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# Access to Soft-Surface, Green Exercise Trails in Mountainous, Urban Municipalities

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**ABSTRACT:** Soft-surface exercise infrastructure (ie off-road, mountain, and dirt trails) has been a particularly valuable community asset in mountainous, urban municipalities. This off-road, trail infrastructure can encourage individuals to engage in green exercise (ie physical activity done outside while in nature, for example, mountainous trails and near waterways). Green exercise can be helpful for encouraging individuals to participate in exercise who otherwise may not; it is especially helpful for promoting mental well-being and a sense of being connected to the environment. This study characterizes trail access and predictors among urban, mountainous municipalities in the Utah Wasatch Front region. Access was determined using two-standard deviation ellipses (2SDE) activity space analysis, and predictors were identified using multiple linear regression. About 42% municipalities had no trailhead access (ie no trailhead within its corresponding activity space). Trail density and trailheads were significantly correlated ( $r=0.49$ ,  $P=.004$ ). There was a significant trail density cluster in the southern area of the study region, centered all over the city of Alpine. Reduced-model regression yielded trailheads and home income as being significant predictors of trail density, and trail density and elevation as being significant predictors for trailheads. Results demonstrate patterns of access to green exercise trails that align with socioeconomic and municipal elevation. The results of this research should be insightful for those who work in exercise promotion and urban planners.

**KEYWORDS:** bicycling, infrastructure, trail, green exercise, spatial

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## Introduction

Many urban, mountainous municipalities have abundant natural setting for “green” recreational exercise. Exercise facilities are primarily manifested in trails, which can be used for mountain biking, trail running, hiking, equestrianism, and other outdoor recreation activities. Green exercise is a physical activity done outside while in nature (eg mountainous trails, near waterways, wilderness areas, countryside, and urban green areas), and it is beneficial to physical and mental health.<sup>1,2</sup> Access to green exercise has most often been examined in large municipalities,<sup>3,4</sup> but there is little research that explores green space access in the American Intermountain West. This study sought to examine access to green exercise space (ie off-road and soft-surface trails) among urban Utah municipalities. The urban area of the Utah Wasatch Mountain Range spans roughly 65 km north and 65 km south of Salt Lake City. This setting is similar to those found in other urban, mountainous areas such as Denver and Boulder, Colorado; Santa Fe and Albuquerque, New Mexico; or Geneva, Switzerland.

## Background

Any exercise, “green” or otherwise, is beneficial for reducing a host of morbidities and mortalities such as diabetes and obesity.<sup>5</sup> Individuals who use their built environment (eg for walking or biking) to facilitate this activity decreased rates of obesity, diabetes, and increased levels of overall physical activity.<sup>6,7</sup> There appears to be an inverse relationship between distance to built-environment resources and using green spaces (ie those who live closer are more likely to use green space).<sup>8</sup> Thus,

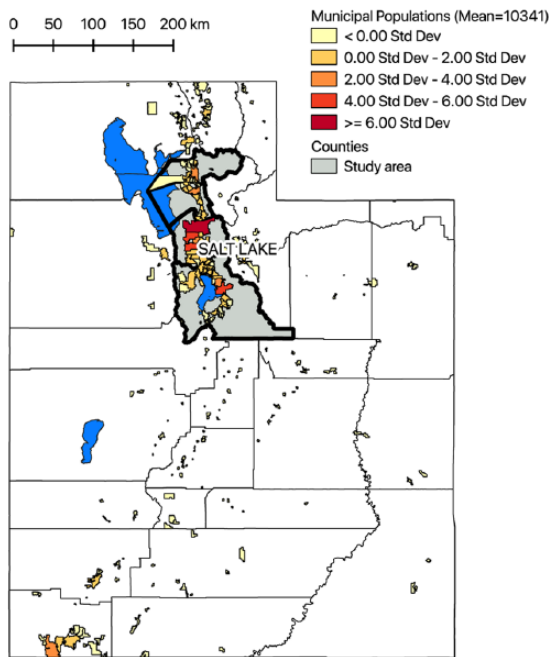
our study seeks to explore the green exercise (ie off-road and soft-surface trails) access in an urban, mountainous region.

