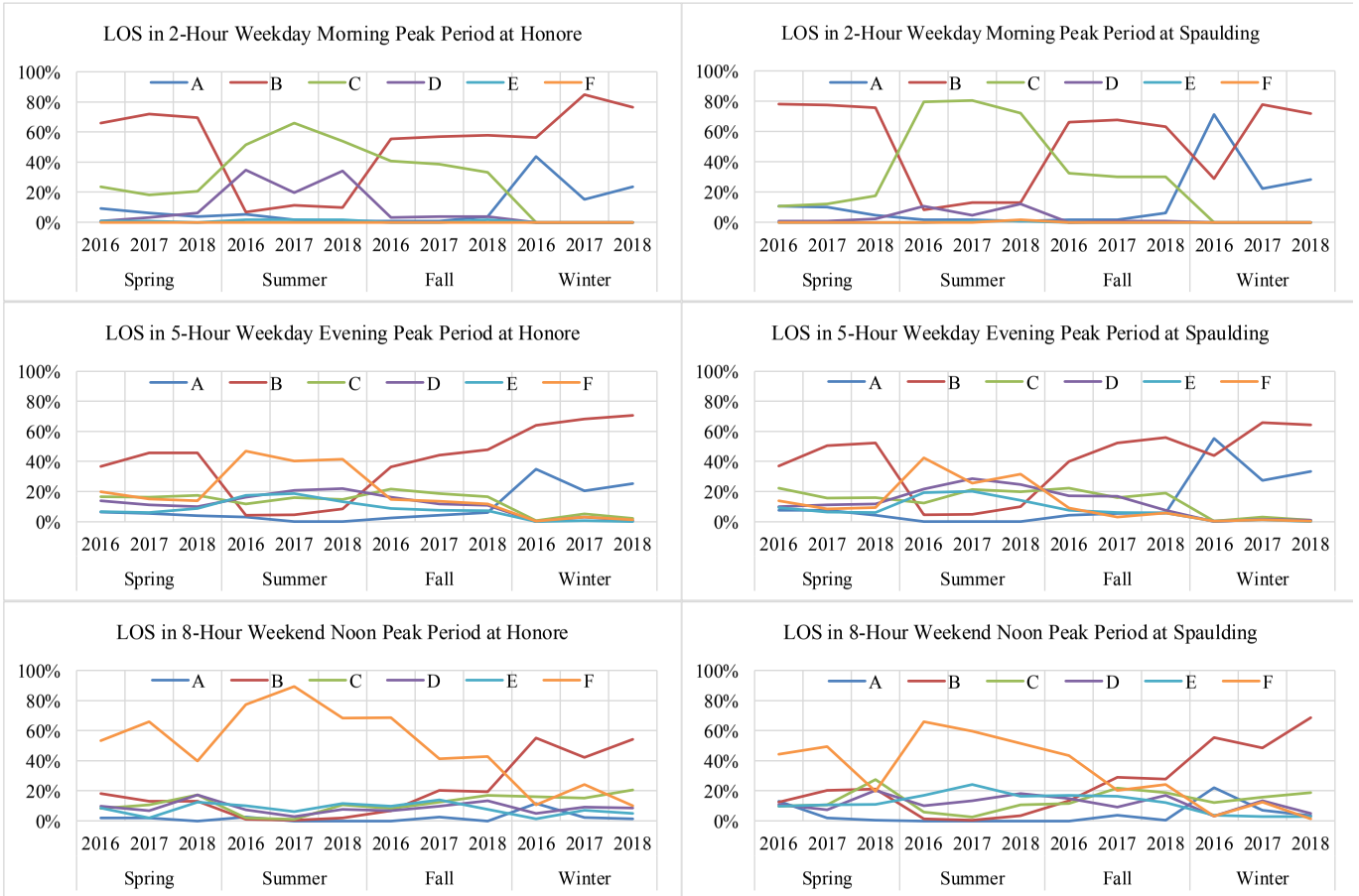

Figure 3. Annual and seasonal distributions of Shared-Use Path Level of Service (SUPLOS) of The 606

We conclude none of the three hypotheses assessed in this note fully explains the declines. Other hypotheses for the declining use include changes in user preferences and perceptions of the resource, changes associated with resource condition, and the loss of a novelty effect that contributed to high levels of use immediately following the opening of The 606. Changes in user preferences and perceptions may be associated in complex ways with changes in ethnicity and race of residents in nearby neighborhoods. Additional field studies involving new observations and surveys of trail users and neighbors are needed to assess whether trends in use are associated with changes in ethnicity of populations near the trail. Among other studies, simultaneous deployment of sensors on all access points would provide useful information about differential use of sections of the trail. New Census data, projected to be released in 2021, will be useful in assessing trends.

Finally, as authors in the recent (2018) Special Issue of this journal devoted to visitor monitoring observed, despite the importance of monitoring and the availability of low-cost sensors, automated monitoring of facilities is not standard practice (English & Bowker, 2018; Jones et al., 2018; Snider et al., 2018; Ziesler & Pettebone, 2018). In this case, for example, public agencies would not have known that use was declining had not a non-profit partner (The Trust for Public Land) installed these two sensors. The cost of these sensors was about $10,000, or roughly one one-hundredth of one percent of the cost of The 606 (i.e., $95 million). These monitoring data, when combined with readily available weather data, have enabled modeling of patterns of use, analyses that rule out variations in weather as the principal cause of declines in the use of The 606, and analyses of congestion and LOS. Small investments in monitoring can help inform management of important, expensive public recreational facilities.

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