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Student Led Campus Desire Path Evaluation Using Pictometry® Neighborhood Imagery

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Abstract

A student led evaluation of desire paths (e.g., paths created by pedestrians on an open landscape) across the Stephen F. Austin State University (SFASU) campus was performed within a senior level spatial science course in order to create a method for mitigation of desire paths and for campus beautification. Each desire path on campus was identified with the length of each path measured in the field and categorized by the condition of the path in order to assess and determine a necessary solution for each path identified. In addition, Pictometry® high spatial resolution digital imagery was used to determine if the categorization of the conditions of the desire paths, as well as the length of each desire path, could be identified and quantified without the need to measure each individual desire path in the field. Students, within an interactive hands-on classroom environment, compared in-field desire path measurements with Pictometry® on-screen measurements to determine the effectiveness of remotely sensed Pictometry® imagery to identify and quantify desire path location and length respectfully.

Keywords: Desire paths, Campus beautification, Pictometry®, Capstone, Spatial science

Introduction

In a capstone senior level spatial science sequence of two courses at Stephen F. Austin State University (SFASU) two undergraduate students completed a project analysis to provide solutions to campus conditions of desire paths. Desire paths are created by the natural ecology of the environment that has developed over time by pedestrians detouring from sidewalks and creating new paths on the landscape (Nichols, 2014). Desire paths tend to indicate the inefficiency of location of existing sidewalks. Desire paths are formed by foot traffic or bicyclists traveling on unpaved areas that follow the shortest distance (path) between location and destination. The desire paths identified on the campus of SFASU in Nacogdoches, Texas, reduce the aesthetic value of the campus while posing a risk for accidents.

Spatial science is an integral part of the natural resource curriculum in the Arthur Temple College of Forestry and Agriculture (ATCOFA) at SFASU and students pursuing a Bachelor of Science in Spatial Science can select one of two tracks in their major focusing on either natural resources management or surveying. The field of spatial science, via a recent curriculum evaluation within ATCOFA, was deemed a preferred skill set (4.22 on a 5point scale) for natural resource undergraduate students (Bullard, 2015). Additionally, the ability to apply analytical skills to measure and predict needs for natural resources is an important competency (4.30 out of 5) and students at ATCOFA were deemed to be well prepared in that endeavor via a recent curriculum evaluation (4.29 out of 5) (Bullard, D. Coble, T. Coble, Darville, Rogers, & Stephens Williams, 2014; Bullard, Stephens Williams, T. Coble, D. Coble, Darville, & Rogers, 2014).

Associated with desire paths is wayfinding, which is the mental process that pedestrians go through while they search for the most desirable path to travel between two physical locations. Wayfinding consists of four stages: Orientation, Route Decision, Route Monitoring, and Destination Recognition (Lidwell, Holden, & Butler, 2012). The first step, Orientation, is the process of locating one's place in the environment relative to the destination. The second step, Route Decision, is the selection of a path of travel across the landscape, usually the most clearly marked or the shortest distance. Route Monitoring is the process of continually updating the individual spatially in relation to their destination along the route of travel; the individual continually updates their location mentally for assurance of traveling along the correct path. The last step in the process is Destination Recognition where the traveler locates the end point of their path and adjusts their trajectory to meet the desired destination.

Desire paths are caused and created by application of the steps in way finding for both humans and animals. When people orient themselves between the beginning of their journey and the end, they make their route decision and continually process the route for problems or corrections. People generally take the shortest and most heavily used path to their destination even across an open unpaved landscape (Helbing, Keltsch, & Molnár, 1997) (Figure 1). Initially, pedestrians take direct ways to their destinations, but over time they begin to use already existing trails, as this is more comfortable than clearing new paths. With this selection process, frequently used trails are more attractive than others and are chosen most often, leading to reinforcement that makes them even more attractive. The effects of these paths can range from ephemeral trails to hazardous from erosion and uneven ground with a steep incline, exposed tree roots and rocks (Helbing, Keltsch, & Molnár, 1997). People tend to follow more developed trails and this information can be used

Figure 1. Example of a desire trail on the campus of SFASU

to both assess and repair desire trails (Helbing, Molnár, & Schweitzer, 1998). Reasons for establishing informal or desire trails include access to areas not reached by formal trails; avoiding undesirable conditions; exploration; poor trail marking; shortcuts to reduce hiking time; investigation of interesting plants or animals; or orienteering and geocaching (Wimpey &Marion, 2011). Once desire paths are formed, master plans and urban plans often view these as problematic and use barriers to block them or impede development (Norman, 2011) (Figure 2).