Prior research shows that access to outdoor physical activity resources, including trails, is an important predictor for participation. For example, Huston et al<sup>9</sup> reported that proximal access to recreational facilities was positively associated with leisure activity engagement (odds ratio [OR]=2.28, [1.30–4.00]). Roemmich et al<sup>10</sup> reported that children are significantly more likely to utilize parks and be physically active with increase park density in their neighborhood. However, Franzini et al<sup>11</sup> point out that access to outdoor physical activity resources is unequal across neighborhoods and that the starkest differences are between socioeconomic and racial groups. Gladwell et al describe the positive benefits to outdoor exercise, green exercise, being increased physical activity and improved well-being. They also describe access to outdoor recreation as being an important barrier for participation.<sup>12</sup> This is important in the context of findings by Librett et al<sup>13</sup> who reported that trail users were much more physically active than non-trail users (OR=2.3, [1.9–2.8]) and that trail users largely rely on infrastructure within their own community to their trail activities. Thus, built environment is shown to, in part, be a determinant of green exercise.

Green exercise appears to be particularly beneficial to mental well-being. On comparing individuals who completed the same exercise routine indoors and outdoors, general results showed that outdoor exercise was more beneficial to mood, energy, and well-being.<sup>14</sup> Similarly, Pretty et al<sup>2</sup> reported on the benefit of green exercise for improving mood and self-esteem.



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**Figure 1.** Population by municipality in Utah. The map shows the highly populated area between Utah and Weber Counties. Counties with municipalities selected for this study are indicated in gray.

The effect of exercising outside can be seen across rural and urban settings. This effect is moderated by the pleasantness of the scene (eg landscapes or vistas compared with dilapidated buildings or junk yards).<sup>15</sup> Both men and women experience benefits of using green exercise, but men seem to experience greater mood and self-esteem boosts. Young people also tend to benefit the most from green exercise, but all age groups receive positive benefits.<sup>1</sup>

These findings can, in part, be described using health behavior theory. A foundational concept of the Social Cognitive Theory is that of reciprocal determinism; that individuals, their environment, and their behavior form an important relationship where changes to one (eg environment) can lead to changes in the other (eg behavior).<sup>16,17</sup> In other words, individuals are producers and products of their environment. Another important element of Social Cognitive Theory is self efficacy, and individual's belief or confidence they are able to accomplish a task. Lack of access to outdoor physical activity resources has been shown as an inhibitor to self efficacy in context of the Social Cognitive Theory, and a reducer of individual physical activity.<sup>18,19</sup> Thus, examining trail access serves to explore the health behavior characteristics of environmental determinism.

Specifically, this environmental justice literature has mostly focused on urban areas, and there's relatively little work on access to outdoor recreation in mountainous areas from this perspective (however, Floyd & Johnson outline that part of the problem is how we conceptualize and operationalize environmental justice in outdoor recreation<sup>20</sup>). Studies examining environmental justice in urban areas have found differing

access to parks by race and ethnicity, including park size where whites were more likely to be nearer larger parks<sup>3</sup> and ethnic minorities being nearer more congested parks.<sup>21,22</sup> Wolch et al<sup>23</sup> argue that efforts to increase green space in urban settings can lead to gentrification and displacement of the very residents it was aimed to help. Though this urban-environment relationship has been well documented, the urban-wilderness interface has not. Therefore, our study seeks to examine soft-surface trails within a mountainous, semi-urban region.

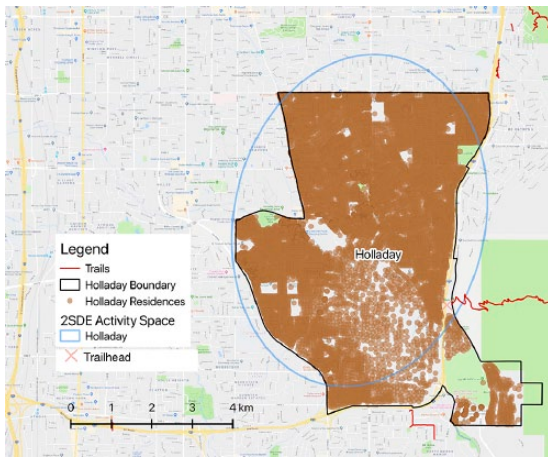
Most prior efforts to address access and environmental justice have examined the issue from a neighborhood, tract, or block group perspective. Prior literature has shown that residents are more likely to recreate using facilities in their own neighborhoods.<sup>3,4,22</sup> These studies make observations in large, urban settings (eg Baltimore or Los Angeles), where each neighborhood or zip code would have greater residential density and population density than many municipalities in the Intermountain West. With this fact, it is worth considering the rural-urban municipality as comparable to the urban neighborhoods of these other cities. At least geospatially and culturally, there are similarities. Similarly, some studies have used zip code as its geographic unit,<sup>24,25</sup> but in the Intermountain West, many municipalities, even those classified as urban, only have a single zip code. Rigolon et al<sup>26</sup> note the micro-level analysis as a limitation of park access in the United States because it limits the broad context view municipal-wide analysis allows. Others noted the value of city-level is also where many policy, funding, and facilities management decisions are made.<sup>26,27</sup>

We specifically sought to address the following research questions: (1) What is the prevalence of municipal trail head access?; (2) Is there significant spatial clustering of trailhead access?; and (3) What are municipal-level predictors of trail density and trailhead access?

