Fish Tail Park

Methods

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Recognition

This research was done with field research support from students in China: Yehao Wang, Graduate student in Landscape Architecture at Peking University; Aoran Su, Xi Chen, and Shiwei Wu, Undergraduate students in Landscape Architecture at Chongqing University; and Yuru Wang, Gaici Li, and Yuzhen Fan, Undergraduate students in English at Nanchang University. Their dedicated work under the summer heat of Nanchang has made the extensive data collection plan possible.

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Overall Research Strategies

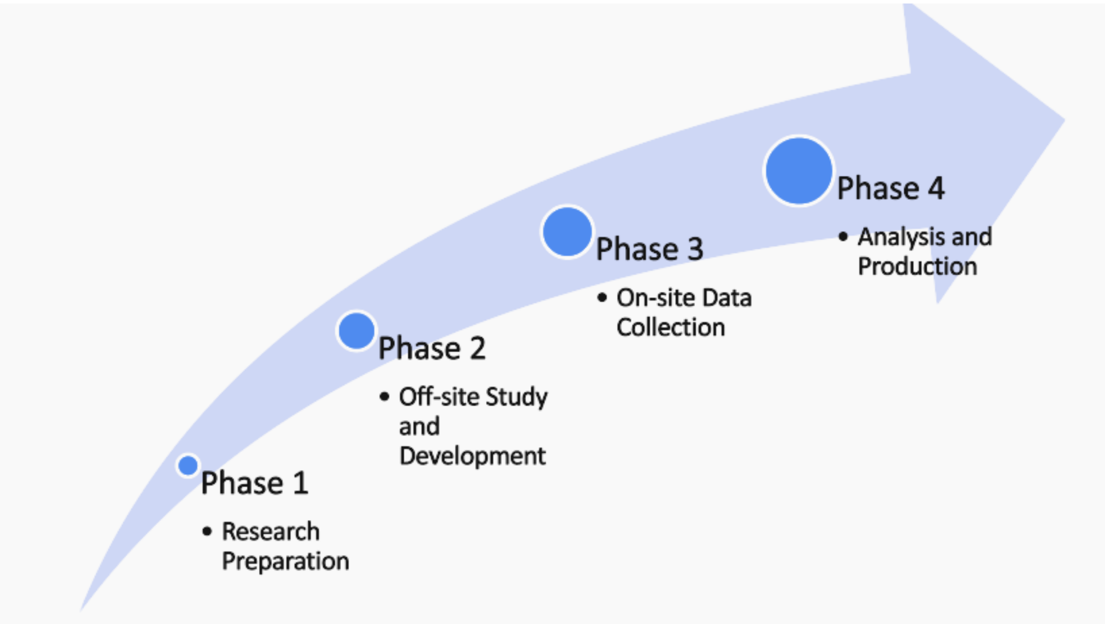


Figure A: Overall research planning

This research was planned in four phases: research preparation, off-site study and development, on-site data collection, and analysis and production. The research project was selected for funding by LAF by the end of year 2022, and work commenced mainly between January and August of 2023. Within this period, the team focused on finding a more extensive on-site collection window, which was determined to be from end of June to late July in Nanchang, China, due to alignment with summer break in US and China. Phasing of the research work was planned around this window.

In Phase 1, from December 2022 to March 2023, the team conducted an initial site visit to familiarize themselves and create 3D model of the park. This period also involved extensive research planning and literature review, complemented with a meeting with the Turenscape team to learn more about the park. Phase 2, spanning from March to June 2023, was dedicated to developing a detailed benefits list, continuing the literature review with a focus on methodologies. This phase also encompassed off-site benefits measurement and on-site work planning, alongside ensuring IRB compliance and team training. July 2023 marked the beginning of Phase 3, which was dedicated to on-site data collection. Over 25 days, the research team stationed at the site with 3-5 people working at any given day, and conducted surveys, gathered comprehensive weather data, and held interviews with Turenscape team. The final phase, Phase 4 in August 2023, involved the analysis of the collected data and the creation of visual representations to effectively convey the findings. This structured approach, from initial site exploration to in-depth analysis and visualization, ensured a robust and all-encompassing research process.

To allow the team to work on the research in the months leading up to the on-site window, many project documentations were shared with the research team from Turenscape, in addition to a short, one-day site visit in January which provided first-hand experience for the team and a 3D scanned model of the site.

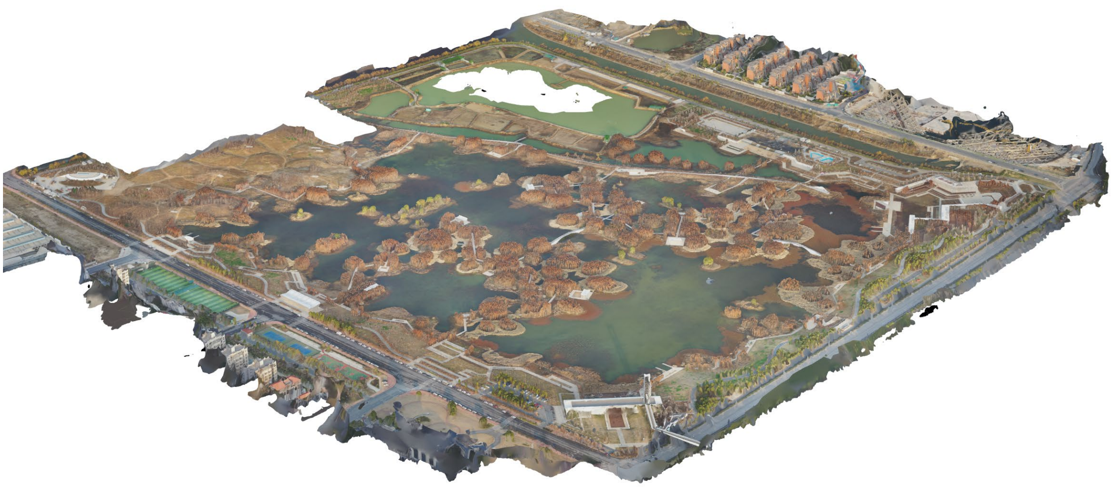
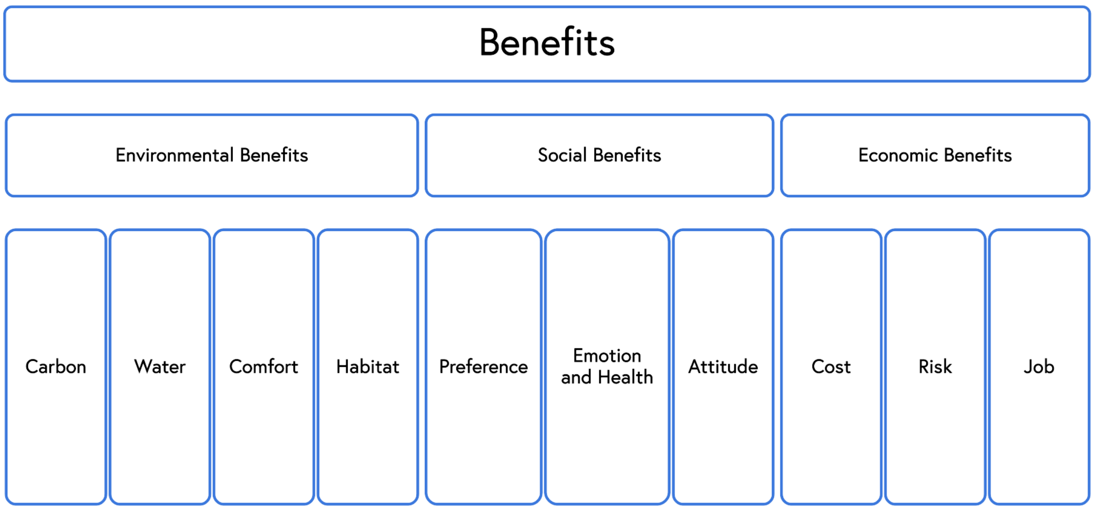


Image A: 3D scanned model of the site.

Fish Tail Park, our research site, is an exemplary, award-winning project which turned a brownfield site of urban fishery and coal ash dumping into an urban ecological park. The park features a unique set of performative and spatial / experiential targets centered around aquatic ecology, including habitat services for migrating birds. The research is designed around understanding the various aspects of this aquatic ecology and experience.

Image B: Fish Tail Park in fall season.

We have established some general areas of interest in each of the three prescribed categories, as follows:



For environmental design, Fish Tail Park stands out in a few areas: 1) the amount and density of new trees installed at a very early stage of the project, roughly 3 years prior to project completion, 2) a significant topographical intervention which is employed to create stormwater management capacity, and 3) various habitats and niches created to process water and establish a living ecosystem and support migratory birds as a part of their passage. This is what team based its decision on what to evaluate for environment benefits.

For social benefits, we are particularly interested in how the aquatic, wild ecology as an experience provides possible health benefits like reduction of stress and helping improve attitudes and opinions related to environmental issues. This part of the study was evaluated primarily through an intercept survey designed with an interdisciplinary team involving expertise in psychology and ecosystem services evaluation.

Economic benefits mostly look at associated outcomes from some of the environmental and social factors, for example Willingness to Pay for park visits (see Experimental Methods), in addition to looking at employment.

This document will discuss our findings in greater detail below.

Environmental Benefits

Improves water quality by 34-50% based on water quality indicators like reduction in total nitrogen, chemical oxygen demand, and total organic carbon, when comparing inlet to outlet of the constructed wetland system.

Background

The design of Fish Tail Park included a water quality improvement component. To the south of the park is a large lake area called Anxi Lake, which displays a Category V* water quality, and to the North of the park is the Southern branch of Gan River. Water comes into Fish Tail Park via an inlet on the South side and exits to a channel which connects to the river on the North side. The design of this park has a goal of elevating water quality from Cat V to Cat IV through a series of designed wetland components totaling to an area of 319,162 sqm (total park area is 455 ha), including the Sedimentation area, Plant Comprehensive Purification area, and Deep and Sallow Pond Stability Zone. However, because of land use challenges, the park ended up not implementing a large, 154,767 sqm cell-treatment area was not implemented, mostly Deep and Sallow Pond Stability Zone according to original plan, was not implemented, leaving only 319,162 sqm of treatment area mostly composed of plant purification in a connected open-water system, and also resulted in change in outlet area from the southeast side of the park to the north. See Figure 1.

Figure 1. Inlet and outlet location at Fish Tail Park. Inlet comes from Aixi Lake in the south and outlet to Mingshan Drainage in the north.

Note: Water quality targets are based on Environmental Quality Standards for Surface Water (GB 3838-2002) published by the Ministry of Ecology and Environment of the People's Republic of China, where Category IV quality is defined as the water is mainly suitable for industrial use and other amusement purposes that do not involve the water coming into contact with skin and Category V quality is defined as the water is mainly suitable for agricultural use and general landscape use. See: https://www.mee.gov.cn/ywgz/fgbz/bz/bzwb/shjbh/shjzlbz/200206/t20020601_66497.shtml

The field work collects data aiming to answer the following questions:

1. Can a pattern of water quality improvement from inlet to outlet be established?
2. Do landscape vegetation elements and their composition influence water quality on a micro level, and how?
3. Does bathymetry influence water quality on a micro level, and how?

Useful Abbreviations and Units:

TOC (mg/L) - Total Organic Carbon. TOC is used to indicate the amount of organic carbon in water samples. Generally, the lower the TOC value is, the better the water quality.

COD (mg/L) - Chemical Oxygen Demand. COD is used to indirectly determine the amount of organic compounds in aquatic systems and is therefore COD useful as an indicator of organic pollution in surface waters (Faith, 2006, p. 41; King, Scheepers, Fischer, Reinecke, & Smith, 2003). Generally, the lower the COD value is, the better the water quality.

UV275 (au/cm) - Ultraviolet Absorption on 275MM Band Value.

EC (au/cm) - Electrical conductivity measures water's ability to conduct electricity, influenced by temperature, ion concentration, and valence. A higher EC indicates more electrolytes and total dissolved solids, making it a useful indicator in assessing water quality.