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2018, Vol. 8, No. 4

Figure 2. Example of an installed desire trail barrier to impede traffic flow at SFASU

To quantify and delineate these trails, both on the ground observation and remote sensing can be used. However, given the size of most desire paths the remotely sensed data format used to identify and quantify desire trails must be of high spatial resolution. Pictometry® Neighborhood hyperspatial remotely sensed digital imagery, with a 4-inch spatial resolution at nadir collected from four cardinal directions, can be displayed within a user friendly web-based interface to identify and quantify earth surface features with the small footprint of desire paths.

Pictometry® is an aerial application process patented by Pictometry International Corporation (Rochester, NY). Pictometry® data are acquired from aircraft with a vertical perspective and 40 degrees off-nadir to create a composite image (Gerke & Kerle, 2011; Wang, Schultz, & Giuffrida, 2008). Kulhavy, Unger, Hung and Douglass (2014) found Pictometry® was more accurate than LIDAR data in assessing height measurements; and baldcypress tree heights (Unger, Hung, & Kulhavy, 2014). Pictometry® did not differ from Google Earth measures but did from Unmanned Aerial Systems from a DJI Phantom 4 Pro drone (Viegut, Kulhavy, Unger, Hung, &Humphreys, 2018).

A student led evaluation of desire paths at SFASU was performed within a senior level spatial science class to determine if desire path locations can be identified via remotely sensed means in lieu of costly and time consuming ground observations. In addition, desire paths were analyzed using five categorizations (i.e., Hazardous, Erosive, Tracking Issue, Lost Sidewalk, Unsightly) and four types of solutions (i.e., Physical Barrier, Vegetative Barrier, New Sidewalk, Consolidation of Sidewalks). The final product of the student led desire path assessment and solution proposal will be used as a resource for campus beautification assessment and a reduction of potential liability from desire paths.

Methods

The student led assessment of desire path evaluation was performed on the campus of SFASU

Journal of Studies in Education
ISSN 2162-6952
2018, Vol. 8, No. 4

in Nacogdoches, Texas. The desire paths were initially identified on-screen within aweb-based interface using Pictometry® Neighborhood Imagery from 2013 with a spatial resolution of 10 cm obtained from the Pictometry® website (Figure 3). The length of all desire paths identified on-screen were then measured within the Pictometry® on-screen web-based interface to the nearest 100th of a meter (Figure 4). Once measured, student led solutions for each desire path were proposed and all desire path locations were digitized on-screen and imported into ESRI ArcMap software creating a map showing the spatial locations of each desire path on the SFASU campus.

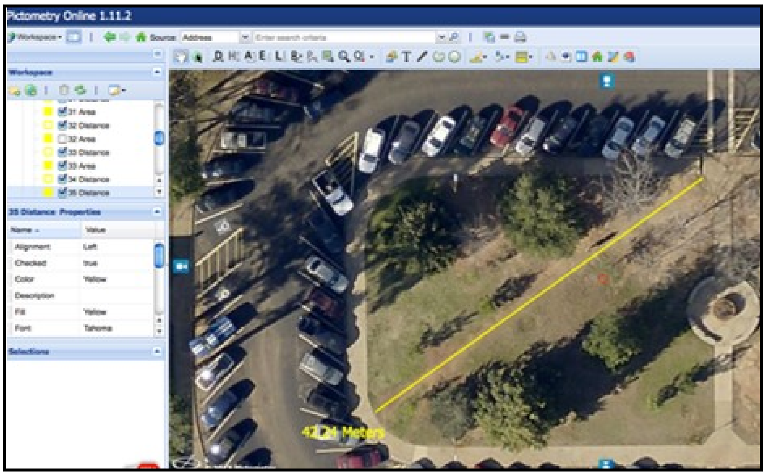

Figure 3. Identifying a desire trail on-screen within the Pictometry® web-based interface

Each desire path identified on-screen within the Pictometry® web-based interface was then visited in the field and the length and width of each desire trail was measured to the nearest 100th of a meter using a 50-meter tape. Each path was categorized as: 1) Hazardous: indicating a steep grade, tripping hazard, or falling hazard; 2) Erosive: where a path creates an erosion control issue; 3) Tracking Issue: close to or leading to a building entrance, creating a potential situation of excessive soiling; 4) Lost Sidewalk: a remnant of previous buildings, a path that is created by a dead end sidewalk; or, 5) Unsightly: a path that poses no other threat than being unappealing aesthetically.

