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Research Article

COVID-19 compliance among urban trail users: Behavioral insights and environmental implications

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A R T I C L E I N F O

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Physical distancing
Off-trail behavior
Signage
Trail width
Physical density

A B S T R A C T

Public green spaces provide physical and mental respite, which have become essential and elevated services during the COVID-19 pandemic. As visitation to public parks and recreation areas increased during the pandemic, the challenge of maintaining visitor safety and protecting environmental resources was exacerbated. A key visitor safety practice during the COVID-19 onset was maintaining a physical distance of six feet (1.8 m) between groups. A novel data set documented and compared physical distancing compliance and off-trail behavior on multiple-use trails across multiple states and within select U.S. communities, attending to the impact of select environmental factors. Nearly 6000 observations revealed physical distancing compliance varied and the environmental factors of trail width, density, and signage influenced its variability. Similarly, off-trail movement was related to trail width and density. Clearly the environment matters as people negotiate the 'new normal' of physical distancing during physical activity and outdoor recreation participation. Given the ongoing COVID-19 pandemic and likelihood of future health crises, this project provides important information and insight for trail and other public green space management, monitoring, and modelling moving forward.

Management implications: As both trail width and visitor density impacted physical distancing, a combination of trail design that accommodates distancing requirements and density management practices that provide sufficient trail user spacing is essential to retain safe and active trail use.

Off-trail movement was influenced by both trail width and density, so ensuring safe off-trail spaces exist and using durable off-trail materials can minimize disturbance and protect visitors.

Signage is inconsistently significant to influence trail-compliant distancing behavior, but optimizing its placement and content may improve effectiveness.

Compliant trail behavior varied by trail width, visitor density, and trail location; therefore, site-specific information is necessary to understand possible visitor behavior and design/implement mitigation strategies.

1. Introduction

During the onset of the COVID-19 pandemic, recreational trails provided respite, physical activity, and active transportation as denizens flocked to parks and trails in unprecedented numbers across the globe. Increased outdoor recreation activity ranged from a 291% increase in Oslo, Norway (Venter et al., 2020), 140% increase in peri-urban forests in Germany (Derks et al., 2020; Drake et al., 2020), and 146% among state trails in parts of the United States (Oftedal, 2020). However, these reported changes were inconsistent both within and across metropolitan areas; some reported more intense activity in the urban periphery than the urban center (Lopez et al., 2020; Venter et al., 2020) while others

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reported an initial decrease and then return to typical or slightly elevated use levels (Drake et al., 2020). Among outdoor enthusiasts, urban residents decreased their distance travelled for outdoor activities more than rural residents, thus placing greater pressure on urban recreation resources (Randler et al., 2020; Rice et al., 2020). As such, both public green spaces and trails have been hailed as 'critical infrastructure' during pandemic periods (Derks et al., 2020; Lopez et al., 2020). Access to outdoor spaces is suggested as an important indicator in COVID-19-related decision making (Raboisson & Lhermie, 2020) with calls to develop, maintain, or renovate the trails and parks for improved public health (South et al., 2020, p. P606).

A challenge during pandemics like COVID-19 lies in simultaneously maintaining visitor safety and protecting the resources they are visiting, both of which are important to visitors and managers (Gobster, 1995; Lopez et al., 2020; American Trails, 2020). Another challenge relates to collecting behavioral data regarding visitation patterns (Bauch & Galvani, 2013). In response, during spring 2020, community and natural resource planners scrambled to understand optimal and safe management while COVID-19 science evolved. Visitor protection included minimizing exposure to COVID-19 (and future health issues) as well as maintaining a safe recreation space. In the U.S. this safe space included visitors maintaining a six-foot (1.8 m) space between parties. Resource protection included minimizing impact to the flora and fauna surrounding green space infrastructure. However, as visitor density increased through the early stages of COVID-19, visitor safety and negative environmental issues became more apparent. Initially and continuing through the pandemic, significant educational efforts emerged, dominated by safety messaging that encouraged physical distancing (Center for Disease Control (CDC) 2020; Sutton, 2020). Beyond education, managers around the world also implemented user limits and one-way trails to reduce encounters and exposure (IUCN, 2020; McGinlay et al., 2020). In response to the significant use increases, several cities temporarily opened up roadways for pedestrians and recreational use while closing them to motorized traffic to protect the health of both visitors and natural resources (i.e. Milan, Seattle, Minneapolis).