TEM (Celsius) - Temperature. Temperature may affect water properties and chemical characteristics, and microbes and metabolic rates.

TDS (ppm) - Total Dissolved Solids is the amount of solid particles dissolved in water, including hydrogen carbonate ions, salts, calcium, and more. TDS is mainly an indicator for drinking water and is believed to affect the taste of water.

Method:

<u>Device Used</u>

The team selected a mobile water quality meter model LS310 manufactured by Shenzhen Linshang Technology Co., Ltd under standards GB5749-2006, GB/T5750-2006, JJG 821-2005 and JJG 376-2007. Based on its User Manual, the device provides measurements of COD, TOC, UV275, TDS, Electrical Conductivity, and Temperature for various types of water including non-sewage surface water to a reasonable level of accuracy. See Figure 2. Within these parameters, the instrument measures COD, TOC, and UV275 using ultraviolet absorption spectrophotometry, and it measures the conductance between electrodes to determine the water's TDS and Electrical conductivity. It can therefore be expected that the data for COD/TOC/UV275 will be associated, and data for TDS/EC will be associated.

5FlTmY 2XyJZV dvZJN5 gLYy5t bbBFd3 ds4L6O cCJRF

Sensor	Parameters	Range	Accuracy
LS 310	COD (Chemical Oxygen Demand)	0-100mg/L	0-5mg/L:±0.5mg/L;5-100mg/l
LS 311	TOC (Total Organic Carbon)	0-100mg/L	0-5mg/L: ±0.5mg/L; 5-100mg,
LS 312	UV275(Ultraviolet Absorption Valu	0-1.0au/cm	0-0.1au/cm: ±0.01au/cm; 0.1-
LS 313	TDS (Total Dissolved Solids)	0-2000ppm	±3%FS, FS is the full scale valu
LS 314	Electrical conductivity	0-4000us/cm	±3%FS, FS is full scale value
LS 315	Temperature	0-50°C	±1°C

LS 310 Water Quality Meter

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Figure 2. (left) Parameters, range and accuracy for the device. (right) image of the device

The team selected this device for its flexibility in deployment, which allows for measurement at all points that the team is interested in exploring without waiting time or expensive lab fees.

Sampling Locations

- The research team selected 14 points in the park as locations for collecting water samples (Figure 3). The locations were selected according to their location along the direction of movement for water as well as based on landscape characteristics around them. Reasoning for selecting the points can be described with the following:
  - Inlet/outlet areas: point 14 is located where water enters into the wetland system, and point 13 is located where the water leaves the park.
  - Enroute, based on unique locations and landscape features: points 1-7 are located on the forested islands in the middle of the park and surrounded by landscape elements such as water ponds, islands and water streams. Points 1,3 and 6 are located at the edge of large water bodies, while Points 2,4 and 7 are surrounded by water forest islands. Points 2 and 5 are connected to channels which flow through the islands. Point 12 is located at the beginning of a stable area of deep and shallow ponds.
  - Enroute, along a partially implemented treatment area: points 8-11 are located along a Comprehensive Plant Purification Area, which was only partially implemented due to land use conflicts.

Figure 3 Photos of water quality sampling locations

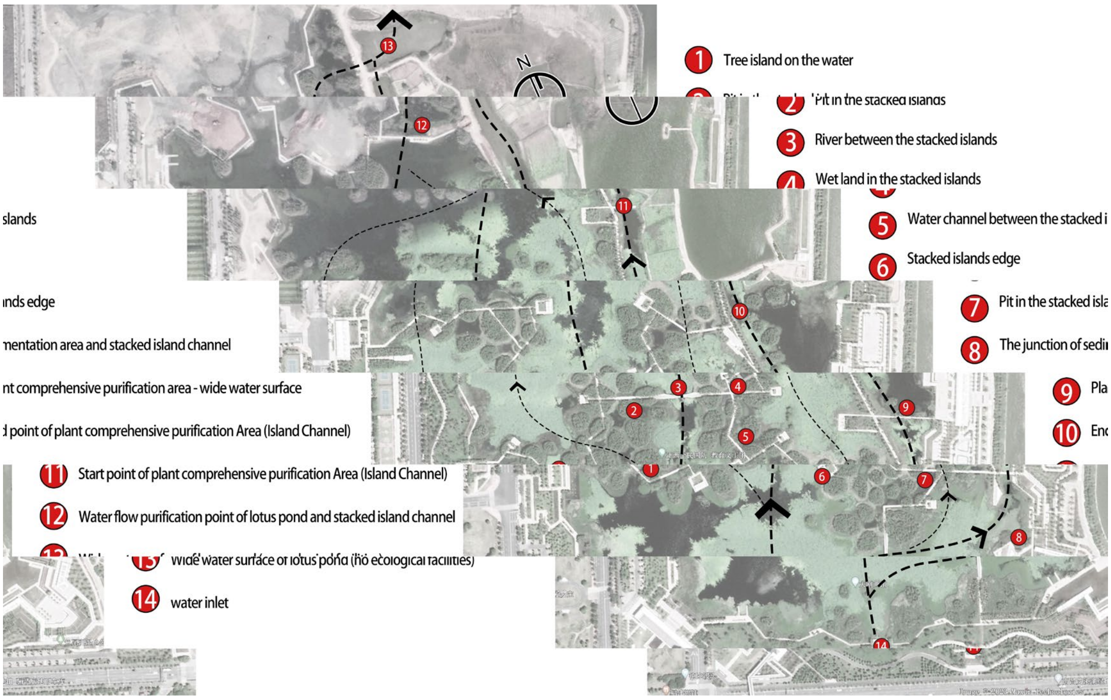


Figure 4 Distribution of water sampling points across the Park for water quality tests.

Sampling Dates and Protocols

- Water samples were collected using a plastic cup attached to an extendable rod reaching up to 7 meters. Then, the measuring device was inserted into the cup and operated following instructions from the User Manual for data readings.

Figure 5 Water sample collection tool.

- The water samples were collected on the following dates: July 7th, 11th, 14th, 18th, 19th, 20th and 21st of July 2023. At the beginning, the data collection was twice a week, then we decided to increase frequency to 3 times a week. For each water test day, the team utilizes an online app 2bulu, which offers the capacity to document the time, date, route, and picture records for data reading of each location. Then, at the end of each day, all numbers are entered digitally and formatted using the following table, and cross-checked for any error.

Location	Special Location	Landscape Elements	COD	TOC	TDS	UV275	Electrical Conductivity	Temperature	Score	Water Quality
1										
2										

Figure 6. Example of water quality data record format. See https://www.2bulu.com/share/share_track.htm?trackId=IYd7fCHKaATp%252FR2KBg5Tzw%253D%253D for example of one sampling day.

<u>Comparing the Data Collected</u>

Consistent with the initial research questions posed, the team looked at several ways of exploring and comparing the data. For question 1, on a macro level, to establish if a positive change can be documented across the site, the team compared data collected from points 13 and 14, located at beginning and end of the system. Then, to begin to understand water quality performance on a micro level, we also identified several possible routes of water, namely Points 14-1-12, Points 14-2-12, Points 14-6-3-12, Points 14-6-5-4-12, Points 14-7-12, and Points 9-10-11-13. For question 2, we realized that it was difficult to design a way to single out vegetation as an explanatory factor and suggests further study in this area. Finally, for question 3, we compared to understand how deeper and shallower pockets of water in the same area displays any difference.

For the calculations, the team averaged the data records of water quality samples collected on July 7th, 14th, 18th, 19th, and 20th, 2023. The data included COD, TOC, UV275, TDS, Electrical Conductivity, and Temperature. Notably, certain data points were not included in the calculations, for the following reasons: 1) data availability. The research team modified sampling plans based on initial observations and communications with the design team. Therefore, Points 12 and 13, as well as deep and shallow pockets, had no data on July 7th, 14th, and 18th. Point 5 had no data on July 14th. On July 19th, points 9, 10, 11, 12, and 13 had no data on UV275, TDS, Electrical Conductivity, and Temperature due to device display screen problems; 2) data reliability. The team found unusual readings in available data, points 1 and 13 on July 11th, points 9 on July 14th, and points 9 and 10 on July 19th, and points 11 and 12 on July 19th, and made the determination that they are not reliable. See Figure 7.

	7/7/2023							7/11/2023						
Locations	COD	TOC	TDS	UV275	Electrical	Temperat	Score	COD	TOC	TDS	UV275	Electrical	Temperat	Score
1	6.6	9.4	94	0.094	187	31.6	44	22.3	31.9	0	0.319	0	33.3	33
2	9.65	13.8	100	0.138	200	33.1	32	11	15.7	102	0.157	203	32.7	32
3	8.25	11.8	100	0.118	200	32	34	8.9	12.7	103	0.127	205	32.6	32
4	8.58	12.3	103	0.123	205	32.6	32	9	12.9	106	0.129	212	32.9	32
5	9.3	13.3	104	0.133	208	33.7	32	9.6	13.8	99	0.138	198	33	32
6	8.4	12	103	0.12	205	33.1	33	9.6	13.7	109	0.137	218	34.2	32
7	9.09	13	104	0.13	207	32.5	32	10.9	15.6	108	0.156	215	33.9	32
8	6.84	9.77	120	0.098	240	35.3	42	9.2	13.2	126	0.132	251	36.7	31
9	8.5	12.2	102	0.122	203	32.3	33	10.6	15.1	106	0.151	212	35.3	32
10	8.89	12.7	100	0.127	199	32.6	32	9.8	14	106	0.14	212	34.6	32
11	8.63	12.3	101	0.123	201	32.5	32	9.4	13.5	106	0.135	212	34.3	32
12								9.2	13.1	91	0.131	181	34.2	32
13								12.7	18.2	0	0.182	0	32.2	33
14	17.3	24.7	96	0.247	192	33.6	32	13.9	19.8	93	0.198	185	33.9	32

	7/14/2023							7/18/2023						
Locations	COD	TOC	TDS	UV275	Electrical	Temperat	Score	COD	TOC	TDS	UV275	Electrical	Temperat	Score
1	9.76	13.9	98	0.139	196	33	32	10.5	15	101	0.15	202	31.6	32
2	14.1	20.2	102	0.202	203	32	32	12.9	18.4	97	0.184	194	31.3	32
3	12.3	17.6	101	0.176	202	32.9	32	11.9	17	90	0.17	180	31.1	32
4	15.8	22.5	104	0.225	207	33.1	32	11.2	15.9	98	0.159	196	31.5	32
5								13.1	18.7	94	0.187	187	31.9	32
6	12.9	18.4	3	0.184	6	33.8	33	12.2	17.5	89	0.175	178	32	32
7	15.9	22.8	107	0.228	213	33.1	32	13.4	19.1	97	0.191	194	31.4	32
8	18.8	26.9	127	0.269	254	34.7	31	13.9	19.8	99	0.198	197	33.3	32
9	15.6	22.2	0	0.222	0	32.1	33	12.9	18.5	108	0.185	216	33.1	32
10	13.1	18.7	108	0.187	215	32.9	32	13.5	19.3	107	0.193	213	32	32
11	15	21	104	0.214	207	32.6	32	14.9	21.3	109	0.213	218	33.3	32
12	10.1	14.4	86	0.144	172	31.1	32	13.4	19.2	90	0.192	179	31.2	32
13	11.5	16.4	103	0.164	206	32.8	32	16.7	23.8	96	0.238	192	29.5	32
14	14.9	21.2	84	0.212	168	30.9	32	24.1	34.4	69	0.344	137	29.7	32

	7/19/2023							7/20/2023						
Locations	COD	TOC	TDS	UV275	Electrical	Temperat	Score	COD	TOC	TDS	UV275	Electrical	Temperat	Score
1	6.37	9.1	89	0.091	178	32.2	47	7.3	10.4	92	0.104	184	30.8	39
2	9.38	13.4	99	0.134	198	32.2	32	5.7	8.1	101	0.081	202	32.5	52
3	7.65	10.9	91	0.109	181	31.5	36	9.9	14.2	93	0.142	186	30.2	32
4	6.48	9.25	94	0.093	188	30.5	45	7.67	11	95	0.11	190	32	36
5	7.74	11.1	92	0.111	183	31.7	36	29.7	42.5	87	0.425	173	32	32
6	6.57	9.38	92	0.094	183	32.1	45	13	18.6	93	0.186	185	31.5	32
7	6.03	8.62	98	0.086	196	31.5	49	31.3	44.7	94	0.447	187	31.7	32
8	9.3	13.3	142	0.133	284	30	31	31.9	45.5	92	0.455	183	31	32
9	23.3	33.3	0	0.333	0	31.3	33	9.3	13.3	108				32
10	13	18.5	0	0.185	0	33.4	33	6.88	9.82	108				
11	100	100	134	1	267	33.9	31	10.6	15.1	108				33
12	83.4	100	1	1	2	30.8	33	8.2	11.7	110	0.117	219	32.5	34
13								6.2	8.8	97	0.089	193	31.4	48
14	13	18.5	71	0.185	141	31.4	32	21.3	30.4	77	0.304	154	31.7	32

The average exlude blue (have 0 in tds+EC)and red values no data avilable

Figure 7 Water quality data record with highlight for excluded data. Red highlights no data available for that point. Excluded points are highlighted in blue.