## Methods

### Setting

The Western face of the Wasatch Front mountain range is the most populated region in Utah, where about 80% of the state population resides (Figure 1).<sup>28</sup> This narrow strip of land is roughly 140-km long and 5- to 30-km wide. The Salt Lake metropolitan area and Provo-Orem have population-weighted densities exceeding 4250 people per square mile (1642 per square km) which places them among the top 50 most densely populated cities in the United States.<sup>29</sup> The natural environment in this area affords residents the ability to find green exercise spaces (eg hiking, skiing, and mountain biking). If predictions are correct, Utah's population is expected to double by the year 2050.<sup>30</sup> Many other mountainous states, such as Colorado and Arizona, have experienced greater than 6% population growth in the past 15 years.<sup>31</sup> This region was selected because it has a long (140 km) region of urban municipalities that directly borders mountain land; it can provide insights into other similar regions; and, data were widely available to answer



**Figure 2.** Activity space for Holladay, UT. The map shows residents of Holladay, Utah, the corresponding activity space, and one trailhead appearing within the activity space.

research questions posed in this article. The purpose of this article is to characterize trail access in an urban, mountainous area.

### Urban municipalities

Utah municipalities were chosen based on urban classification and geographical proximity to the western face of the Wasatch Mountains. The USDA Business & Industry defines “urban areas” as municipalities with greater than 50 000 residents and their adjacent and contiguous neighbors.<sup>32</sup> This criterion yielded 33 municipalities found in four counties bordering the Wasatch front. Two municipalities were not included because of their distant location from this aggregated core of urban areas along the Wasatch Front (St. George in southern Utah, and Logan, in northern Utah).

### Data and analysis

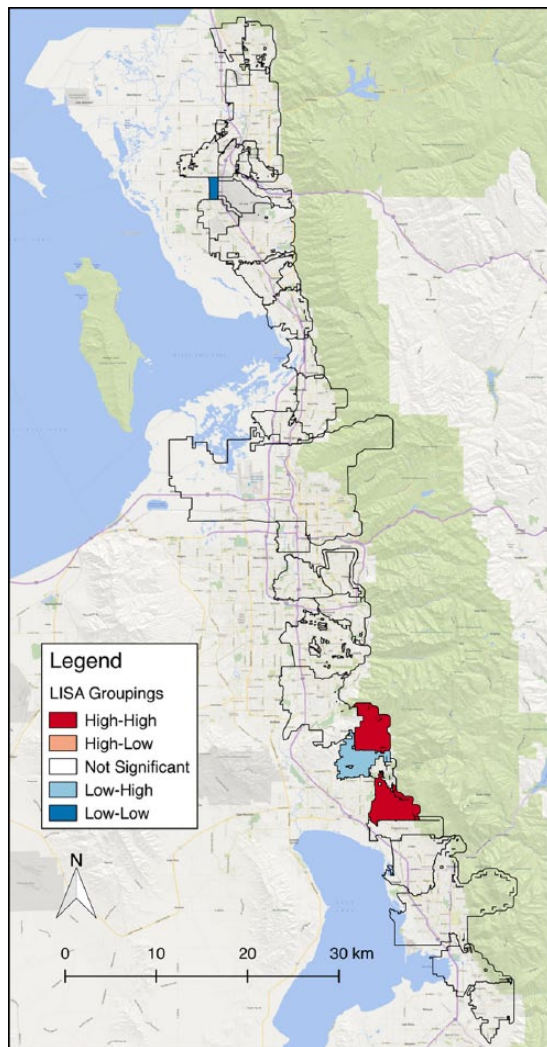
Socioeconomic and commuting data for each municipality were obtained from the US Census.<sup>33</sup> The state-wide trail system geographic information systems (GISs) shapefile and municipal boundaries were obtained from the Utah State mapping portal website.<sup>34</sup> A 1-km buffer was added to the mountain-facing side of each municipality (East) to capture trailheads that may not have been within city limits (roughly 90% of land within this buffer is private, city-owned land<sup>35</sup>). The trails shape file was clipped to the buffered municipalities to measure trailhead access. Similarly, household point data were obtained from the same portal website for activity space analysis.<sup>36</sup> R statistical software was used for data management analysis<sup>37</sup> and QGIS was used for geospatial visualization.<sup>38</sup>