As the pandemic ensues through 2021 and other health crises likely follow, urban green space managers and community planners need to continue to evolve their management in a 'new normal' to retain visitor safety and protect resources. "Physical distancing" or "social distancing" remain phrases any organization that hosts visitors must consider. Informed management is a challenge, however, as foundational data is missing due to the pandemic's recency and a lack of comparative data. Subsequently, this project reports on a data set from select U.S. urban paved trails during the COVID-19 onset. In particular, our interests focused on physical distancing compliance and how selected setting features (trail width, density and COVID-19-related signage) related to both on and off-trail behavior. We anticipate this will contribute to the expected 'major' upheaval in monitoring and modelling for pedestrian management (Honey-Roses et al., 2020; Salganik, 2019).

2. Literature

Retaining or improving access to safe outdoor recreation and public recreational and park spaces is essential to achieve improved health, lower health care costs, and the community well-being benefits they afford (Blahna et al., 2020; Thomsen et al., 2018; White et al., 2019). The U.S. government has prioritized both physical and mental health, emanating from the ongoing 'obesity epidemic' and its associated costs (Hale et al., 2020) as well as the fact that nearly one in five U.S. adults struggles with mental health (Mental Health America, 2019) and eight in ten report stress (APA 2017). The COVID-19 pandemic has exacerbated those issues (Meyer et al., 2020). With ongoing physical distancing constraints due to COVID-19, local outdoor areas are serving important roles to improve both physical and mental health. Providing positive health-related opportunities poses particular challenges during a pandemic as exposure to COVID-19 is possible if people do not follow safe practices. Given COVID-19's recency, actual data on health-behavior compliance is absent. Reported compliance has been reported through surveys (Katz et al., 2020), but actual behavioral research is scant. In a novel review of select CCTV video during spring 2020, Hoeben et al. (2020) estimated physical distancing on a busy corner and reported greater distancing compliance when shelter-at-home restrictions were in place; however, compliance waned over time.

For recreation managers and planners, understanding if and how increased use impacts the physical environment is of interest. In particular, this project assessed visitor compliance to maintain physical distancing while staying on paved trails. Although research on visitor behavior and its management has a long history (Manning, 2011), off-trail movement is still noted as a key compliance problem in 2020 (Goh, 2020; Goh et al., 2017; Saunders et al., 2019) with obvious negative environmental implications for soil and vegetation (Hockett et al., 2017; Leung et al., 2011; Marion, 2016; Park et al., 2008). Several factors influence compliance, including visitor density and onsite signage.

Although staying on trail is often a choice, Sim et al. (2018) noted that visitor density and perceived crowding could reduce compliance. Indeed, a fifth of respondents at a national park indicated that moving past others and getting away from crowds on the trail were reasons why they walked off trail (Park et al., 2008). Similarly, Korpilo et al. (2018) reported crowding avoidance behavior as a motivation for off-trail use in an urban forest, suggesting the percent of off-trail crowding avoidance behavior would have been higher if the park were relatively smaller. Hoeben et al.'s (2020) CCTV monitoring during the COVID-19 onset revealed a strong relationship between the number of people on the street and non-compliance. During times of airborne illness, distancing is important to reduce spread of the illness; therefore, Freeman and Eykelbosh (2020) recommend allowing and enabling people to spread out as much as possible in outdoor spaces to reduce disease transmission risk. Density can certainly be a function of the space provided, partially dependent on trail width. Visitor comfort and freedom decrease when the need to pass others increases, and the amount of space available to make a move decreases; this means that the probability that a passing move will be blocked by other users increases (Patten et al., 2006). Extending this, clearly options to remain safe on the trail decrease with these as well.

Beyond density management, signs are an important everyday environmental management tool that govern, shape, and direct appropriate behaviors (Campbell et al., 2019). Signs are especially pertinent in situations where the presence of park personnel is not possible (Saunders et al., 2019). Communicating about management is both important and influential as the public may be more receptive to approaches that provide more information (Jensen, 2000; Gundersen et al., 2017). Evidence exists that signs, in combination with other management approaches, likely reduce non-compliant visitor behavior (Vande Kamp et al., 1994) and impact trail behavior (Ham et al., 2009) by discouraging visitors from going off trail (Bradford & McIntyre, 2007; Goh, 2020; Hockett et al., 2017). Beyond the use of signs to protect park resources, signs promote safe behaviors such as reducing entry into a dangerous river (Girasek, 2019); however, relatively little is understood about the role of signs in promoting such behavior (Saunders et al., 2020).