1. Change between inlet/outlet

Based on comparison of all water quality parameters measured (Figure 8), it can be concluded that Fish Tail Park has successfully improved the water quality in the park. Each reading of COD, TOC, TDS, and UV275 of the lake water decreased. Below, we will calculate both net decrease and change percentage using the following formula:

Net Decrease = Average Data (Point 13) - Average Data (Point 14)

Change % = Net Decrease / Average Data (Point 14) x 100%

A. COD

Average COD over the 6 days of data measurement area calculated to be 17.4 at Point 14 (inlet), 11.4 at Point 13 (outlet). Improvements are calculated as follows:

COD Net Decrease = 11.4 - 17.4 = -6

COD Change % = -6/ 17.4 = -34.4%

B. TOC

Average TOC over the 6 days of data measurement area calculated to be 24.8 at Point 14 (inlet), 16.3 at Point 13 (outlet).

TOC Net Decrease = 16.3 - 24.8 = -8.5

TOC Change % = -8.5/ 24.8 = -34.2%

C. TDS

Average TDS over the 6 days of data measurement is calculated to be 81.6 at Point 14 (inlet), 98.6 at Point 13 (outlet).

TOC Net Increase = 98.6 - 81.6 = 17

TOC Change % = 17/ 81.6 = 20.8%

D.UV275

Average UV275 over the 6 days of data measurement is calculated to be 0.24 at Point 14 (inlet), 0.16 at Point 13 (outlet).

UV275 Net Increase = 0.163- 0.248 = -0.085

UV275 Change % = -0.085/ 0.248= -34.2%

The change in between inlet/outlet indicates the park has improved water quality by averaging reduces in the values COD, TOC, UV275 by 34.2% and increase in TDS 20.8%.

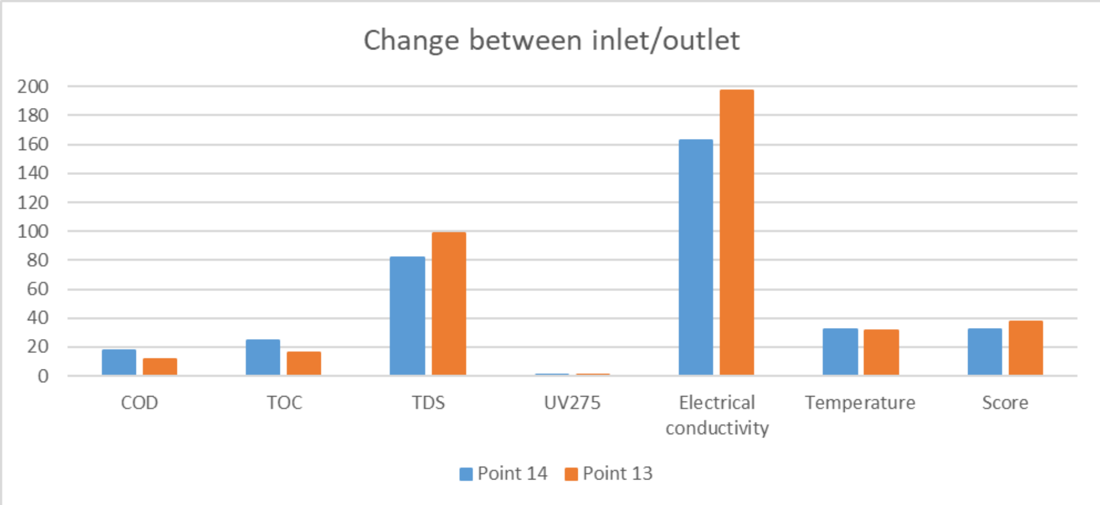


Figure 8. Average data in water quality parameters between Point 14 (inlet) and Point 13 (outlet)

2. Change along treatment flow

To understand how water quality changed along the route of flow (see Fig 4), we selected a series of point-sequences and made calculations to compare their net change and percent change. We have found that water quality is not always improving along the route. In 3 out of 5 point-sequences compared, 3 saw a decrease in water quality along some micro-segments. This may indicate deficiencies within the wetland system, and further field research is suggested. See next section for one possible reason.

A. Points 14-1-12

The average water performance on the route 14-1-12, the COD at point 14 measures 17.4, point 1 measures 8.1, point 12 measures 10.2. See Figure 9. Percent change is calculated by comparing each point to the previous point, as follows:

Segment 1, point 14 to point 1:

Change % = (8.1 - 17.4) / 17.4 = -53.4%

Segment 2, point 1 to point 12:

Change % = (10.2 - 8.1) / 10.2 = 20.6%

Along this route, it can be observed that the first segment showed significant water quality gain indicated by decrease in COD value, while that gain somewhat diminished over the second sector.

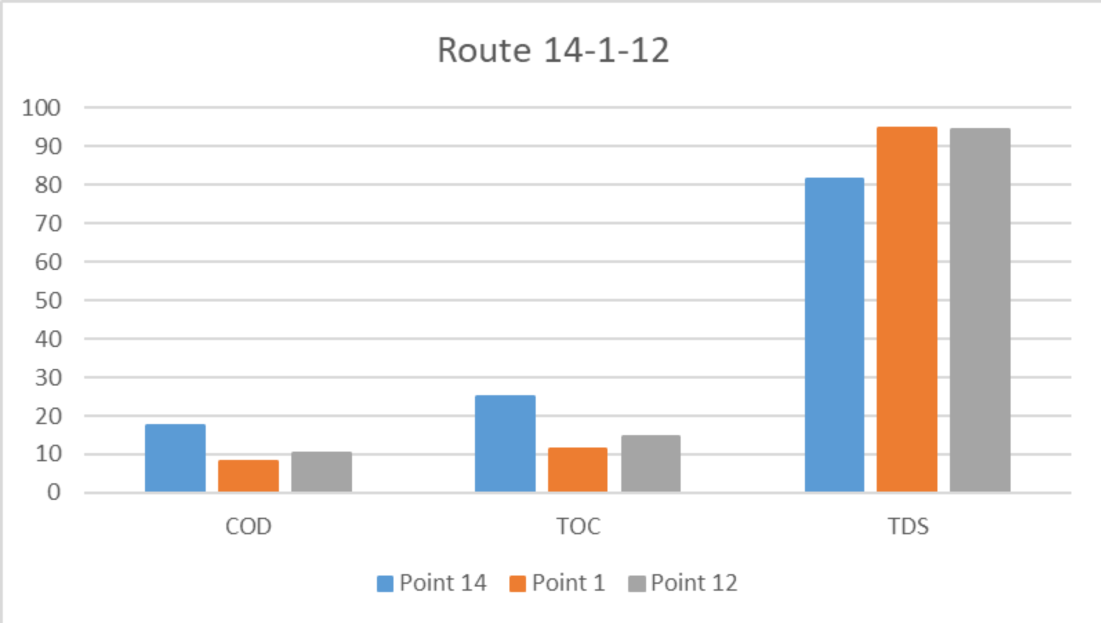


Figure 9. Water quality parameters along Points 14-1-12.

B. Points 14-2-12

The average water performance on the route 14-2-12, the COD at point 14 measures 17.4, point 2 measures 10.4, point 12 measures 10.2. See Figure 10. Percent change is calculated by comparing each point to the previous point, as follows:

Segment 1, point 14 to point 2:

Change % = (10.4 - 17.4) / 17.4 = -40.2%

Segment 2, point 2 to point 12:

Change % = (10.2 - 10.4) / 10.4= -19.2%

On this route, it can be observed that the initial part had a noteworthy improvement in water quality, as shown by a decrease in COD value. However, this improvement was not as significant in the second part.

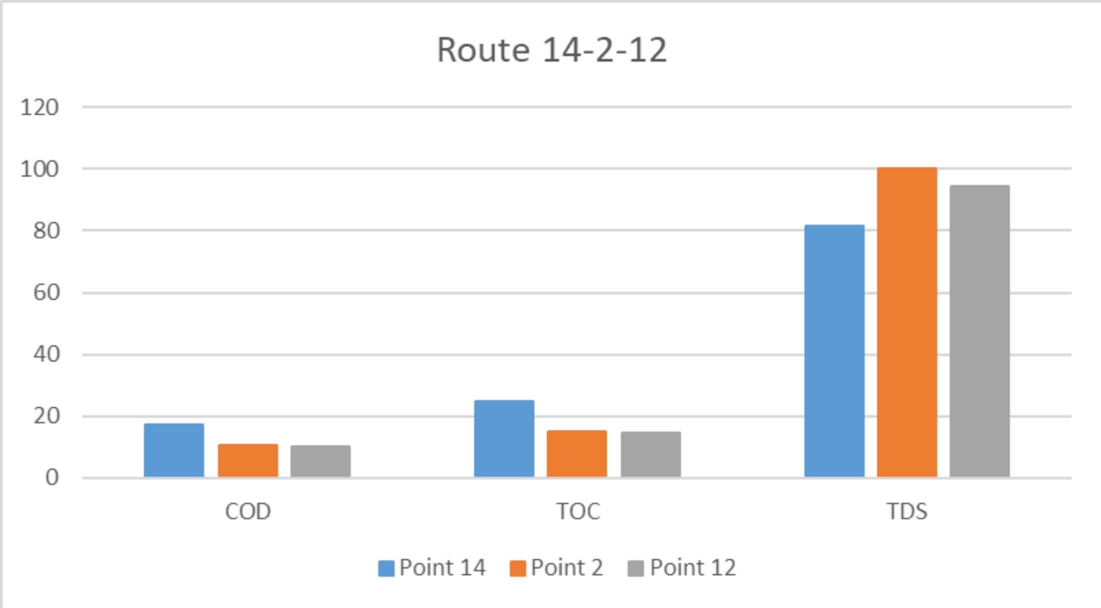


Figure 10. Water quality parameters along Points 14-2-12.

C. Points 14-6-3-12

The average water performance on the route 14-6-3-12, the COD at point 14 measures 17.4, point 6 measures 10.4, point 3 measures 9.8, and point 12 measures 10.2. See Figure 11. Percent change is calculated by comparing each point to the previous point, as follows:

Segment 1, point 14 to point 6:

Change % = (10.4 - 17.4) / 17.4 = -40.2%

Segment 2, point 6 to point 3:

Change % = (9.8 - 10.4) / 10.4 = -5.7%

Segment 3, point 3 to point 12:

Change % = (10.2 - 9.8) / 9.8= 4%

Along this route, it can be observed that the first segment has a notable improvement in water shown by a decrease in COD value, while the second segment slightly improves the water quality. Water quality then decreased slightly in the third segment.