These conditions were used to propose possible solutions for issues posed by each path. More than one condition can be applied to categorize a desire path. The solutions were discussed with the students during the physical assessment to present a remedy for each path. The paths were listed with one of the four solutions including: 1) Physical Barrier: fence, large rock, art installation; 2) Vegetative Barrier: flowerbed, terracing, signage; 3) New Sidewalk: pave, gravel, or brick over a path if it will persist and is useful; or, 4) Consolidation of Sidewalks: remove lost sidewalks and use the existing desire path as a template for new construction. It should be noted that more than one condition may be used to categorize a path. However only one solution, the one recognized as the best between human travel and cost efficiency was presented for each path.

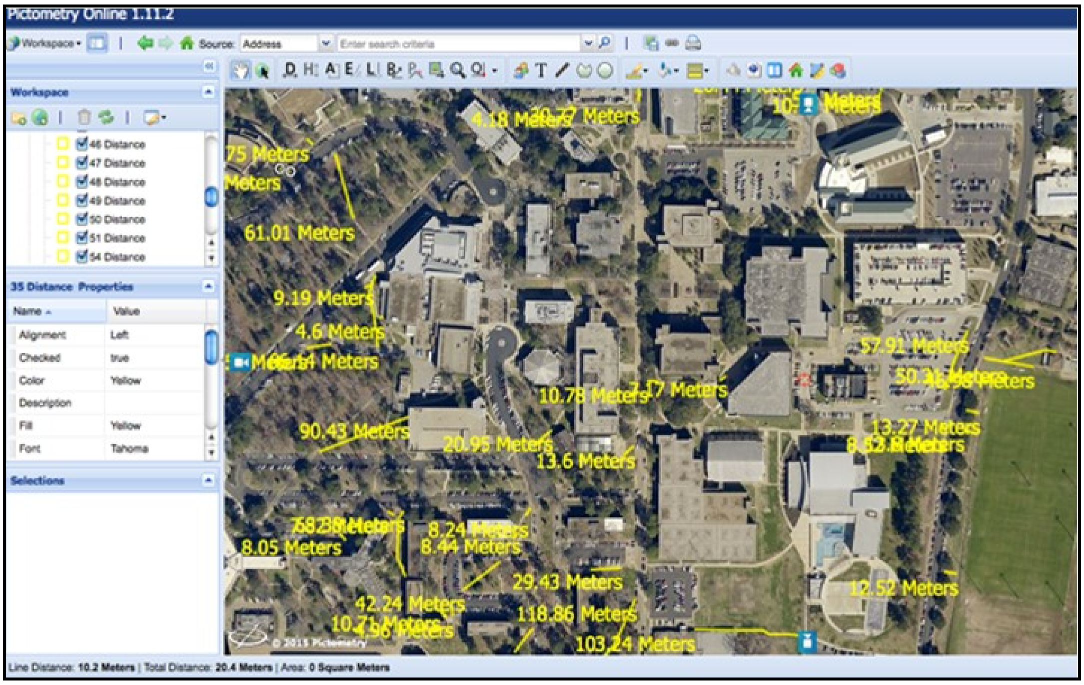

Figure 4. Measured desire trail length on-screen within the Pictometry® web-based interface

Results

A total of 69 desire trails were identified within the Pictometry® online web-based interface that measured at 1.9 m for the shortest and 88.4 m for the longest, with an average length of 24.2 m. The69 trails were visited in the field and measured for length, resulting in a shortest trail of 2.4 m and a longest trail of 91.4 m, with an average trail length of 24.4 m. Each trail was calculated for percent error, by dividing the difference between the actual and Pictometry® lengths by the actual length and multiplying by one hundred percent (Table 1). The percent errors ranged from 0.00% to 20.42% with an average error of 2.18%. A paired t-test was conducted comparing the length measurement of trails between Pictometry® and field measurement, with the null hypothesis that the mean lengths of the two approaches is the same. The results revealed a p-value of 0.0344 for two-tail (t statistics = 1.9955, df = 68), indicating there is no significant difference between the two approaches statistically at the level of significance set for 0.01 (Table 2). A scatter plot was constructed depicting the relationship between Pictometry® length measurements against field measurements. A strong linear relationship was found with a Pearson correlation coefficient of 0.996 with the regression equation having a slope of 1.0175 (Figure 5).