Although intuitively it seems as if information about management would influence attitudes and acceptance, evidence for messaging effectiveness is inconsistent. In direct opposition to the idea of signage effectiveness, Hendricks et al. (2001) found persistent violations of biker trail etiquette despite long-term management attempts. Guo et al.'s (2015) stated-choice model revealed that respondents who received an educational message were more likely to hike off trail than those who did not. In more nuanced findings, Park et al. (2008) found direct methods like fencing more effective than signage in keeping people on trail and Kidd et al. (2015) found park personnel contact better than signage. Thus questions remain about the impact of signage on visitors' behavior to protect their safety and the resource.

Based on this background information and the COVID-19 related concerns, our particular interests focused on:

If and how much are urban trail visitors complying with CDC physical distancing recommendations and does it vary by site?

Does physical distancing compliance vary with the context afforded by the environmental design, specifically trail width, visitor density, and signage presence?

If and how many urban trail users go off trail to comply with CDC physical distancing?

Does off-trail behavior vary with trail characteristics, specifically trail width and visitor density?

Based on the existing literature, we hypothesized that trail width would positively relate to physical distancing compliance and staying on trail. Conversely, we anticipated visitor density would negatively relate to physical distancing compliance and staying on the trail. Given the mixed evidence on the impact of signage on behavior, we offered no hypotheses for its presence and impact on either distancing or staying on trail.

3. Methods

3.1. Study sites

A variety of multiple-use trails within U.S. urban-suburban environments were selected for the project based on safe researcher access and trail type. To ensure research access throughout possible COVID-19 related travel restrictions, we selected publicly managed trails within proximity of trained observers' homes (due to stay-at-home restrictions in many of the localities, especially during the first half of the data collection period; Table 1). For comparison purposes of walking rates and weather patterns (Carlson et al., 2019; Martin et al., 2005), we included trails in both northern and southern U.S. regions (Fig. 1; Figs. 2–8).

Our northern sites included those in the midwestern United States, namely Minnesota and Illinois. In Minnesota, two sites were selected within five miles (8.05 km) of each other: Wedgewood Park and the Sather Trail. The Wedgewood Park trail connects neighborhoods and encompasses a playground, baseball diamond and open greenspace with a 37-car parking lot. Housed within the Mahtomedi community (population 7676; US Census Quick Facts 2019), Wedgewood Park is 11.25 acres (4.55 ha) within the 126-park system and the 8-foot (2.4 m) trail is less than a mile (1.6 km), looping around the fields and serving also as a connector role to neighborhoods. The Sather Trail connects other trails, is part of a larger 10-mile (16.1 km) trail system, and is anchored by two beach areas in the White Bear Lake community (population 25,875; US Census Quick Facts 2019). The 10-foot-wide (3.1 m) Sather Trail connects to two of the cities' 24 parks. In Illinois, Hessell Park Trail was selected. The eight-foot-wide (2.4 m) paved path is one mile (1.6 km) in length located around the perimeter of Hessell Park. The 22.2 acres (9 ha) park's amenities include a large playground, splash pad, picnic pavilions, tennis courts, and volleyball courts. Hessell Park is part of the Champaign Park District, which has more than 50 parks and serves a community of 88,909 (US Census Quick Facts 2019).

Study sites in the southern U.S. region were in Texas and Florida. In Texas, two multiple use sites managed by the City of Waco Parks and Recreation Department were selected. The Waco River Trail and the Cotton Belt Trail are about 11 miles (17.7 km) apart on opposite ends of Waco (population: 139,236; US Census Quick Facts 2019). To the east and adjacent to the Brazos and Bosque rivers, the 12-foot-wide (3.7 m) Waco River Trail is about five miles (8 km) long and connects to several trails within Cameron Park (at 416 acres (168.35 ha), one of the largest city parks in Texas) and links downtown Waco with nearby neighborhoods, Baylor University on the south end, and McLennan County Community College on the north. On the west side of Waco, the 2.5-mile (4 km) long Cotton Belt Trail runs through an area of open fields and over Cloice Creek. At the west end, the 15-foot-wide (4.6 m) trail terminates in a loop at Trailblazer Park. There is also access with parking areas at the midpoint and at the east end of the trail. In Florida, two 10-foot (3 m) wide trails in Gainesville, Florida within two miles (3.22 km) of each other were included: Depot Park and the Gainesville-Hawthorne Trail. Depot Park is a 32-acre (12.95 ha) park in downtown Gainesville (population 133,997; US Census Quick Facts 2019) managed by the City of Gainesville Parks Recreation & Cultural Affairs Department. A little more than one mile (1.6 km) of paved trails runs through the park and winds through newly restored wetlands, an historic railroad depot with a small store and restaurant, picnic areas, grassy areas, and a playground. The Gainesville-Hawthorne State Trail is located southeast of Depot Park on the outskirts of Gainesville. The section is also managed by the City of Gainesville but continues to a 17-mile (27.36 km) stretch of paved trail to the town of Hawthorne, Florida, using a former railroad corridor. The section surveyed is one of the busier sections as it connects Gainesville residents with Paynes Prairie Preserve State Park.