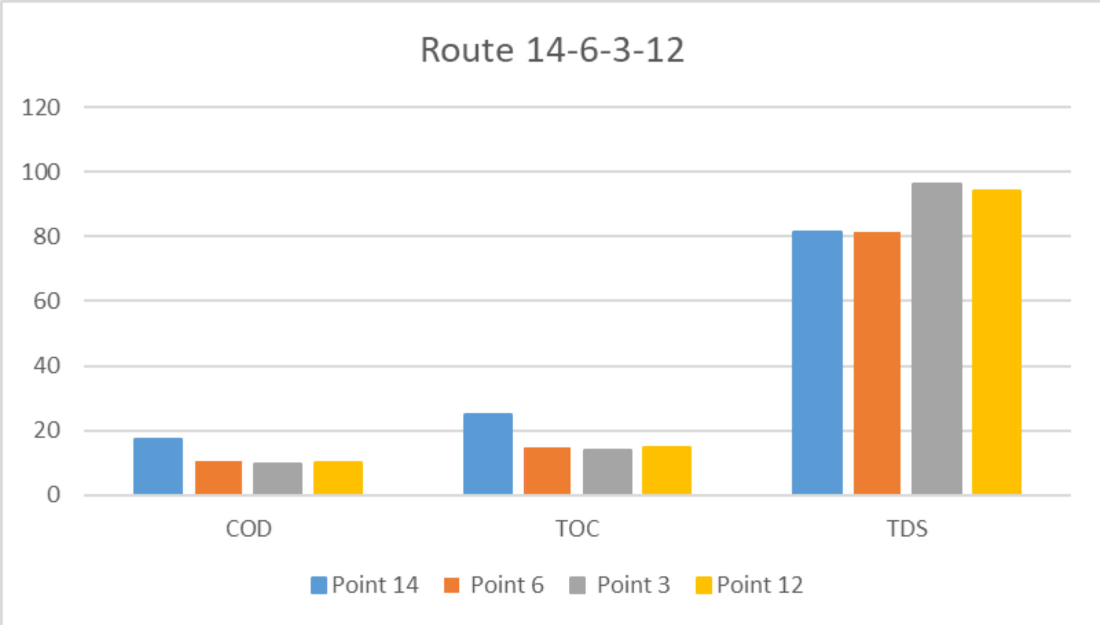


Figure 11. Water quality parameters along Points 14-6-3-12.

D. Points 14-6-5-4-12

The average water performance on the route 14-6-3-12, the COD at point 14 measures 17.4, point 6 measures 10.4, point 5 measures 13.8, point 4 measures 9.78, and point 12 measures 10.2. See Figure 12. Percent change is calculated by comparing each point to the previous point, as follows:

Segment 1, point 14 to point 6:

Change % = (10.4 - 17.4) / 17.4 = -40.2%

Segment 2, point 6 to point 5:

Change % = (13.8- 10.4) / 10.4= 32.6%

Segment 3, point 5 to point 4:

Change % = (9.7 - 13.8) / 13.8= -29.7%

Segment 4, point 4 to point 12:

Change % = (10.2 - 9.7) / 9.7 = 5.1%

Along this route, it can be observed that segment 1 shows a notable enhancement in water quality as evidenced by a reduction in COD value, which is then followed by a considerable reversal in segment 2. Segment 3 displays water quality improvement and the final segment losing that gain slightly.

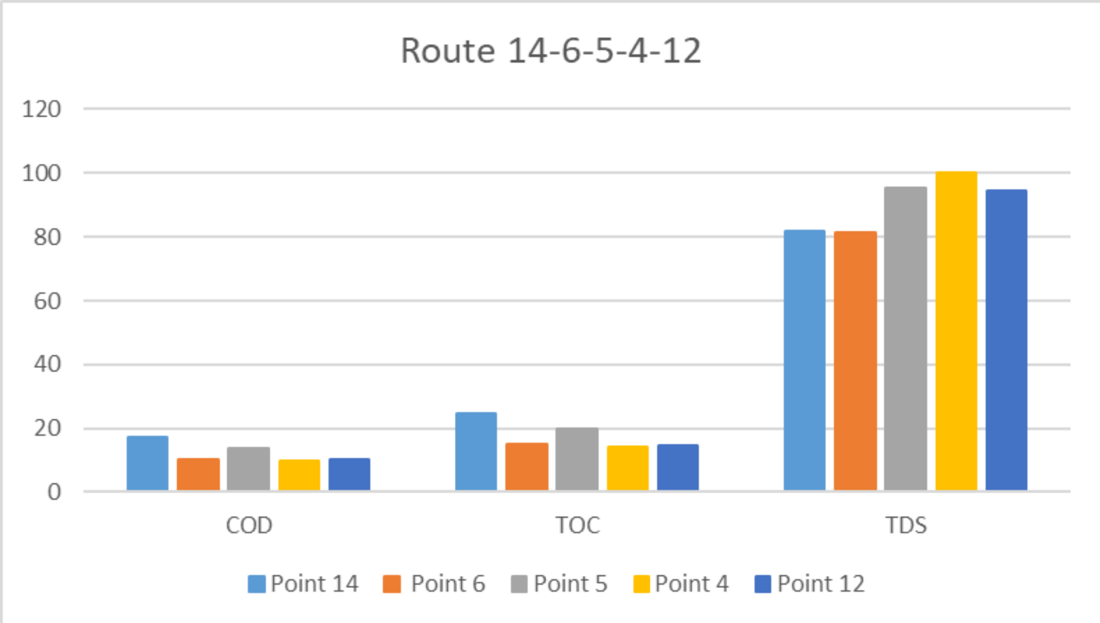


Figure 12. Water quality parameters along Points 14-6-5-4-12.

E. Points 14-7-12

The average water performance on the route 14-7-12, the COD at point 14 measures 17.4, point 7 measures 14.4, point 12 measures 10.2. See Figure 13. Percent change is calculated by comparing each point to the previous point, as follows:

Segment 1, point 14 to point 7:

Change % = (14.4- 17.4) / 17.4 = -17.2%

Segment 2, point 7 to point 12:

Change % = (10.2 - 14.4) / 14.4=-29.1%

Along this route, it can be observed that the first segment showed significant water quality gain indicated by decrease in COD value, while that improvement increased over the second sector.

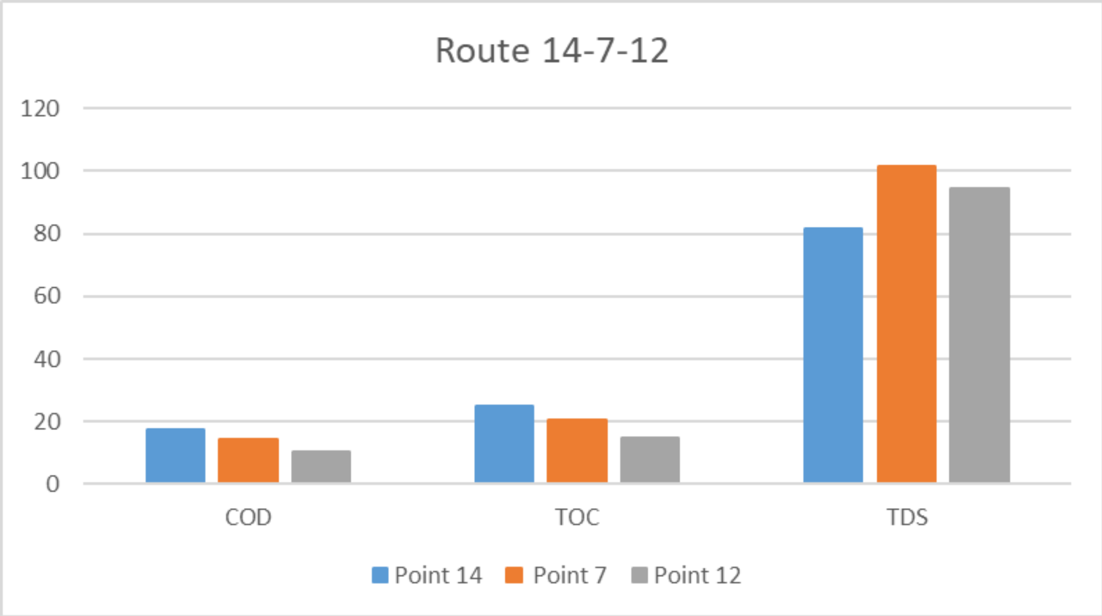


Figure 13. Water quality parameters along Points 14-7-12.

F. Points 14-9-10-11-13

The average water performance on the route 14-9-10-11-13, the COD at point 14 measures 17.4, point 9 measures 10.3, point 10 measures 10.4, point 11 measures 11.7, point 13 measures 11.4. See Figure 14. Percent change is calculated by comparing each point to the previous point, as follows:

Segment 1, point 14 to point 9:

Change % = (10.3 - 17.4) / 17.4 = -40.8%

Segment 2, point 9 to point 10:

Change % = (10.4- 10.3) / 10.3 = 0.97%

Segment 4, point 10 to point 11:

Change % = (11.7 - 10.4) / 10.4 = 12.5%

Segment 4, point 11 to point 13:

Change % = (11.4 - 11.7) / 11.7= -2.5%

On this route, it can be observed that the initial part had a noteworthy improvement in water quality, as shown by a decrease in COD value. Segment 2 saw no meaningful change, whereas segment 3 saw slight decrease in water quality. Finally, water quality improved slightly in segment 4.

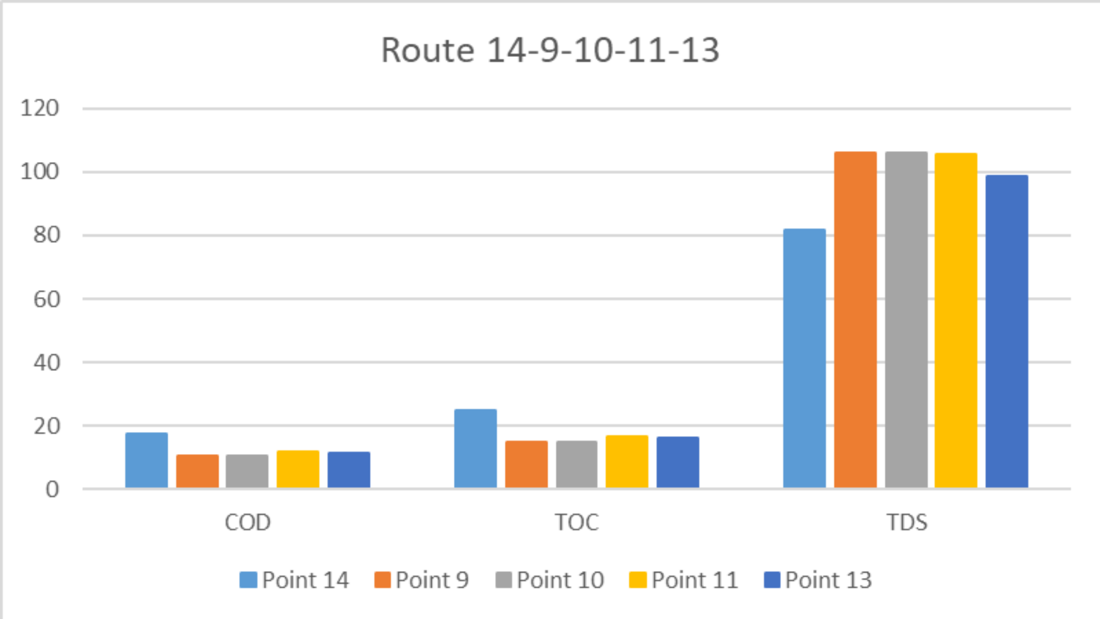


Figure 14. Water quality parameters along Points 14-9-10-11-13.

3. Change between deep/shallow pockets of water within the island group.

Within the aqua forest island groups, generally two types of water configurations can be observed. Type 1 is shallow water with a flat bottom, usually forested on top with no herbaceous plants, meaning they are mostly fully shaded. The depth of water varies by overall water level and is observed to be around 9-10 inches when the team is there. Type 2 is deep water pockets, usually found in the middle area between 4 or more islands. They tend to be surrounded by herbaceous plants around their periphery, then by trees of the islands beyond, and are largely open and exposed to sunlight with limited shade. On site, it can be observed that Type 1 has categorically better water quality, based on their respective color and transparency.