Journal of Studies in Education
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2018, Vol. 8, No. 4

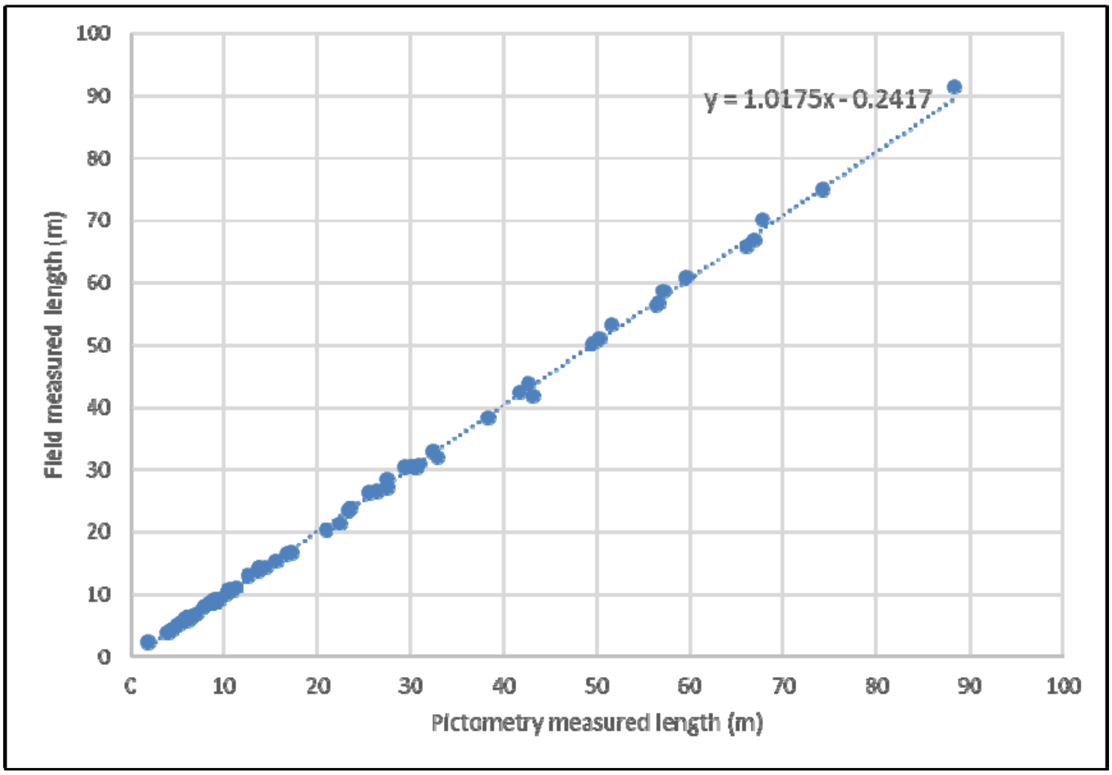

Figure 5. A scatterplot between 69 Pictometry® estimated path lengths and each actual path length

Journal of Studies in Education
ISSN 2162-6952
2018, Vol. 8, No. 4

Table 1. Desire path length measurements of Pictometry® estimated length and actual length and percent disagreement (error) between the two measurements with solution per desire trail