3.2. Observation protocol

A systematic observation protocol was developed based on past research and the questions of interest. The observation protocol was piloted and refined to afford more complete and accurate data; revisions expanded trail activity categories and led to a slight reformatting to enhance data recording efficiency.

Trained observers were stationed along the trail unobtrusively, within viewing of a predetermined 'observation zone' selected to maximize visibility and observer safety; zones varied by site. The first observed group, defined as one or more people travelling together in the observation zone, was tracked throughout the zone, noting the number of encounters with other groups. Encounters could be in any direction. For the observed group and any group it encountered, observers estimated the distance between groups with an ultimate determination as to if they were six feet or more apart, and those groups where all members were six-foot or more apart were considered compliant. Distance

Table 1
Paved site details for observation of physical distancing on urban trails.

Trail name	Community size	Trail width (ft/m)	Trail length (miles/km)	Signage present part of data collection	# of groups observed through zone
Florida-Depot Park (DP)	133,997	10/3.1	~1/1.6	yes	607
Florida- Hawthorne (HRT)	133,997	10/3.1	~17/11.26	yes	439
Illinois-Hessel Park (HP)	88,908	8/2.4	~1/1.6	yes	411
Minnesota-Sather (S)	25,875	10/3.1	~10/16.09	yes	2550
Minnesota-Wedgewood Park (W)	7,676	8/2.4	<1/1.6	yes	396
Texas -Cotton Belt (CB)	139, 236	15/4.6	~5/8/-5	no	408
Texas -Waco River (WRT)	139, 236	12/3.7	2.5/4.02	yes	1175

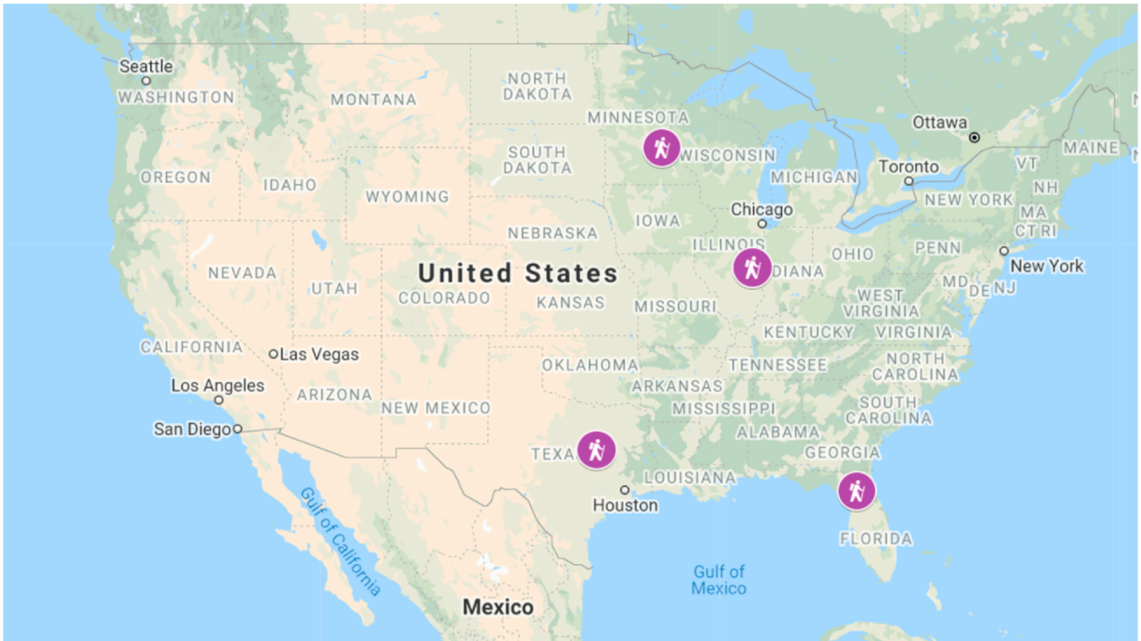

Fig. 1. Hendricks, W. Google Maps. May 3, 2021.

Fig. 2. Sather trail, White Bear Lake, MN (I.E. Schneider, 2020).

estimation was practiced during training using small marker flags to help observers gauge distances. In addition, we noted if the entire group moved to avoid the other if necessary to maintain distance and if it moved off trail. If any of those observed went off the trail, we noted how

Fig. 3. Wedgewood park trail, Mahtomedi, MN (I.E. Schneider, 2021).

many per group left the trail. For each observation period, we noted if COVID-19-related signage was present.