**Trailhead access.** A trailhead is the access points to a trail or network of trails. Access to trailheads within municipalities was determined, first by computing each municipality’s activity space, and second, by determining if the activity space overlapped with trailheads. Activity space can be thought of as a

way to explain individual’s movements and how they are likely to interact with their environment, including how accessible community resources are.<sup>39</sup> In our case, we used a two-standard deviation ellipse (2SDE) around the municipality residential points. This provides a two-dimensional ellipse or activity space. If a point of interest were to appear within that ellipse it is very likely the resident population has access to it. In our case, we observed if trailheads were within each municipality’s activity space. For example, Figure 2 shows the city of Holladay (population 26 400), the corresponding activity space, and one trailhead present within that space. Though there are other methods to measure access, our focus on municipal-wide analysis leads us to this larger scoped analysis. The activity space provides insight into “coverage” or “cumulative opportunities” within the core area of the municipality.<sup>4</sup>

**Deciphering spatial patterns of municipal trail densities.** Determining if municipalities exhibit spatial patterns with respect to trail density was done so using two-step process. First, the global pattern across the entire space was determined using Moran’s  $I$  for spatial autocorrelation (ie  $I < 0$  is a uniform pattern,  $I = 0$  is a random pattern, and  $I > 0$  represents a clustered pattern).<sup>40</sup> Although these results determine what type of pattern exists, the nature of the pattern remains unknown. A second step is needed to visualize local clusters. Second, determining the nature of the pattern was determined using Local Indicators of Spatial Autocorrelation (LISA). This procedure works by comparing individual municipality variables with neighboring municipality variables.<sup>41</sup> In essence, this is a comparison of the standardized municipal observation, the standardized spatial lag (or average of the municipality neighbors), and the local Moran’s  $I$  statistic. Results from this analysis typically produce a combination of “high” or “low” in a two-word sequence for each municipality (eg high-high or high-low). The first word indicates the individual municipality’s variable, and the second word indicates what the individual municipality’s neighbors (ie spatial lag) variable is in comparison to the individual. For example, for trail density, a high-low result demonstrates an individual municipality that has high level of trail density and its neighbors are generally low.

**Identifying predictors of trail density and trailhead access.** Municipal-level predictors were identified using multiple linear regression with trail density as the dependent variable and municipal-level predictors as the independent variables. Assumptions for linear regression, namely normal distribution and equal variance, were determined using Normal QQ and equal variance plots. Municipal-level variables used were population density;<sup>24,27</sup> median household income, housing value, poverty rate, educational attainment, and property tax;<sup>26,42-45</sup> businesses, land area, elevation;<sup>46</sup> percent women;<sup>47</sup> and bicycle and walking commuters.<sup>48</sup> Backward elimination was used to find a best-fit model.<sup>49</sup>



**Figure 3.** Localized clusters of trail density urban Utah municipalities. Analysis shows the results of LISA analysis, where the first word indicates the individual municipality and the second word represents the aggregated measure, or lag, of its neighbors (eg Highland [center, blue] is low for trail density and its neighbors are high for trail density).

## Results

A total of 33 urban municipalities were surveyed along the western face of the Wasatch Mountains. On average, municipalities had 19.64 km (standard deviation [SD]=30.63, range=[0, 153.93]) of off-road, soft-surface trails. On average, municipalities had 2.10 (SD=2.45) trailheads and an average trail density of 0.54 km/km<sup>2</sup> (SD=0.60). Excluding municipalities that had no trailhead, municipalities with a trailhead had an average trail density of 0.78 km/km<sup>2</sup> (SD=0.64) and an average of 3.63 trailheads (SD=3.92). Roughly, two in five municipalities had no trailhead access within its activity space (42.4%), and 57% of these had no trailheads within 2 km of municipal boundaries.

Trail density was observed in a significant clustering pattern ( $I=1.54$ ,  $P=.06$ ). Since this initial step is used to justify proceeding with a more spatially local analysis, the slightly elevated  $P$  value is noted but considered low enough to proceed with LISA analysis. Number of trail heads was not significantly

clustered ( $I=0.06$ ,  $P=.48$ ) and appeared to be a random pattern. Trail density and number of trailheads were significantly correlated ( $r=0.49$ ,  $P=.004$ ), indicating that increased number of trailheads is related to greater trail density. Figure 3 shows a large, positive cluster of trail density around the Alpine/Pleasant Grove area, indicating that these areas have significantly high trail density, as do their neighbors.

Trail density and trailheads were regressed on the set of municipal-level predictors using multiple linear regression. Backward elimination was used to identify variables from among this set that were significant predictors of trail length. Table 1 presents the full and reduced models for both model sets. Both trail density and trailheads were significant predictors for the opposite models, due to their correlated nature. In the reduced model, median household income was a significant predictor for trail density; and elevation was a significant predictor for trailheads.