Length in Pictometry® (Meters)	Actual Length (Meters)	Length % Error	Condition	Solution
1.9	2.4	20.4%	1	Physical Barrier
3.9	3.9	0.0%	5	Vegetative Barrier
4.0	3.9	2.6%	2	Vegetative Barrier
4.3	4.2	2.4%	2	Vegetative Barrier
4.6	4.5	2.2%	2, 3	Physical Barrier
5.0	5.0	0.0%	2, 3, 4	Consolidate Sidewalk
5.4	5.5	1.8%	2	Consolidate Sidewalk
5.9	6.1	3.3%	1, 2, 3	Physical Barrier
6.0	5.9	1.7%	1,2,3	Physical Barrier
6.3	6.4	1.6%	1, 2, 3	Physical Barrier
6.3	6.1	3.3%	1,2, 3	Physical Barrier
6.7	6.7	0.0%	1, 2	New Sidewalk
6.7	6.7	0.0%	2, 3	New Sidewalk
7.2	7.0	2.9%	3	Vegetative Barrier
7.8	7.9	1.3%	2	Vegetative Barrier
7.8	7.9	1.3%	1, 2, 3	Physical Barrier
8.5	8.5	0.0%	1,2	Vegetative Barrier
8.6	8.5	1.2%	1	New Sidewalk
8.7	8.8	1.1%	1, 2	Physical Barrier
9.0	9.1	1.1%	2	New Sidewalk
9.2	9.0	2.2%	2	Vegetative Barrier
9.3	9.1	2.2%	2, 3	Physical Barrier
9.4	9.1	3.3%	2, 3	Vegetative Barrier
9.5	9.0	5.6%	1	Physical Barrier
10.3	10.1	2.0%	2, 3, 4	Consolidate Sidewalk
10.4	10.6	1.9%	1, 2, 3	Physical Barrier
10.5	10.7	1.9%	2,3	Physical Barrier
10.7	10.9	1.8%	2, 3, 4	Consolidate Sidewalk
11.1	10.7	3.7%	1,2,3	Physical Barrier
11.3	11.1	1.8%	1, 2, 3	Physical Barrier
12.6	13.0	3.1%	1,2	New Sidewalk
13.6	13.8	1.4%	2	Physical Barrier
13.8	14.3	3.5%	1,2	New Sidewalk
13.8	14.3	3.5%	1	Vegetative Barrier
14.5	14.4	0.7%	5	Physical Barrier

Journal of Studies in Education
ISSN 2162-6952
2018, Vol. 8, No. 4

Table 1 (continued)

Length in Pictometry® (Meters)	Actual Length (Meters)	Length % Error	Condition	Solution
15.6	15.3	2.0%	1,2	New Sidewalk
16.7	16.5	1.2%	1, 2, 3	Physical Barrier
17.3	16.6	4.2%	1, 2, 3	Vegetative Barrier
21.0	20.4	2.9%	5	New Sidewalk
22.4	21.3	5.2%	1, 2, 3	Physical Barrier
23.4	23.5	0.4%	5	New Sidewalk
23.6	23.8	0.8%	5	Vegetative Barrier
25.5	26.3	3.0%	1,2,3	Physical Barrier
26.4	26.6	0.6%	5	New Sidewalk
27.5	28.6	3.8%	1, 2, 3	Physical Barrier
27.5	27.1	1.5%	1,2,3,4	New Sidewalk
29.5	30.5	3.3%	3	Physical Barrier
30.1	30.5	1.3%	4	Consolidate Sidewalk
30.2	30.5	1.0%	1, 2, 3	Physical Barrier
30.8	30.5	1.0%	1	Physical Barrier
31.0	30.9	0.3%	1,2	Physical Barrier
32.4	32.9	1.5%	2,3	New Sidewalk
32.9	32.0	2.8%	1, 2, 3	Physical Barrier
38.4	38.3	0.3%	2, 3	New Sidewalk
41.7	42.4	1.7%	1	Physical Barrier
42.6	43.9	3.0%	1,2	New Sidewalk
43.2	41.8	3.3%	2, 3	New Sidewalk
49.5	50.2	1.4%	1	New Sidewalk
50.3	50.9	1.2%	4	Physical Barrier
51.6	53.3	3.2%	2, 5	New Sidewalk
56.4	56.4	0.0%	2, 3, 5	Physical Barrier
56.6	56.7	0.2%	2, 3	Physical Barrier
57.1	58.8	2.9%	1,2	Physical Barrier
59.6	60.8	2.0%	3,5	New Sidewalk
66.1	65.9	0.3%	1, 2	Physical Barrier
66.9	66.8	0.1%	2	New Sidewalk
67.8	70.1	3.3%	2, 3	New Sidewalk
74.3	74.9	0.8%	4	New Sidewalk
88.4	91.4	3.3%	2	New Sidewalk

Note: Condition codes: 1. Hazardous, 2. Erosive, 3. Tracking issue, 4. Lost sidewalk, and 5. Unsightly.