Observations occurred throughout the day and week between March 29 and June 30, 2020. Throughout the day, we observed across four time blocks (sunrise to 9:59 a.m., 10 to 1:59 p.m., 2 to 5:59 p.m., and 6 p.m. to sunset). Given the anticipated leisure-time shifts due to COVID-19 where people were more in control of their time, we sought observations across weekdays and weekends when there were no dangerous weather advisories such as hazardous warnings due to temperatures, winds, or storms. Observation sessions ranged from one to two hours in length to maximize reliability (Rowley, 1978) and minimize observer fatigue in high-density trail-use situations.

3.3. *Analysis*

Descriptive and comparative analyses ensued to understand compliance, and compare across sites and environmental attributes. We coded both compliance items as 0 or 1. A trail density proxy was created

Fig. 4. Hessell park trail, Champaign, IL (K. Shinew, 2020).

using the maximum number of observations during an observation period. Both distancing and trail movement compliance exhibited non-normal distributions (Shapiro-Wilk 0.765 and 0.636, $p < .000$ respectively). As such, follow up comparisons were performed with chi-squared tests and Cramer's V or Phi association tests, based on the number of groups compared. A Spearman-correlation assessed the relationship between our trail density proxy and physical distancing compliance.

4. Results

Across the seven paved mixed-use trails, a total of 5986 groups were observed throughout the predetermined zones (Table 2). Within these, the percentage of groups that had encounters with others varied significantly across sites from a high of more than 80% on the Sather Trail to fewer than 20% at the Wedgewood Trail. Observed group sizes ranged from one to 10 people and, similarly, the groups encountered from one to eight people. As one might expect, both observed and encountered group size was negatively correlated with distancing compliance (−.16 for each, $p < .05$). However, these relationships were not of interest in this analysis and thus our attention turns to the trails.

In four of the seven sites, encounters most frequently complied with CDC physical distancing recommendations. However, compliance rates were significantly different both within an urban area and across communities (Table 2). Specifically across communities, compliance at the Gainesville, Florida sites were significantly lower than all other sites. Within communities, compliance differed between the two Waco, Texas sites (CB and WRT) and two Minnesota metropolitan sites (S and W).

Physical distancing compliance was related to all three environmental variables assessed: trail width, density, and signage presence. Considering trail width, physical distancing compliance was highest on the 8- (2.4 m) and 15-foot (4.6 m) trails (Table 3). Trail width significantly related to physical distancing compliance but not in the expected direction. Physical distancing compliance was lowest on the 10-foot (3.1 m) trails – where only one of five encounters were compliant – and significantly different from all other trail widths. Given the potential impact of the number of encounters on compliance and its relationship to density and visitor fatigue with complying, we compared the number of observations with encounters for context. When considering trail width and number of observations with encounters, significantly more observations with encounters occurred on the narrower eight-foot trails than any of the others (Table 4). The number of groups with encounters on the 10- and 15-foot trails (3.1 m and 4.6 m) did not differ but there were significantly more encounters observed on the 12-foot (3.7 m) trail than on the 15-foot (4.6 m) trail.

In a similar vein, our trail density proxy was inconsistently related to physical distancing compliance (Table 5). At four of the seven sites, a significant relationship emerged between physical distancing and maximum number of trail observations per period. However, the relationship was only moderate at two, both Gainesville sites, and weak at the other two (Minnesota S and Texas WRT) and varied in direction: positive among the Gainesville sites and negative at the others.

Where trail areas included COVID-19 and/or physical distancing signage, we considered its relationship to CDC distancing compliance. In four of these five sites, signage presence was significantly related to distancing compliance (Table 5). The relationship between signage and distancing compliance was strongest at the Waco HRT site, but still moderate at the Gainesville HRT site. While significant, the relationship between signage presence was weak at both Minnesota sites. Again, the relationship direction differed where Florida sites were negative and Texas positive.

Beyond complying with CDC physical distancing recommendations, we wanted to understand if people were consistently complying with trail etiquette, specifically staying on the trail. Overall, the majority of visitors did not step or go off trail. The percent of groups observed with anyone moving off trail varied significantly by site (Table 6) from a high of 42% at the Champaign site to a low of 5% at the Gainesville sites. Similar patterns emerged for groups encountered going off trail. Fewer than 10% of any encounters had both groups moving off trail, and then only at one site. As in the physical distancing compliance findings, significant differences within cities and between the sites emerged.