## Discussion

We sought to characterize urban, mountainous green exercise trail access among municipalities bordering the Wasatch Mountains in Utah. In general, trail density correlated with trailhead access points. In addition to this, elevation was a significant predictor for trailheads and home value was a significant predictor of trail density. There was some clustering effect for trail density. Roughly, two in five municipalities had no trailhead in their activity space.

The correlated nature of trail density and trailheads may be explained in two ways. In reciprocal determinism, more trails contribute to more trailheads, vice versa and so on.<sup>16</sup> Another way would be the “herd effect” described among bicyclists. Jacobsen and colleague<sup>48,50</sup> described the additive effect having bicyclists in a community. The more bicyclists there are in an area, the safer they tend to be on the road. It is thought that more bicyclists on the road create a protective, “herd effect” on the collective bicycling population. It may be a similar mechanism with trail density, trailheads, and participant usage, in that more participants lead to more trails, and so on. It is possible that municipalities with more trails tend to have a more developed trail use society and culture, thus driving the capital infrastructure investment.

We expected some level of geographic variation for trail density among municipalities, but the location of those “highs” and “lows” were previously unknown. Geographic variation has been noted in a variety of other settings. For example, bicycle crashes<sup>24</sup> and access to physical activity facilities and exercise performance.<sup>51</sup> Because of this, trail density and access was not expected to be uniform across the space studied. There may be topological differences among these locations that make trail building more conducive. More likely, these patterns correspond to municipal-level differences in socioeconomic levels, and/or trail use. Some of these same socioeconomic factors were significant predictors of municipal trail length, namely higher home

**Table 1.** Predictors of trail density and trailheads among Utah urban, mountainous municipalities.

MODEL	TRAIL DENSITY			TRAILHEADS		
	B	SE (B)	T	B	SE (B)	T
<b>Full</b>						
Population density	0.00026	0.00045	0.55	-0.00041	0.0029	-0.14
Median income	0.000012	0.000015	0.88	-0.000030	0.00010	-0.31
Land area	0.015	0.011	1.85	-0.011	0.72	-0.15
Elevation	0.00085	0.00065	1.29	-0.055	0.0042	-1.30
Home value	-0.0000007	0.0000032	-0.21	0.000007	0.00002	0.36
Poverty	5.29	3.70	1.43	-13.8	24.6	-0.56
Businesses	-0.00012	0.000099	-1.22	-0.000049	0.00066	-0.06
Female %	8.43	10.8	0.78	-67.7	68.4	-0.99
Educational attainment	1.47	1.92	0.76	-1.65	12.4	-0.13
Bicycle commuter %	11.97	20.6	0.58	-100.5	130.8	-0.76
Walking commuter %	-11.11	9.71	-1.15	39.5	63.4	0.62
Property tax rate	-369.4	248.5	-1.48	1351.0	164.8	0.82
Trailheads	0.076	0.031	2.42*	-	-	-
Trail density	-	-	-	$\beta=3.10$	3.10	2.42*
R <sup>2</sup>	0.53			0.42		
<b>Reduced</b>						
Median income	0.000012	0.000005	2.72*			
Trailheads	0.076	0.025	2.94**			
R <sup>2</sup>	0.39					
Elevation	-			-0.0049^	0.0026	-1.87^
Trail density	-			3.33	0.91	3.67***
R <sup>2</sup>	-			0.31		

\*\*\*P < .001; \*\*P < .01; \*P < .05; ^P < .10.

income (higher home income correlated with more trails, or increases in US\$10 000 income results in roughly 0.12 more km/km<sup>2</sup>). Over the space of a municipal boundary interface with the mountain area, this can result in many more kilometers of trails available. One study notes that bicycling infrastructure often attracts and caters to higher socioeconomic groups.<sup>52</sup> This higher home value could be related to greater municipal-driven trail development. For example, Draper City (population=45 285, trail density=1.98 km/km<sup>2</sup> [highest among study area], and home value=US\$371 000 [third highest in study area]) have significant municipal trail development investment.<sup>53</sup>

Elevation being a significant predictor within the trailhead model may be a function of convenience. As noted by Jones et al,<sup>8</sup> proximity and green exercise are inversely related. Thus, higher elevation is more distant from residential areas. This may have

developed naturally as a result of the reciprocal determinism: participant is a producer and product of their environment.<sup>16</sup> That is, users do not want to travel far to participate in green exercise.