Figure 15. Photo of Type 1 (left) and Type 2 (right) water.

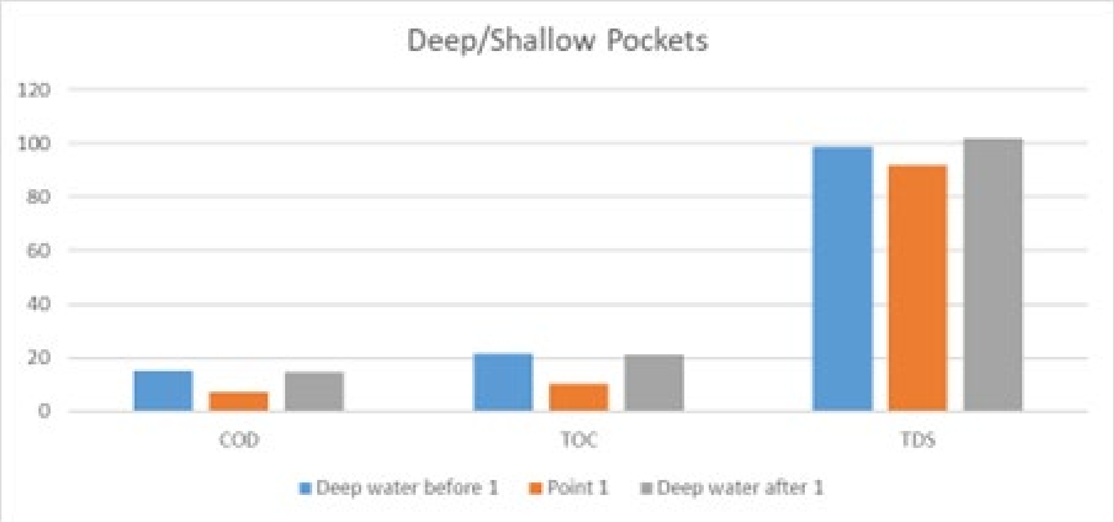
To understand the performances between Type 1 and Type 2 water in this area, the team added additional water sampling points. Figure 16 is a zoom-in of Figure 4 to the area of investigation. Within Figure 16, Point 1 is Type 1 water and Point 5 is Type 2 water. Two groups of comparison were created by adding sampling points to the original water sampling plan.

One group is centered around Point 1 (Type 1, shallow) and includes two new sampling points in Type 2 (deep) water areas immediately connected to Point 1. The other group is centered around Point 5 (Type 2, deep) and includes one new sampling point in Type 1 (shallow) water area immediately downstream. This data collection plan was added towards the end of the research and only one reliable collection was made on July 20th.

Figure 16. Location of proposed deep and shallow pockets.

The comparison of water quality around Point 1 shows that Type 1 water has better water quality than Type 2 water. The readings of COD and TOC of the water are significantly higher in the two Type 2 sampling points, in comparison to Type 1 (Point 1). The COD for Type 2 water before Point 1 measures 15, Point 1 measures 7.5 (-50%), and Type 2 water after Point 1 measures 14.8. The TOC metric follows the same pattern.

However, the same comparison around Point 5 is not conclusive. COD for Point 5 (Type 2) measures 29.7, whereas the Type 1 sampling point before Point 5 measures 29.1 (-2.0%).



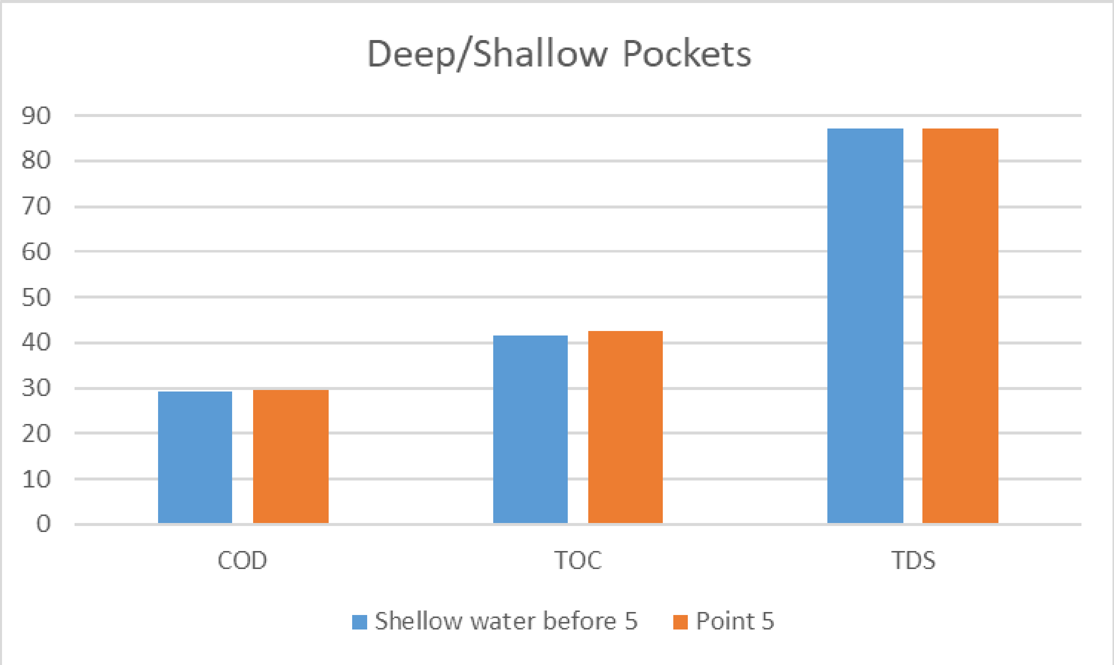


Figure 17 (above) water quality levels for deep water before and after point 1, and point 1; (below) water quality levels for shallow water before point 5, and point 5

Additional Discussion:

Based on interview conversations with the design team, one possible explanation for water quality issues in deeper pockets of water within the island groups is sectional water exchange. There was no channel or pipelines linking the bottom of the pockets to the larger open water, resulting in a lower exchange rate at deeper parts of the water. The design team believes in the importance of having two depth settings for ecological reasons, but suggested future design could be improved by adding pipelines to address the exchange rate issue.

Sources:

"生态环境部关于印发《生态环境部关于加强固体废物污染防治工作的通知》的通知." Ministry of Ecology and Environment of the People's Republic of China. June 1, 2002. https://www.mee.gov.cn/ywgz/fgbz/bz/bzwb/shjbh/shjzlbz/200206/t20020601_66497.shtml.

(Faith, 2006, p. 41; King, Scheepers, Fischer, Reinecke, & Smith, 2003)

Environmental Water Quality Information - Environmental Protection Administration, ROC (Taiwan). "Environmental Water Quality Information." Electrical conductivity (EC), May 28, 2020. https://wq.epa.gov.tw/EWQP/en/Encyclopedia/NounDefinition/Pedia_48.aspx.

Environmental Water Quality Information - Environmental Protection Administration, ROC (Taiwan). "Environmental Water Quality Information." Temperature, May 28, 2020. https://wq.epa.gov.tw/EWQP/en/Encyclopedia/NounDefinition/Pedia_17.aspx.

Environmental Water Quality Information - Environmental Protection Administration, ROC (Taiwan). "Environmental Water Quality Information." Total dissolved solids (TDS), May 28, 2020. https://wq.epa.gov.tw/EWQP/en/Encyclopedia/NounDefinition/Pedia_07.aspx

Limitations:

- Water quality may be influenced by various factors like time of day, month of year, weather in the preceding days such as rain events, sun exposure, etc. While we have collected samples frequently, they were still collected in a short window of time and therefore the records may not reflect on all performance conditions.
- The device is only accurate to its designed capacity and limited by the fact that it is a small hand-held device and cannot offer the sample level of reliability as lab test results.

Increases flood storage capacity by approximately 188,016,433 gallons, equivalent to 284 Olympic-sized swimming pools.

Background:

Fish Tail Park was designed to serve a flexible sponge to implement water storage benefits. During the rain and flood seasons, water flows from Aixi lake located to the south of the site through a pumped inlet and is stored by the park. The pumps operating at max speed are capable of bringing approximately 10-15 cubic meters per second of water in. The water then passes through several levels of oxidation cells before reaching the park, or, during extreme events, enters the water body directly. The park itself is sunken from its surrounding area, and key elevation levels can be seen in Figure 18.

Method:

The team utilized the grading plan provided by the firm and used Rhino to recreate a simplified extrusion storage model and calculate its capacity at various key levels. The water storage capacity volume was then converted into equivalent Olympic swimming pools for easier visualization.

Calculations:

V (Regular Fluctuations) = V (water surface 1 x (16.4-16.0)) - V (islands) = 120230 m3 - 11770 m3 = 108,460 m3

V (Annual flood) = V (water surface 2 x (17.5-16.4)) + V (Regular Fluctuations) = 360,530 m3 + 108,460 m3 = 468,990 m3

V (20 Year flood) = V (water surface 3 x (18.5-17.5)) + V (Annual flood) = 385,750 m3 + 468,990 m3 = 854,740 m3

V (20 Year flood, imperial) = 854,740 m3 x 219.969152 gallon/m3 = 188,016,433 gallons.

Limitations:

- The volume calculated did not consider built or natural elements within the retention area, for example bridge, platform, trail, trees, etc. The model is simplified and does not include slope area around the islands.

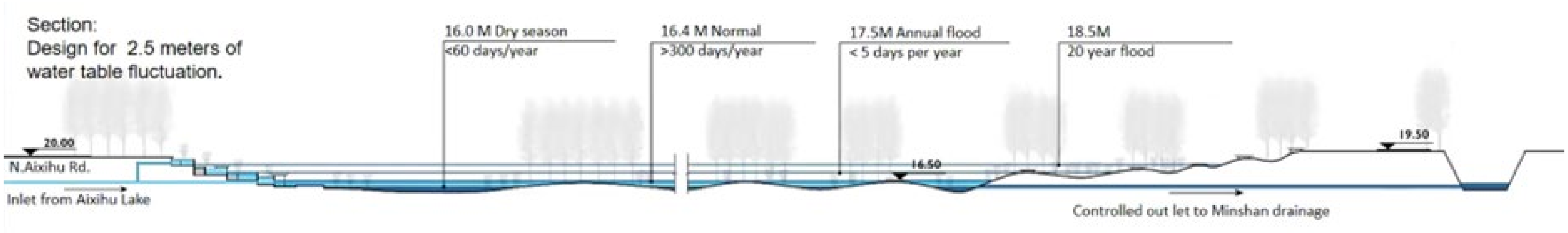


Figure 18 section of key water levels

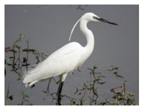
Creates habitat for at least 12 observed bird species.

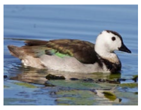
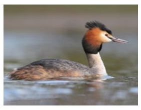
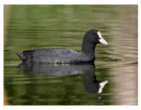
Background

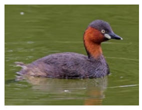
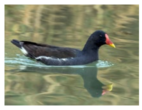
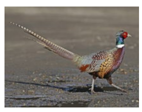
The park is a part of an important migrating bird corridor as defined by local planning documents. As such, providing habitat for birds has been an important objective for this park. The design team identified several kinds of feeding and nesting grounds, including dense woods preferred by some species of egrets, shallow water wetlands, and other areas with plant cover.