As we did with physical distancing compliance, we assessed the relationship between trail width and density to off-trail movement: both were significantly related. Specifically, off-trail behavior was highest on the narrowest trail and low, but not the lowest, on the widest trail (Table 7). Our data set enabled comparison within regions and cities where we found significant but weak relationships between encounters and off-trail behaviors on trails with similar widths but in different locations (Table 8). Examining within community differences, however, revealed that despite more encounters at the Florida HRT site, off-trail movements were similar to its DP companion (Table 9).

5. Discussion

Collecting behavioral data during a pandemic is challenging (Bauch & Galvani, 2013). This data set compared physical distancing compliance across multiple states and within select U.S. communities. Results revealed physical distancing compliance varied, and the environmental factors of trail width, density, and signage influenced its variability. Similarly, off-trail movement was related to trail width and density. Clearly the environment matters as people negotiate the 'new normal' of physical distancing, physical activity, and public outings. Given the ongoing COVID-19 pandemic and likelihood of future health crises, this project provides important information and insight for trail and other public green space management moving forward.

Visitors' compliance with physical distancing guidelines differed by region, with trail users in Florida showing much lower compliance than

Fig. 5. Cotton Belt trail, Wilco, TX (C. Wynveen, 2020).

other U.S. regions. This result points to the complexity of understanding visitor behavior and how it might be affected by local culture, risk perception, and other variables difficult to measure through observation. It is likely that this variability cannot be explained through simple messaging and trail design but requires more extensive socio-psychological analysis of trail users – pointing to the need to understand users' attitudes and perceptions to better provide safe green space access and opportunities (Hoeben et al., 2020; Prosser et al., 2020; Walker et al., 2019).

As hypothesized, trail width related to physical distancing compliance and the staying on trail, however, the relationship was nonlinear. Findings reveal that trail width is important, but not the sole factor impacting physical distancing compliance. For example, trails with the same widths but in different communities had different physical distancing compliance levels. Integration of other factors is likely important. For example, the safety (e.g., the visitor is not moving into vehicular traffic) and the surface of the off-trail environment likely impacts both the ability to comply and off-trail behavior. Two of the sites with the greatest overall compliance (Illinois and one of the Minnesota sites) have grass along the trails which may explain why off-trail behavior was highest on these narrower trails. If moving off the trail is relatively easy, then that ease could increase compliance. Relatedly, at the Illinois site, off-trail behavior was higher for both observed and encountered groups, again suggesting ease and perceived safety of moving to be compliant. As such, considering the interaction of widths with surfaces in new and refurbished trails is important in terms of protecting visitor health during public health crises.

Also as hypothesized, our density-proxy related to physical distancing, but inconsistently. Density's negative relationship to physical distancing compliance at two trails mirrors that of Hoeben et al. (2020). These authors offer a causal explanation that as density increased, the restricted space affected park visitors' willingness or ability to physically distance. Another explanation is that increased density served as a visual cue of normalcy and visitors were more likely to forget to physically distance. A more simple explanation is that visitor activity may influence distancing compliance, with some activity groups

Fig. 6. Waco river trail, Wilco, TX (C. Wynveen, 2021).

Fig. 7. Depot park, Gainesville, FL (T. Stein, 2020).

more easily able to move and distance than others. Hoeben et al. note the physical distancing directives only work in conjunction with stay-at-home orders, thus suggesting place-specific crowd-control policies.

The generally positive relationship of signage to compliant trail behavior is similar to some of the past literature (Bradford & McIntyre, 2007; Goh, 2020; Ham et al., 2009). Previous findings (Campbell et al., 2019; Girasek, 2019) suggest the importance and effectiveness of signs to promote safe visitor behavior. This is especially pertinent when the presence of face-to-face interactions with park personnel is not possible (Saunders et al., 2019) or advisable for public health reasons (CDC), such as during the COVID-19 pandemic. Although neither the sign text nor visual content was examined in this study, it is worth noting that their messaging was clearly specific to the pandemic. The outlier for the impact of signage was at the FL HRT site where it was negatively related to physical distancing compliance which mirrors some past research (Hendricks et al., 2001; Guo et al., 2015). The section of the FL HRT observed was long and straight where users may focus on the activity and likely not consider messaging or other factors. Also, signs placed at the trailhead were often difficult to see due to placement and quick fading, subsequently reducing their visibility. Another consideration is the timing of observations, with most compliant behavior observed early in the season when the situation was fresh on people's minds (Prosser et al., 2020) and prior to its politicalization.