This study has inherent limitations. As this was an exploratory research, we only examined one metropolitan, mountainous region at a single point in time. Although there are other ways to classify a municipality as urban or not, we chose to measure urban using the USDA Business & Industry classification. In the Intermountain American West, there are much fewer large metropolitan areas than the Eastern United States or European countries. This classification allowed us to include municipalities along the Wasatch Front. We measured municipalities as being mountainous as those with boundaries adjacent to the mountains. We chose not to include municipalities not directly bordering the mountains because the study purpose was to examine trailhead

access. In addition, we did not have access to bicycling data from these areas. For most of them, these data does not exist. For the few who do collect these data, it is infrequently collected and the measures are generally not comparable. This study only analyzed data for 33 municipalities across one metropolitan region in the United States. Despite this, there are important lessons worth considering in other comparable areas, such as New Mexico, California, Colorado, the Swiss Alps (eg Geneva), or Southern British Columbia, Canada.

Our research demonstrates patterns of access to green exercise trails that differ by location and with respect to home value and elevation. The discovery that 42% of municipalities do not have trailhead access may be a restriction on actual green exercise. These unpaved, mountainous trails may be a way to provide infrastructure for individuals to get adequate exercise.<sup>1</sup> In municipal investment, Dill and Carr point out that built infrastructure gets used.<sup>54</sup> These mountainous trails have also been shown to improve mental health and act as a way to improve mood and self-esteem.<sup>2,15</sup> It is important for parks and land managers, as well as public health practitioners interested in promoting exercise to consider ways to promote “green” exercise via off-road, soft-surface trail development. Future research needs to examine the relationship between trail infrastructure and actual participant behavior. It would be beneficial to examine other urban, mountainous regions as well (eg municipalities in Colorado, California, British Columbia, and other European regions) Urban, mountainous municipalities have ample opportunity to engage participants in green exercise. Some appear to be making this a reality for residents and others are not. It is recommended for city planners, recreation managers, and public health officials to consider a variety of ways to promote green exercise. This may include trail building programs<sup>55-57</sup> or transit to trail programs; in either case, residences have easier access to green exercise space.

### Author Contributions

RC and ES conceived of the research idea. ES performed data collection. RC performed data analysis and wrote the manuscript in consultation with ES. All authors reviewed background literature, discussed the results, and contributed to the final manuscript.