Method

As there is no data recorded for previous years, neither before nor after construction, the team relied on the observation records and testimony of bird enthusiasts on-site to compile a list of returning bird species and the performance of this park. One of the enthusiasts interviewed has been making frequent visits to the park since its opening. The list includes the following species:

	Scientific Name	Description	Order	Genus	Family	Picture
Migrating birds (summer)	Egretta garzetta	Known as Little Egret is a white aquatic bird with long black legs that feeds in shallow water.	Pelecaniformes	Egretta	Ardeidae	 © Bhaarat Vyas
	Ardeola bacchus	Known as the Chinese pond heron is a freshwater bird found in East Asia with white wings, yellow eyes and legs, and feeds on insects and fish.	Pelecaniformes	Ardeola	Ardeidae	 © Neoh Hor Kee
	Ixobrychus sinensis	The Yellow Bittern is a small bittern with a short neck and long bill. It is found in tropical Asia and the male is more richly	Pelecaniformes	Ixobrychus	Ardeidae	 © Jens Eriksen

		colored than the female.				
	Nettapus coromandelianus	Known as the cotton Pygmy-goose is a small duck that is found in India and Southeast Asia. It has a white head and neck, as well as a dark crown and eyes.	Anseriformes	Nettapus	Ardeidae	 © Eric Barnes
Migrating birds (winter)	Podiceps cristatus	Known as the Great Crested Grebe, is a water bird found in Europe, Asia and africa. It has an elegant and long neck.	Podicipediformes	Podiceps	Podicipedae	 © PierreMontieth
	Fulica atra	Known as The Eurasian Coot, is a stocky waterbird ,with dark gray color. Inhabits both freshwater and brackish marshes, lakeshores, and riverways; occasionally on saltwater.	Gruiformes	Fulica	Rallidae	 © António Cruz
Resident birds	Nycticorax nycticorax	Black-crowned Night Heron, with black cap, upper back, and shoulders, gray wings, rump, and tail. It found Europe, Asia, and	Pelecaniformes	Nycticorax	Ardeidae	

		North and South America				
	Tachybaptus ruficollis	Known as Little Grebe, is a small wetland bird with dark feathers above and a rufous-colored neck and flanks. It found Europe, Asia, and most Africa.	Podicipedidae	Tachybaptus	Tachybaptus	 © Zhong Ying Koay
	Gallinula chloropus	Known as Eurasian Moorhen, is a dark waterbird. Inhabits fresh and brackish marshes, on ponds and lakes.	Gruiformes	Gallinula	Rellidea	 © Markus Craig
	Halcyon smyrnensis	Known as White-throated Kingfisher, it has a large head, brown feathers, an electric-blue back, and a heavy orange bill, found in wetlands, lakes, and agricultural fields	Coraciiformes	Halcyon	Dacelonidae	 © James (Jim) Holmes
	Alcedo atthis	Known as Common Kingfisher, it is a blue-and-orange bird. Founded along rivers, streams, lakes, and ponds that have small fish.	Coraciiformes	Alcedo	Alcedinidae	 © Ian Davies
	Phasianus colchicus	Known as Ring-necked Pheasant, it has a red face and an iridescent green	Galliformes	Phasianus	Phasianidae	

		neck featuring a prominent white ring. The species is native to Asia.				© Matt Davis

Examples of birds observed by the team in Fish Tail Park and reported by local birders.

Figure 19 observed bird species on the site

It is worth noting that a 2014 study on 1,111-acre Aixi Lake, directly south of the park and established in 2007, documented a total of 56 species and 6,586 individuals. At 78.8 acres, or 7.09% of Aixi Lake's area, Fish Tail Park has achieved 21.4% of its species after two years of regular operations. Although this is not a fair comparison due to data collection periods and methodologies being vastly different, this shows promise for the number of species found at Fish Tail Park as compared to its neighbors.

Additionally, based on a paper which documented 89 created wetlands to create a model, Fish Tail Park's performance is about 50% lower than the model predicted, which may be explained by the short period of time since the park's establishment.

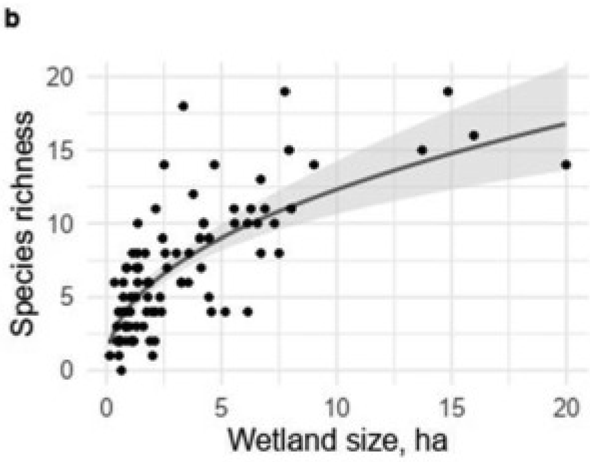


Figure from Kačergytė et al. 2021.

Calculations:

12 species were reported by local birders and observed by the CSI team at Fish Tail Park.

Sources:

Kačergytė, Ineta & Arlt, Debora & Berg, Åke & Żmihorski, Michał & Knape, Jonas & Rosin, Zuzanna & Pärt, Tomas. (2021). Evaluating created wetlands for bird diversity and reproductive success. Biological Conservation. Volume 257. 109084. 10.1016/j.biocon.2021.109084.

Shao Mingqin, et al. (2014). Preliminary Studies of the Bird Diversity in Aixi and Yaohu Lake in Nanchang City, *Hubei Agriculture Science* (02),382-384. doi:10.14088/j.cnki.issn0439-8114.2014.02.002.

Limitations:

- Accounting for bird species is based on on-site interviews with local bird spotters who regularly station at and photograph birds at the park, therefore this is secondary data.
- Comparison of performance is limited by current research on bird species performance in urban ecological parks.

Lowers temperatures within the park, with average temperatures on forested islands measuring 2.0-4.6% cooler and on the park's peripheral pathways measuring 1.4-2.4% cooler than the surrounding streets.

Improves human thermal comfort on a summer afternoon by an average of 5.9% on the forested islands and 2.5% on the park's peripheral pathways as compared to the surrounding streets.

Additionally: Wind speed (for cooling effect) was measured at 23.2-53.3% higher at the edge of the park, and 36.5%-168% higher on the forested islands at the center, as compared to streetside

Background:

While it may generally be expected that places with more greenery and shade will offer improvements to thermal comfort performance, Fish Tail Park offers a unique opportunity to examine the effects on a micro-level relative to certain spatial strategies and may reveal useful lessons for future designs that have heat mitigation as one of their goals. This investigation is possible as spaces at Fish Tail Park are distinctively different because of the aqua-forest island design approach. Specifically, three categories of spaces were identified.

Figure 20: Locations of sampling categories

Cat 1: Sidewalk

This type of space can be found along the periphery of the park. It is 3 meters wide, paved using unit pavers and has street trees alongside planted at approx. 3 meter intervals, but is otherwise directly adjacent to asphalt paved slow / car lanes. If slow lane is present, the slow lane is 5 meters wide, followed by a green buffer with street trees planted at 5.5m intervals, before reaching car lanes. Based on the orientation of sunlight, it may have some limited shading from street trees.

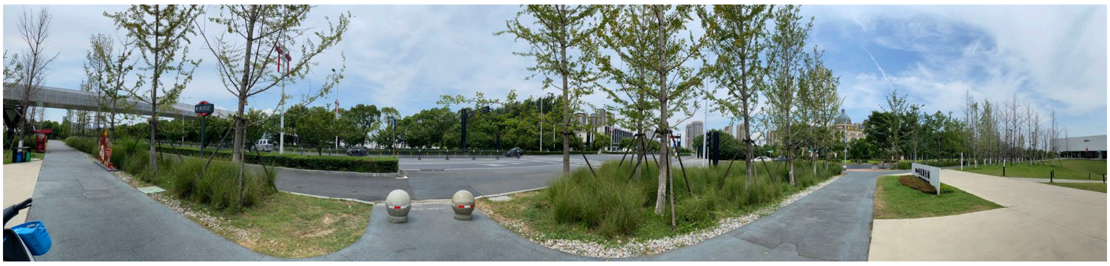


Figure 21 photo of point 1 located on the southwest corner of Fish Tail Park

Figure 22 photo of point 12 located along Wugongmio Road

Cat 2: Belt-landscape

This type of space is inside the park and in a belt-like configuration running along the periphery. Tree planting in this area is inconsistent. Some areas have trees spaced 5m apart, and in others trees are scattered. In general, the shading in this area categorically similar to Cat 1 and is limited. However, distinctively, this area is defined by a stepping down of elevation totaling to about 3 meters from city road level towards the water. If any major difference is found here, elevation may be a primary explanatory factor.

Figure 23 photo of point 9 showing the elevation change towards the water

Cat 3: Aqua-forest Islands

The third type is the forested islands, located at the center of the park and surrounded by various sizes of water bodies. It is characterized by densely planted metasequoia trees along with aquatic plants, with the exception of a few open platforms and two raised arc bridges. It would be interesting to observe the performance of this deliberate gesture of high density planting, and how humidity and wind speed changes within these denser pockets of landscape, while some of the open areas may help isolate the effectiveness of water area from shade.

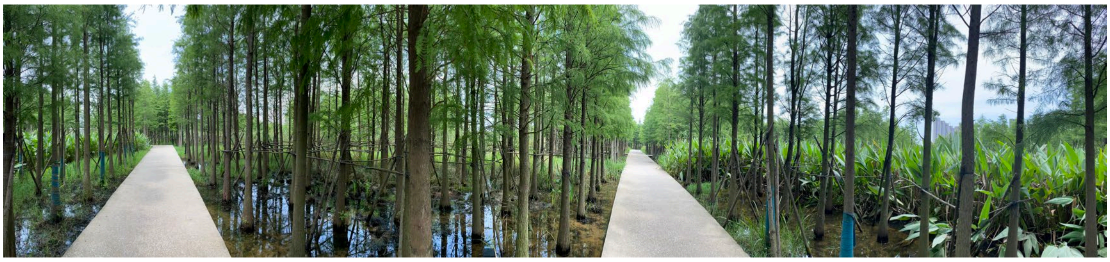


Figure 24 photo of point 15 showing densely planted metasequoia trees along with aquatic plants

Figure 25 photo of point 16 showing raised arc bridge

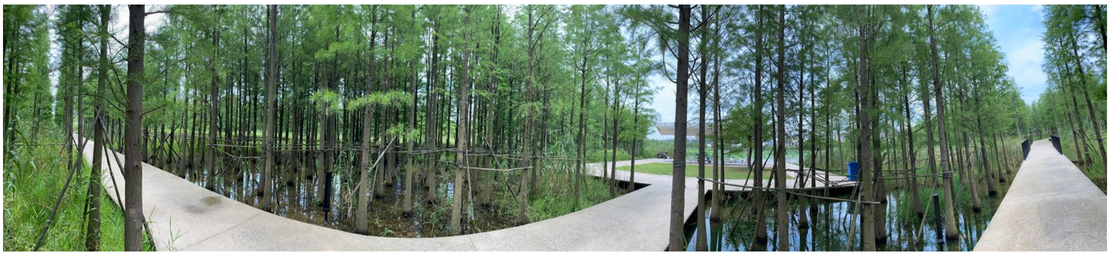


Figure 26 photo of point 18 showing open platform

To perform this study, the research team collected data 3x per day over 17 consecutive days on temperature, humidity, and windspeed, in hopes of revealing not only raw environmental data changes, but also perceived thermal comfort changes.

Method:

<u>Device Used</u>

The team selected DL333203 Handheld Windspeed Gauge produced by Deli Tools, and UT333 Handheld Temperature/Humidity Gauge produced by Uni-Trend Technology (China) Co., Ltd. Their published specifications are laid out in Figure 27, which shows their range and accuracy to measure temperature (in unit of degrees Fahrenheit), humidity (in unit of RH relative humidity in percent), and windspeed (in unit of meter per sec) at Fish Tail Park.