Finally, trail width and density were significantly related to off-trail movement. As expected, off-trail behavior was highest on the narrowest trail, and comparisons of trails with similar widths but in different locations noted significant but weak relationships between encounters and off-trail behaviors. As noted by Patten et al. (2006), when the users have the desire to pass others, the amount of space available and the probability that a passing move will be blocked has implications for users' comfort. These considerations are particularly important when passing others goes beyond desire but also has health and safety implications.

6. Limitations and future research

As with other studies there are limitations associated with our method and findings that also yield future research opportunities, including extending the sites, settings, and other variables and the use of other research methods.

A limitation is that our sites focused on urban and accessible trails. The sites the research team had access to were conveniently sampled to retain researcher access during the pandemic and were not necessarily representative of the majority of trails or trail users. Although we had multiple sites in three of our states, increasing the number and types of trails will likely lead to further insights and vary the site user demographic profiles. Given the varied impact of COVID-19 by race and ethnicity, such expansion and purposeful sampling is imminently important (Gross et al., 2020). Further, demographic characteristics such as age and gender may impact compliance. While the U.S. population is urbanizing and subsequently urban environments are important, understanding compliance and influencing factors in suburban and rural areas is also important (Martin et al., 2005). Suburban and rural

Fig. 8. Hawthorne trail, Gainesville, FL (T. Stein, 2020).

Table 2
Encounters and physical distancing compliance among trail sites observed, 2020.

Site	Florida DP	Florida HRT	Illinois HAS	MN S	MN W	Texas CB	Texas WRT	Chi Squared	Cramer V
% any encounters (n = 5986)	47.0[ab]	60.1[c]	53.3[bc]	82.7[d]	17.4[e]	37.5[a]	45.7[ab]	1089.42[a]	.427[a]
% encounters compliant (n = 3603)	20.7[a]	14.0[a]	61.6[b]	43.0[b]	58.2[bc]	51.3[bc]	62.9[c]	317.87[a]	.297[a]

Superscript denotes categories whose proportions do not differ significantly from each other at the 0.05 level.
[a] = $p < .001$.

public green spaces also provide mental and physical health benefits (Martin et al.), serve as nature-based tourism destinations (Dwyer & Edwards, 2000), and include a variety of environmental types. Given the uncertainty of COVID-19 cases and the likelihood of increased outdoor activity year-round, extending the observation beyond spring and summer in areas with a cold climate would be useful and likely inform winter maintenance opportunities as well as future infrastructure planning.

Our environmental assessment included objective and fairly easily measured variables. However, additional consideration of trail conditions and perceptions of trail quality may be useful. While we included encounters from all directions, we did not address encounter direction specifically or encounter duration which would both impact exposure and safety issues. In addition, while we had a proxy for density, we do not have the visitor perceptions of how that impacted their experience. Similarly, in terms of signage, as noted we assessed only its presence not

Table 3
Comparing trail encounters and physical distancing compliance by trail width, 2020.

Trail width ft/m	8/2.4 (n = 2961)	10/3.1 (n = 1442)	12/3.7 (n = 1175)	15/4.6 (n = 408)	Chi Squared	Cramer's V
% any encounters	78.6[a]	42.9[bc]	45.7[c]	37.5[b]	794.28[a]	.364[a]
% encounters compliant	57.4[a]	20.1[b]	37.1[c]	48.7[ac]	299.56[a]	.288[a]

Superscript denotes categories who proportions do not differ significantly from each other at the 0.05 level.
[a] = $p < .001$.

Table 4
The relationship between physical distancing compliance and maximum number of encounters during an observation period, 2020.

	Florida DP	Florida HRT	Illinois HAS	MN S	MN W	Texas CB	Texas WRT
Max number of observations during observation period	65	104	33	55	31	21	61
Correlation of % encounters compliant	.495[b]	.346[b]	.062	-.068[b]	-.020	-.072	-.100[a]

Where.
[a] indicates significance at the .05 level and.

[b] at .01.

Table 5
Comparing physical distancing compliance by signage present, 2020.

Site	Florida HRT	Illinois HAS	MN S	MN W	Texas WRT
% compliant with sign present	0.00	62.7	55.4	51.2	36.4
Chi Square	47.129[a]	1.125	8.45[b]	4.33[c]	137.76[a]
Phi	-.423[a]	.072	-.064[b]	.254[c]	.506[a]

where,
[a] = $p < .001$.

[b] = $p < .01$.