Journal of Studies in Education
ISSN 2162-6952
2018, Vol. 8, No. 4

Table 2. Paired t-Test results between Pictometry® and field measurements

	Length in Pictometry® (Meters)	Actual Length (Meters)
Mean	24.19	24.37
Variance	432.70	448.34
Observations	69	69
Pearson Correlation	0.9996	
Hypothesized Mean Difference	0	
df	68	
t Stat	-2.1592	
P(T<=t) one-tail	0.0172	
t Critical one-tail	1.6676	
P(T<=t) two-tail	0.0344	
t Critical two-tail	1.9955	

Students rated each desire path using the five classification categories, with some desire paths fitting multiple categories. Once all desire paths on the SFASU campus were rated, the students began to interpret the results (Figure 6). From the desire paths, erosive path condition was the leading condition in the categories with 37% of the conditions. Following the leading condition, hazardous (26%) and tracking issues (25%) desire paths together accounted for 51%. Lost sidewalk (5%) and unsightly (7%) desire path conditions were less frequent with both found less than 10% of all conditions. Since each desire path could have more than one condition, determining the percentage of each condition was based on the total number of paths and the count of each condition occurrence. Figure 6 also shows the proportion of desire paths identified with each condition in relation to all of the 69 paths examined. It was found that about three quarters of the paths were eroded, and about half of the paths were hazardous and/or had tracking issues.

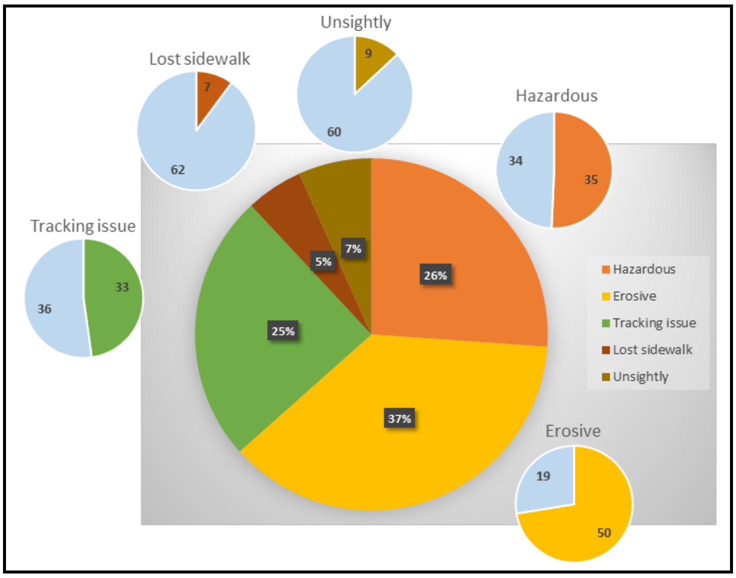

Figure 6. Conditions (n = 134) of desire paths and the proportion of each condition in relation to all paths examined (n = 69) on the SFASU campus

After finishing the investigation of the desire paths assessment, the students determined a solution for the individual desire paths according to their condition; only one solution was assigned to a desire path to address the most concerning condition. From the results reflected in Figure 7, installing a physical barrier would account for 45% of the solutions. Adding new sidewalks accounts for 32% of the solutions using current paths as templets for creating the new sidewalks. Seven percent of the solutions we proposed were to consolidate current sidewalks; and 16% of the solutions proposed were to add vegetative barriers such as flowerbeds, or terracing to prevent pedestrians from traveling on the desire path locations.