### REFERENCES

- Barton J, Pretty J. What is the best dose of nature and green exercise for improving mental health? a multi-study analysis. *Environ Sci Technol*. 2010;44:3947–3955. doi:10.1021/es903183r.
- Pretty J, Peacock J, Hine R, Sellens M, South N, Griffin M. Green exercise in the UK countryside: effects on health and psychological well-being, and implications for policy and planning. *J Environ Plann Man*. 2007;50:211–231.
- Boone CG, Buckley GL, Grove JM, Sister C. Parks and people: an environmental justice inquiry in Baltimore, Maryland. *Ann Assoc Am Geogr*. 2009;99:767–787. doi:10.1080/00045600903102949.
- Talen E. Neighborhoods as service providers: a methodology for evaluating pedestrian access. *Environ Plann B*. 2003;30:181–200. doi:10.1068/b12977.
- Centers for Disease Control and Prevention. Physical activity and health. <https://www.cdc.gov/physicalactivity/basics/pa-health/>. Published 2015. Accessed September 23, 2016.
- Pucher J, Buehler R, Bassett DR, Dannenberg AL. Walking and cycling to health: a comparative analysis of city, state, and international data. *Am J Public Health*. 2010;100:1986–1992.
- Taddei C, Gnesotto R, Forni S, Bonaccorsi G, Vannucci A, Garofalo G. Cycling promotion and non-communicable disease prevention: health impact assessment and economic evaluation of cycling to work or school in Florence. *PLoS ONE*. 2015;10:e0125491. doi:10.1371/journal.pone.0125491.
- Jones A, Hillsdon M, Coombes E. Greenspace access, use, and physical activity: understanding the effects of area deprivation. *Prev Med*. 2009;49:500–505. doi:10.1016/j.ypmed.2009.10.012.
- Huston SL, Evenson KR, Bors P, Gizlice Z. Neighborhood environment, access to places for activity, and leisure-time physical activity in a diverse North Carolina population. *Am J Health Promot*. 2003;18:58–69. doi:10.4278/0890-1171-18.1.58.
- Roemmich JN, Epstein LH, Raja S, Yin L, Robinson J, Winiewicz D. Association of access to parks and recreational facilities with the physical activity of young children. *Prev Med*. 2006;43:437–441. doi:10.1016/j.ypmed.2006.07.007.
- Franzini L, Taylor W, Elliott MN, et al. Neighborhood characteristics favorable to outdoor physical activity: disparities by socioeconomic and racial/ethnic composition. *Health Place*. 2010;16:267–274. doi:10.1016/j.healthplace.2009.10.009.
- Gladwell VF, Brown DK, Wood C, Sandercock GR, Barton JL. The great outdoors: how a green exercise environment can benefit all. *Extrem Physiol Med*. 2013;2:3. doi:10.1186/2046-7648-2-3.
- Librett JJ, Yore MM, Schmid TL. Characteristics of physical activity levels among trail users in a U.S. national sample. *Am J Prev Med*. 2006;31:399–405. doi:10.1016/j.amepre.2006.07.009.
- Thompson Coon J, Boddy K, Stein K, Whear R, Barton J, Depledge MH. Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? a systematic review. *Environ Sci Technol*. 2011;45:1761–1772. doi:10.1021/es102947t.
- Pretty J, Peacock J, Sellens M, Griffin M. The mental and physical health outcomes of green exercise. *Int J Environ Health Res*. 2005;15:319–337.
- Bandura A. Social cognitive theory: an agentic perspective. *Annu Rev Psychol*. 2001;52:1–26. doi:10.1146/annurev.psych.52.1.1.
- Boston University School of Public Health. The social cognitive theory. <http://sphweb.bumc.bu.edu/otlt/MPH-Modules/SB/BehavioralChangeTheories/BehavioralChangeTheories5.html>. Published 2016. Accessed February 18, 2018.
- Booth ML, Owen N, Bauman A, Clavisi O, Leslie E. Social-cognitive and perceived environment influences associated with physical activity in older Australians. *Prev Med*. 2000;31:15–22. doi:10.1006/pmed.2000.0661.
- Wechsler H, Devereaux RS, Davis M, Collins J. Using the school environment to promote physical activity and healthy eating. *Prev Med*. 2000;31:S121–S137. doi:10.1006/pmed.2000.0649.
- Floyd MF, Johnson CY. Coming to terms with environmental justice in outdoor recreation: a conceptual discussion with research implications. *Leis Sci*. 2002;24:59–77. doi:10.1080/01490400252772836.
- Sister C, Wolch J, Wilson J. Got green? addressing environmental justice in park provision. *Geojournal*. 2010;75:229–248. doi:10.1007/s10708-009-9303-8.
- Wolch J, Wilson JP, Fehrenbach J. Parks and park funding in Los Angeles: an equity-mapping analysis. *Urban Geogr*. 2005;26:4–35. doi:10.2747/0272-3638.26.1.4.
- Wolch JR, Byrne J, Newell JP. Urban green space, public health, and environmental justice: the challenge of making cities “just green enough.” *Landsc Urban Plan*. 2014;125:234–244. doi:10.1016/j.landurbplan.2014.01.017.
- Chaney RA, Kim CJ. Characterizing bicycle collisions by neighborhood in a large Midwest city. *Health Promot Pract*. 2014;15:232–242.
- Acevedo-Garcia D. Zip code-level risk factors for tuberculosis: neighborhood environment and residential segregation in New Jersey 1985–1992. *Am J Public Health*. 2001;91:734–741.
- Rigolon A, Browning M, Jennings V. Inequities in the quality of urban park systems: an environmental justice investigation of cities in the United States. *Landsc Urban Plan*. 2018;178:156–169. doi:10.1016/j.landurbplan.2018.05.026.
- Joassart-Marcelli P, Wolch J, Salim Z. Building the healthy city: the role of non-profits in creating active urban parks. *Urban Geogr*. 2011;32:682–711. doi:10.2747/0272-3638.32.5.682.
- Utah AGRC. 2010 demographic data. *Utah GIS Portal*. <https://gis.utah.gov/data/demographic/2010-census-data/>. Published 2010. Accessed September 23, 2016.
- U.S. Census Bureau. Patterns of metropolitan and micropolitan population change: 2000 to 2010. [http://www.census.gov/population/metro/data/pop\\_pro.html](http://www.census.gov/population/metro/data/pop_pro.html). Published 2011. Accessed September 21, 2016.
- Utah Foundation. *A Snapshot of 2050: An Analysis of Projected Population Change in Utah*. Utah Foundation. <http://www.utahfoundation.org/reports/snapshot-2050-analysis-projected-population-change-utah/>. Published 2014. Accessed September 23, 2016.
- U.S. Census Bureau. NST-EST2018-02: Table 2. Cumulative estimates of resident population change for the United States, Regions, States, and Puerto Rico and Region and State Rankings: April 1, 2010 to July 1, 2018 [data file]. <https://www.census.gov/newsroom/press-kits/2018/pop-estimates-national-state.html>.