Sensor	Parameters	Range	Accuracy
DL333203	Wind Speed	0-30 m/s	±5%±0.1m/s
DL333203	Wind Tempe	-10 To 45°C	±2°C
UT333	Temperatur	14 To 140°F	±2°F
UT333	Humidity	0-100%RH	±5%RH

DL333203 UT333

Figure 27 specifications and photos for the devices used for measurement of micrometeorological parameters

Placement of Sampling Points

- Sampling points were placed with a general goal of having good representation in each of the three categories of spaces. For feasibility and to reduce timespan for each measurement trip, the points were placed closer to the southern half of the park along an East-West direction. The points are set at roughly 100 meters apart and set at recognizable spots to ensure consistency in where the collection takes place each day. Points placement also considered a series of imaginary grid lines parallel to the orientation of the park, in order to control influence from other edges of the park and therefore make them more comparable. The resulting sampling points and their respective categories are described as follows:
  - Points 1-6 and 12 are for Cat 1 space and are located outside the park and near urban traffic. Notably, point 12 is on the west side whereas the rest of the points are on the south side; point 6 is also adjacent to a parking lot, in addition to the usual urban edge condition.
  - Points 7-11 and 13 are for Cat 2 space and are located inside the park along the periphery of the park, mostly along the 2-meter-wide concrete path and adjacent to the open water, with the exception of points 11 and 13 at expanded paving areas.
  - Points 12-19 are for Cat 3 space and are located in the core of the park surrounded by water and within the aqua-forest island area. Notably, point 16 is in the middle of an arc bridge connecting two island groups, and therefore does not have any shade.

  See Figure 28 for their placement on the site.

Figure 28 Locations of the sampling points across the site for measurement

Protocol of Data Collection

To collect data for all sampling points while minimizing margins of error, the data collection protocol is laid out as follows:

A. Collection was done by two routes to minimize the time span. The Northern route includes Points 12-19, a total of 8 sampling points which go through the center of the park along the water body and the aqua-forest; the Southern route includes Points 1-11, a total of 11 sampling points done with two E-W runs.

B. Personnel doing the collections switched route to minimize operator's error. UNL personnel were responsible for the Northern Route from July 5th through July 13th, then from July 12th through July 21st they took the Southern route. For each day, the team entered the data reading at each location via Qualtrics using personal mobile devices. Then, at the end of each day, all numbers were put into a database file and cross-checked for any error using the following format:

5FlTmY | 2XyJZV | dvZJN5 | gLYy5t | bbBFd3 | ds4L6O | cCJRF

	A	B	C	D	E	F	G	H	I	J	K	L	
1	Date & Weather Condition												
2		Wind speed			Wind temperature			Temperature			Humidity		
3	Points	9 AM	2 PM	7 PM	9 AM	2 PM	7 PM	9 AM	2 PM	7 PM	9 AM	2 PM	7 P
4	1												
5	2												
6	...												

点击图片可查看完整电子表格

Figure 29 Format of temperature, humidity, wind temperature, and windspeed data records

C. Temperature, humidity, and windspeed were recorded three times a day, at 9am, 2pm and 7pm, and finished as soon as possible to ensure minimum temperature variations. This will yield a total of 19 x 3=57 line data per day, and a total of 57 x 17 = 969 line data in total.

D. All instruments were held at 1.5 m above the ground and recorded data for 30 sec. For temperature measurement, direct sunlight exposure to the device was avoided.

Figure 30, holding the device and taking measurement

<u>Comparing the Data Collected</u>

The team has examined several methods to analyze and compare data. First, the team wanted to determine if the park reduces the urban heat island effect. To do so, the team compared average temperature records outside the park, within the park boundary, and inside the park. Second, the team analyzed microclimate data in three categories: near all city streets, all belt landscape, and all islands. The team calculated changes and percentages for average temperature, humidity, and wind speed for directly comparable locations. For example, we found the average for Cat 1 (points 12, 1, 2, 3, 4, 5, 6), Cat 2 (points 13, 11, 10, 9, 8, 7), and Cat 3 (points 14, 15, 16, 17, 18, 19). Additionally, the team compared points along the same North-South directions for a cross-sectional comparison for temperature, humidity, wind speed, and thermal comfort. For this purpose, points 3-10-14, points 4-9-15, points 3-8-16 (note: 16 is a bridge), and points 6-7-18 were selected.

Calculations:

1. Overall cooling effect

A. Temperature

In order to determine if the park reduces the urban heat island effect, the recorded temperatures over three times a day from July 5th to 20th in 2023 were averaged the results (see Figure 31). The average temperature of Cat 1 locations and Cat 2 locations were compared to Cat 3 locations. Our findings indicated that Cat 1 locations and Cat 2 locations had higher temperatures than Cat 3 locations. For instance, at 2 pm, the average temperature in Cat 1 locations was 99.5, in Cat 2 locations was 97.05 (-2.4% change compared to Cat 1), and in Cat 3 locations was 95.4 (-4.12% change compared to Cat 1). This indicates a 4.1 difference in air temperature between the park and its surroundings.

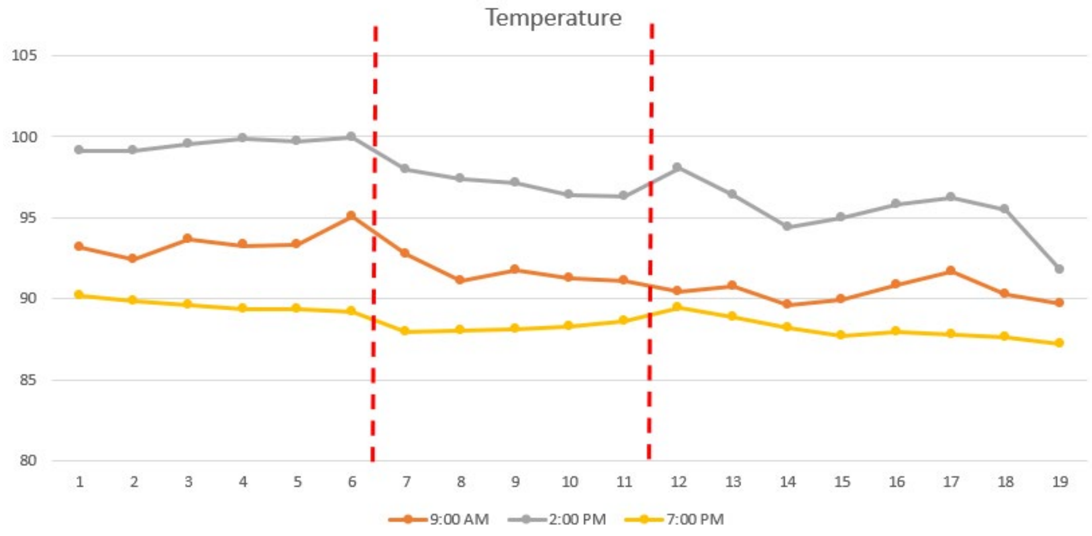


Figure 31 Average Temperature for the period 05 to 20 July, 2023

The average temperature from 05 to 20 July 2023, at 9 am, Cat 1 locations measures 93.04 F , Cat 2 locations measures 91.4 F (-1.7%), Cat 3 locations measures 90.3 F (-2.9%).

The average temperature from 05 to 20 July 2023, at 2 pm, Cat 1 locations measures 99.3 F , Cat 2 locations measures 96.94 F (-2.4%), Cat 3 locations measures 94.7 F (-4.57%).

The average temperature from 05 to 20 July 2023, at 7 pm, Cat 1 locations measures 89.5 F, Cat 2 locations measures 88.3 F (-1.4%), Cat 3 locations measures 87.7 F (-2.04%).

The lower temperature in Cat 2 locations suggests that a cooling effect is immediately observed in the belt-area very close to the road, likely thanks to higher vegetation cover and sunken elevation. The cooling effects continued towards the center of the park, as suggested by data from Cat 3 locations. The overall cooling effects are most pronounced during the heat of the day, measured at 2pm.

B. Humidity

It can be observed that inside the park has higher humidity than outside, and humidity increases towards the islands area.

The average humidity from 05 to 20 July 2023, at 9 am, Cat 1 locations measures 64.4 RH , Cat 2 locations measures 67.4 RH (+4.5%), Cat 3 locations measures 68.6 RH (+6.4%).

The average humidity from 05 to 20 July 2023, at 2 pm, Cat 1 locations measures 56.1 RH , Cat 2 locations measures 59.9 RH (+6.7%), Cat 3 locations measures 60.9 RH (+8.4%).

The average humidity from 05 to 20 July 2023, at 7 pm, Cat 1 locations measures 71.6 RH , Cat 2 locations measures 74.7 RH (+4.2%), Cat 3 locations measures 75.8 RH (+5.8%).

The humidity difference is likely explained by evaporation of plants, where the island area has the greatest density. Higher humidity may result in people feeling hotter and is explored further in the next section of temperature equivalent.

C. Wind Speed

The average wind speed from 05 to 20 July 2023, at 9 am, Cat 1 locations measures 0.425 m/s, Cat 2 locations measures 0.65m/s (+53.3%), Cat 3 locations measures 1.13 m/s (+166%).

The average wind speed from 05 to 20 July 2023, at 2 pm, Cat 1 locations measures 0.44m/s, Cat 2 locations measures 0.54 m/s (+23.2%), Cat 3 locations measures 1.19 m/s (+168%).

The average wind speed from 05 to 20 July 2023, at 7 pm, Cat 1 locations measures 0.28 m/s, Cat 2 locations measures 0.41 m/s (+42.3%), Cat 3 locations measures 0.39 m/s (+36.5%).

Overall, significant wind speed increases can be observed. Further research is suggested to understand the wind dynamics in this park.

2. Overall thermal comfort gain

To better understand people's body-felt thermal experience, it is important to use more than just temperature as an indicator. Thermal comfort in the park was calculated by using Missenard formula, which calculates effective temperature equivalent (EET), experienced by the human body based on air temperature, humidity, and wind speed, and includes the following two: EET : the "major scale" for a naked human (equivalent-effective temperature or EET) and the NEET : "normal scale" for a human dressed in standard clothing (normal equivalent-effective temperature).

EET is calculated using the following formula:

$$EET = t[1-0.003(100-f)] - 0.385v_2^{0.59}[(36.6-t)+0.622(v_2-1)] + \\ +[(0.0015v_2+0.0008)(36.6-t)-0.0167](100-f), \quad (1)$$

In this formula: t is the air temperature in °C, f is the relative humidity %,v is the wind speed in m/s

NEET is calculated using the following formula:

$$NEET = 0.8EET + 7^{\circ}C \quad (2)$$

To make the calculation, we first calculated the average air temperature, humidity, and wind speed over the time period 05 to 20 July, 2023, then made conversions from F to C, and finally calculated EET and NEET using the formula referenced above. Results are illustrated in Figure 32 and 33. It can be seen that the temperature equivalents in Cat 1 locations are generally greater than Cat 2 locations and are generally greater than Cat 3 locations. This indicates a positive role the park plays in reducing thermal comfort.

Notably, EET&NEET at several points within the island area is higher. Several possible explanations are offered here: for point 15, it is in the core of the island area and surrounded by trees, meaning higher humidity and less wind; for point 17, it is surrounded by trees and the platform is not shaded. Also noteworthy is Point 16, which is situated on the top of the bridge above the water channel. Although there is no shade, the computed EET&NEET is lower, likely thanks to wind.

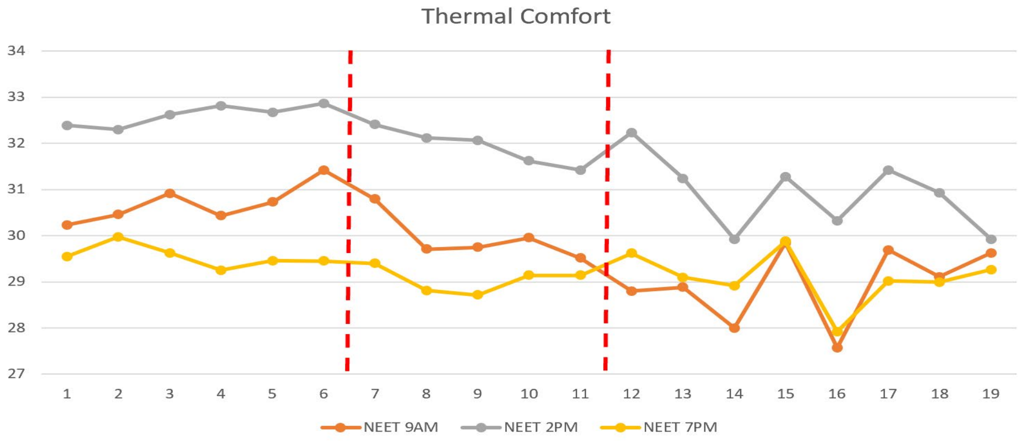


Figure 32 Average of normal equivalent-effective temperature (NEET) from 05 to 20 July, 2023

To further understand the different spaces in the park, the average normal equivalent-effective temperature (NEET) for the different spaces in the park Figure 33, shows that the average NEET in Cat 1 locations and Cat 2 locations is higher than Cat 3 locations. The difference between inside the park and outside the park at 9 AM and 2PM is 1.7 C and it decreases from 7PM to 0.4 C. This indicates the performance of the different spaces in the park.