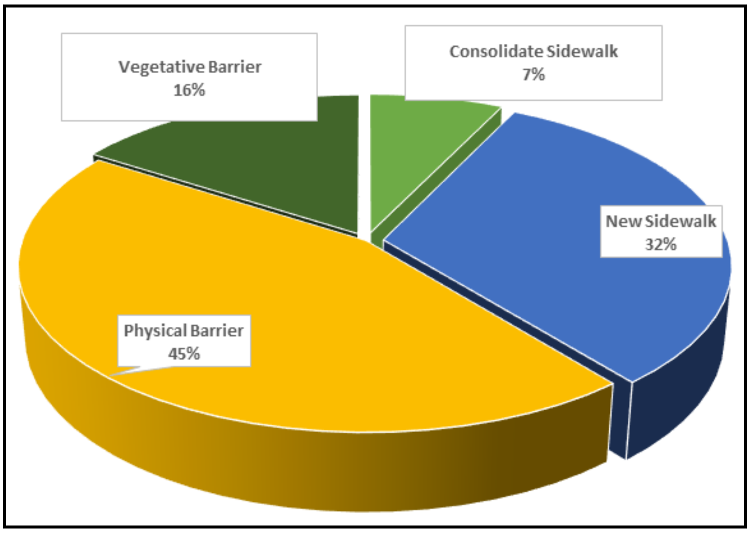

Figure 7. Desire path solutions (n = 69) on the SFASU campus

Discussion

Via an assessment of desire paths on the SFASU campus in Nacogdoches, Texas, the students concluded that desire paths were successfully analyzed using five categorizations and forming four types of solutions using the Pictometry® Neighborhood Imagery. During the evaluation, the desire paths were identified and measured using the Pictometry® online web-based interface, visually inspected, and measured in the field to determine the utility of using remotely sensed Pictometry® digital imagery in the assessment of desire paths. Results indicate that Pictometry® data can be an effective tool to identify and quantify earth surface features remotely more efficiently and in less time than traditional observations conducted in the field. In addition, results indicate that a student led analysis of a campus environment can not only be a valuable learning tool but also provide valuable input to the general campus community.

The end product of the student led desire path assessment can be used as a resource for campus beautification as well as a reduction of liability from dangerous paths across campus. This project can be used in the future by SFASU to project possible costs and remedies associated with desire paths. This sort of student led assessment could also be implemented at SFASU, or at other university campuses, prior to new construction in an attempt to prevent such paths from forming post-construction. The overall beautification and safety of the campus can be potentially increased by using the procedures described in this study and as a resource for campus reduction of potential liability from future desire paths.

References

Bullard, S. (2015). Forestry curricula for the 21st century—Maintaining rigor, communicating relevance, building relationships. *Journal of Forestry, 113*, 52-56. https://doi.org/10.5849/jof.15-021

Bullard, S., Coble, D., Coble, T., Darville, R., Rogers, L., & Stephens Williams, P. (2014). *Producing 'Society Ready' Foresters: A research-based process to revise the Bachelor of Science in Forestry Curriculum at Stephen F. Austin State University*. Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University, Nacogdoches, Texas, ATCOFA Monograph 1-2014. https://doi.org/10.5849/jof.13-098

Bullard, S., Stephens Williams, P., Coble, T., Coble, D., Darville, R., & Rogers, L. (2014). Producing "society ready" foresters: A research-based process to revise the Bachelor of Science in Forestry Curriculum at Stephen F. Austin State University. *Journal of Forestry*, *112*, 354-360. https://doi.org/10.5849/jof.13-098

Gerke, M., & Kerle, N. (2011). Automatic structural seismic damage assessment with airborne oblique Pictometry imagery. *Photogrammetric Engineering and Remote Sensing, 77*, 885-898. https://doi.org/10.14358/PERS.77.9.885

Helbing, D., Keltsch, J., & Molnár, P. (1997). Modelling the evolution of human trail systems. *Nature, 388*, 47-50. https://doi.org/10.1038/40353

Helbing, D., Molnár, P., & Schweitzer, F. (1998). Computer simulations of pedestrian dynamics and trail formation. arXiv preprint cond-mat/9805074.

Kulhavy, D., Unger, D., Hung, I., & Douglass, D. (2015). Integrating hands-on undergraduate research in an applied spatial science senior level capstone course. *International Journal of Higher Education, 4*, 52-60. https://doi.org/10.5430/ijhe.v4n1p52

Lidwell, W., Holden, K., & Butler, J. (2012). *Universal principles of design*. Beverly Massachusetts: Rockport Publishers.

Nichols, L. (2014). Social desire paths: A new theoretical concept to increase the usability of social science research in society. *Theory and Society, 43*, 647-665. https://doi.org/10.1007/s11186-014-9234-3

Norman, D. A. (2011). *Living with complexity.* Cambridge, Massachusetts: The MIT Press.

Unger, D., Hung, I., & Kulhavy, D. (2014). Comparing remotely sensed Pictometry web-based height estimates with in situ clinometer and laser range finder estimates. *Journal of Applied Remote Sensing, 8*. https://doi.org/10.1117/1.JRS.8.083590

Viegut, R., Kulhavy, D., Unger, D., Hung, I., &Humphreys, B. (2018). Integrating unmanned aircraft systems to measure linear and areal features in undergraduate forestry education. *International Journal of Higher Education, 7*, 63-75.

Wang, Y., Schultz, S., & Giuffrida, F. (2008). Pictometry's proprietary airborne digital imaging system and its application in 3D city modelling. *International Archives of Photogrammetry and Remote Sensing, 37*, 1065-1069.

Wimpey, J., & Marion, J. (2011). A spatial exploration of informal trail networks within Great Falls, VA. *Journal of Environmental Management 92*, 1012-1022.