32. USDA. USDA economic research service—rural classifications. <http://www.ers.usda.gov/topics/rural-economy-population/rural-classifications.aspx>. Published 2013. Accessed June 7, 2016.
33. U.S. Census Bureau. Quick facts. <https://www.census.gov/quickfacts/>. Published 2015. Accessed September 22, 2016.
34. Utah AGRC. Coordinating a statewide recreational trails GIS dataset. <http://gis.utah.gov/coordinating-a-statewide-recreational-trails-gis-dataset/>. Published 2014. Accessed October 16, 2015.
35. Utah GIS Portal. Land ownership. <https://gis.utah.gov/data/cadastre/land-ownership/>. Published 2019. Accessed February 1, 2019.
36. Utah AGRC. Address data. Utah GIS portal. <https://gis.utah.gov/data/location/address-data/>. Published 2016. Accessed February 17, 2018.
37. R Development Core Team. R: a language and environment for statistical computing. 2017. <https://cran.r-project.org/>.
38. QGIS Development Team. QGIS Geographic Information System; 2018. <https://qgis.org/en/site/>.
39. Sherman JE, Spencer J, Preisser JS, Gesler WM, Arcury TA. A suite of methods for representing activity space in a healthcare accessibility study. *Int J Health Geogr*. 2005;4:24. doi:10.1186/1476-072X-4-24.
40. Moran PAP. The interpretation of statistical maps. *J R Stat Soc Ser B Methodol*. 1948;10:243–251.
41. Anselin L. Local indicators of spatial association—LISA. *Geogr Anal*. 1995;27:93–115. doi:10.1111/j.1538-4632.1995.tb00338.x.
42. Brownson RC, Baker EA, Housemann RA, Brennan LK, Bacak SJ. Environmental and policy determinants of physical activity in the United States. *Am J Public Health*. 2001;91:1995–2003. doi:10.2105/AJPH.91.12.1995.
43. Parks SE, Housemann RA, Brownson RC. Differential correlates of physical activity in urban and rural adults of various socioeconomic backgrounds in the United States. *J Epidemiol Community Health*. 2003;57:29–35. doi:10.1136/jech.57.1.29.
44. Dahmann N, Wolch J, Joassart-Marcelli P, Reynolds K, Jerrett M. The active city? disparities in provision of urban public recreation resources. *Health Place*. 2010;16:431–445. doi:10.1016/j.healthplace.2009.11.005.
45. Wüstemann H, Kalisch D, Kolbe J. Access to urban green space and environmental inequalities in Germany. *Landsc Urban Plan*. 2017;164:124–131. doi:10.1016/j.landurbplan.2017.04.002.
46. Frank LD, Sallis JF, Conway TL, Chapman JE, Saelens BE, Bachman W. Many pathways from land use to health. *J Am Plann Assoc*. 2006;72:75–87.
47. Garrard J, Handy S, Dill J. Women and cycling. In: Pucher J, Buehler R, eds. *City Cycling*. Cambridge, MA: MIT Press; 2012:211–234.
48. Jacobsen PL. Safety in numbers: more walkers and bicyclists, safer walking and bicycling. *Inj Prev*. 2003;9:205–209. doi:10.1136/ip.9.3.205.
49. Faraway JJ. *Linear Models with R*. Boca Raton, FL: Chapman & Hall/CRC Press; 2004.
50. Jacobsen PL, Rutter H. Cycling safety. In: Pucher J, Buehler R, eds. *City Cycling*. Cambridge, MA: MIT Press; 2007:141–156.
51. Gordon-Larsen P, Nelson MC, Page P, Popkin BM. Inequality in the built environment underlies key health disparities in physical activity and obesity. *Pediatrics*. 2006;117:417–424.
52. Goodman A, Sahlqvist S, Ogilvie D. Who uses new walking and cycling infrastructure and how? longitudinal results from the UK iConnect study. *Prev Med*. 2013;57:518–524. doi:10.1016/j.ypmed.2013.07.007.
53. Draper City. Trails & open space. <http://www.draper.ut.us/116/Trails-Open-Space>. Published 2018. Accessed February 18, 2018.
54. Dill J, Carr T. Bicycle commuting and facilities in major U.S. cities: if you build them, commuters will use them. *Transp Res Record*. 2003;1828:116–123. doi:10.3141/1828-14.
55. Seattle.gov. Trails program (Seattle). <https://www.seattle.gov/parks/volunteer/trails-program>. Accessed February 1, 2019.
56. Fayetteville-AR.gov. Trail construction program. <https://www.fayetteville-ar.gov/1261/Trail-Construction-Program>. Accessed February 1, 2019.
57. International Mountain Bicycling Association. Trail solutions. <https://www.imba.com/explore-imba/trail-creation-and-enhancement/trail-solutions>. Accessed February 1, 2019.