[c] = $p < .05$.

its content. Research reveals varied effectiveness of signage appeals (Guo et al., 2015; Taff et al., 2017; Winter, 2006) and success (Kidd et al., 2015) but recommends consistent messaging for COVID-19 and other health-related issues (Slater et al., 2020). In fact, Kidd et al. revealed signs deployed in their study were ineffective at limiting off-trail use beyond what can be accomplished with trail markers and directional signs. We did not address on-the-ground markers or messaging, which is being used in some settings, and certainly the impact of social media messaging is of interest. Beyond onsite signage, providing real-time density information has informed other COVID-19 related destination choices (Adam et al., 2020), and sharing such information heralded as a 'powerful tool' for policy makers. Further, as mask wearing recommendations emerged in the middle of our data collection period, they were not included in our initial data collection. Given the significant protection afforded by masks and the likelihood of their continued use throughout the COVID-19 pandemic and other potential health crises, including them in future research would be essential.

Data collection itself was obviously labor-intensive. Automating both the data capture and analysis process through videos and computer vision has the appeal to reduce costs, increase the type and breadth of data collected, as well as compare accuracies among collection types. For example, busy trail sections present a challenge to count and estimate distancing: are human observation or are algorithmic assessments of video assessments more reliable and how do the costs compare?

Additional data in the form of interviews, surveys or focus groups could provide insight into user perceptions of COVID-19 fears, experience use histories, and other variables of interest. Visitor displacement is likely due to fear and density issues (Wang & Ackerman, 2019). Further, Lopez et al. (2020) suggest that COVID-19 elicited new users who may not have recreational behavior norms, and therefore may contribute to unsafe encounters. Beyond users, data on non-users can inform ways to retain or improve health and recreation experiences in public green spaces. We look forward to the myriad of data that will emerge during the COVID-19 era and the opportunities to improve resident health and

Table 7
Comparing off-trail movement by trail width, 2020.

Trail width ft/m	8/2.4 (n = 2961)	10/3.1 (n = 1442)	12/3.7 (n = 1175)	15/4.6 (n = 408)	Chi Squared	Cramer's V
% of observed group with any one moving off trail	14.8[a]	5.2[b]	9.2[b]	7.2[ab]	40.308[a]	.119[a]

Superscript denotes categories who proportions do not differ significantly from each other at the 0.05 level.
[a] = $p < .001$.

Table 6
Comparing off-trail movement among select trail sites and groups observed, 2020.

% off-trail behavior/Site	Florida DP	Florida HRT	Illinois HAS	MN S	MN W	Texas CB	Texas WRT	Chi Squared	Cramer V
% observed group	5.6[a]	5.7[a]	42.1[b]	10[ac]	19.7[c]	10.5[ac]	8.2[ac]	235.50[a]	.257[a]
% encountered group	5.3[ab]	3.0[b]	41.1[c]	12.0[d]	14.8[ad]	7.2[abd]	9.2[ad]	232.192[a]	.244[a]
% both groups	.4[ab]	.4[b]	9.5[c]	.7[d]	5.2[d]	.7[abd]	.2[ad]	384.459[a]	331[a]

Superscript denotes categories where proportions do not differ significantly from each other at the 0.05 level.
[a] = $p < .001$.

Table 8
Comparing encounters and off-trail movement between sites with similar widths (8 feet) but in different communities.

Site	Minnesota W	Illinois HAS	Chi Squared	Phi
% any encounters	17.4	53.3	113.001[a]	.374[a]
% off-trail behavior group observed	19.7	42.1	10.19[b]	.193[a]
% off-trail behavior group encountered	14.8	41.1	14.455[a]	.229[a]

[a] = $p < .001$.

[b] = $p < .01$.

Table 9
Comparing encounters and off-trail movement between sites with 10-feet-wide paths and within Gainesville, Florida.

Site	DP	HRT	Chi Squared	Phi
% any encounters	47.0	60.1	17.76***	.130***
% off-trail behavior group observed	5.6	5.7	.001	–
% off-trail behavior group encountered	5.3	3.0	1.702	–

visitor quality while protecting or even improving the environment.

Parks and trails are especially important infrastructure for physical and mental health during a pandemic (Derks et al., 2020; Lopez et al., 2020). Considered an essential service, it is imperative that green spaces are managed for a safe recreational environment (Gstaettner et al., 2019). Our findings provide preliminary information on visitor compliance behavior that can inform visitor management throughout COVID-19 or similar pandemics.

CRediT authorship contribution statement

Ingrid E. Schneider: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft. **Megha Budruk:** Methodology, Writing – original draft. **Kim Shinew:** Methodology, Formal analysis, Investigation. **Christopher J. Wynveen:** Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review and editing. **Taylor Stein:** Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review and editing. **Deonne VanderWoude:** Methodology, Writing – review and editing. **William W. Hendricks:** Methodology, Writing – review and editing. **Heather Gibson:** Methodology, Writing – review and editing.

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