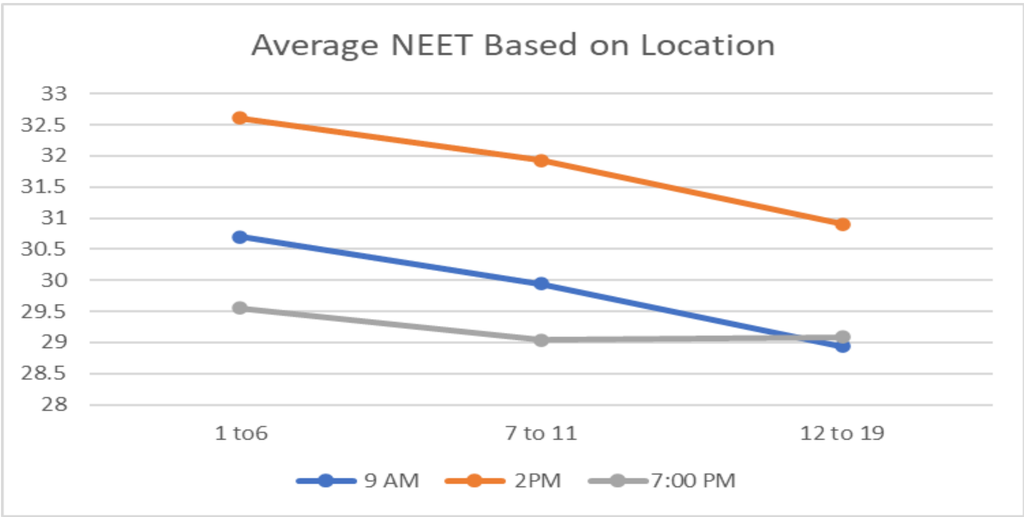


Figure 33 Average of normal equivalent-effective temperature (NEET) from 05 to 20 July, 2023 for Point categories 1, 2, and 3

3. Along imaginary N-S gridlines

To further examine the microclimate data, we also became interested in comparing points which are roughly along the same North-South gridlines for both temp, humidity, windspeed, and thermal comfort comparison. This would allow us to isolate the influence of edge influences from the "sides" and see how data changes as it goes "up" into the park. We have selected the following groups of points to compare: points 3, 10, 14; points 4-9-15; 3-8-16(note: 16 is on bridge), and points 6-7-18. See Appendix 1 for full calculations of the gridlines.

Sources:

Teodoreanu, Elena. "Thermal comfort index." *Present Environment and Sustainable Development* 2 (2016): 105-118.

Katerusha, O., and T. Safranov. "Assessment of bioclimatic resources in the coastal zone of Odessa region." *Aerul si Apa. Componente ale Mediului* (2013): 25.

Teodoreanu, Elena. (2016). Thermal Comfort Index. Present Environment and Sustainable Development. 10. 10.1515/pesd-2016-0029.

Sources:

Teodoreanu, Elena. "Thermal comfort index." *Present Environment and Sustainable Development* 2 (2016): 105-118.

Katerusha, O., and T. Safranov. "Assessment of bioclimatic resources in the coastal zone of Odessa region." *Aerul si Apa. Componente ale Mediului* (2013): 25.

Teodoreanu, Elena. (2016). Thermal Comfort Index. Present Environment and Sustainable Development. 10. 10.1515/pesd-2016-0029.

Limitations:

- It was not feasible to take data measurement at the exact same moment for all the parks, and therefore errors may exist because of time difference in data collection.
- Data produced by the devices is limited by their published accuracy.

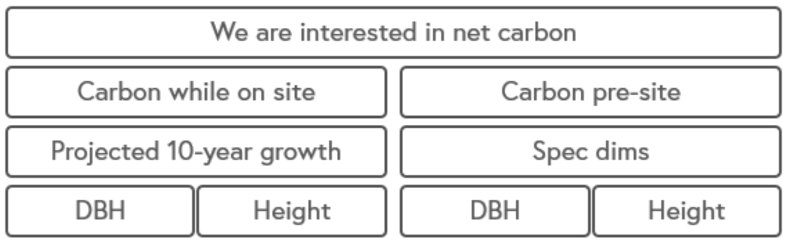
Projected to sequester an estimated 47,906,805 lbs of carbon over the next 10 years in 26,101 newly planted trees.

Background:

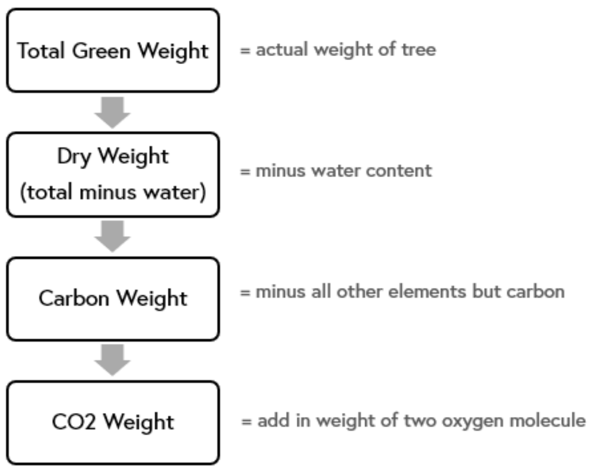
The planting plan provided by the design firm states that a total of 26,101 trees are planted in the park, including 7 canopy species. This significant number of trees is expected to positively impact Nanchang city by increasing carbon sequestration.

Carbon sequestration is a natural process of plants where they take carbon dioxide from the atmosphere and transport it to solid form.

Method:



The landscape architect provided us with a planting plan that was divided into three categories: Canopy trees, Ground covers and aquatic plants. The canopy trees were used to do this analysis as they have high carbon sequestration, then canopy trees were broken down into different species and carbon sequestration calculated for each species using the following method:



Step 1: Determine the total green weight of the tree

D = diameter of tree in inches

W = total weight of the tree Above-ground weight in pounds

H = height of trees in feet

Use one of these equations based on the diameter of the tree:

For trees with $D < 11$:

W = 0.25D2H

For trees with D >= 11:

W = 0.15D2H

Step 2: Determine the dry weight of the tree

Based on publication, the average tree is 72.5% dry matter and 27.5% moisture.

Dry percentage = 0.725 (72.5% expressed as a decimal)

Dry weight = weight of tree * dry percentage

Step 3: Determine the weight of carbon in the tree

Based on publication the average carbon content is generally 50% of the tree's total volume.

To calculate the weight of carbon in a tree we use

Carbon_percentage = 0.5 (50% expressed as a decimal)

Carbon weight = Dry weight * Carbon Percentage

Step 4: Determine the weight of carbon dioxide sequestered in the tree

To calculate the weight of carbon dioxide sequestered in a tree

The atomic weight of Carbon is 12.001115.

The atomic weight of Oxygen is 15.9994.

The weight of CO2 is C+2*O=43.999915.

The ratio of CO2 to C is 43.999915/12.001115=3.6663.

Carbon weight = carbon_weight * ratio of CO2 to C

Calculations:

- **Sapium sebiferum,**

Total Carbon Sequestration / Life Cycle

10-year-old Chinese tallow tree can be expected to have a height of around 13 feet and a trunk diameter of 8 inches

*Internal note: From the database it says: Seedlings should be planted out when they are about 1 m tall. The tree grows rapidly, 5-8.5 m tall with a DBH of 13-17 cm in 10 years, and 10-13 m tall with DBH 30-40 cm in 20-30 years. Recommended stocking rate is 400 trees per hectare, and should be trimmed to a convenient size for hand harvesting. Chinese tallow is only moderately drought tolerant; seedlings especially, need watering during dry periods.

Because our tree is about 6-6.5 m tall and 12-14 cm DBH, we are estimating that this is around 6-10 years old at installation based on this database's description. Therefore, we are taking the lower end of the number for their projected size 10 years after installation, so a DBH of 30cm (11.8in) and a height of 10m (32.8ft)

https://apps.worldagroforestry.org/treedb2/AFTPDFS/Sapium_sebiferum.PDF

For calculation, D uses INCHES as unit, and H uses FT as unit, the resulting number is in LBS

W = 0.25D2H = 0.25(82)(13) = 208lbs. green weight above ground.

208lbs. * 120% = 249.6lbs. green weight (roots included)

249 lbs. * 72.5% = 180.96 lbs. dry weight

180.96 lbs. * 50% = 90.48 lbs. carbon

90.48 lbs * 3.6663 = 331.7 lbs. CO2 sequestered

331.7 lbs / 10 years = 33.1 lbs. CO2 sequestered per year

A total of 2,930 Sapium sebiferum were planted, resulting in a total CO2 sequestration of:

331.7 * 2930 = 971,881 lbs. CO2 sequestered

971,881 lbs / 10 years = 97,188.1 lbs. CO2 sequestered per year

<u>Carbon Sequestration / Pre-Installation</u>

According to the Planting Schedule CAD file, the specification for this tree at planting is a DBH of 12-14CM and a height of 600-650mm. We are taking an average of these numbers for calculation, which is DBH = 13CM (5.1in) and Height = 625cm (20.5 ft)

For calculation, D uses INCHES as unit, and H uses FT as unit, the resulting number is in LBS

W = 0.25D2H = 0.25(5.12)(20.5) = 133 lbs. green weight above ground.

133 lbs. * 120% = 159.6 lbs. green weight (roots included)

159.6 lbs. * 72.5% = 115.7 lbs. dry weight

115.7 lbs. * 50% = 57.9 lbs. carbon

57.8 lbs * 3.6663 = 212.1 lbs. CO2 sequestered

This means trees at installation comes with 212.1 lbs of CO2 already sequestered during their time at the nursery

A total of 2,930 Sapium sebiferum were planted, resulting in a total CO2 sequestration at nursery of:

212.1*2930=621,160 lbs

- **Sapindus mukorossi,**

At 10 years old, a Sapindus mukorossi tree can have a height of 16.91 and 5.09DBH

W = 0.25D2H = 0.25(5.092)(16.91) = 109.74lbs. green weight above ground.

109.74 lbs. * 120% = 131.69lbs. green weight (roots included)

131.69lbs. * 72.5% = 95.47 lbs. dry weight

95.47 lbs. * 50% = 47.74 lbs. carbon

47.74lbs * 3.6663 =175.01 lbs. CO2 sequestered

175.01 lbs / 10 years = 38.3 lbs. CO2 sequestered per year

<u>Carbon Sequestration / Pre-Installation</u>

According to the Planting Schedule CAD file, the specification for this tree at planting is a DBH of 12-14CM and a height of 600-650 cm. We are taking an average of these numbers for calculation, which is DBH = 13CM (5.12in) and Height = 625cm (20.51 ft)

For calculation, D uses INCHES as unit, and H uses FT as unit, the resulting number is in LBS

W = 0.25D2H = 0.25(5.122)(20.51) = 134.28 lbs. green weight above ground.

134.28 lbs. * 120% = 161.14 lbs. green weight (roots included)

111.56 lbs. * 72.5% = 116.83 lbs. dry weight

116.83 lbs. * 50% = 58.41 lbs. carbon

58.41 lbs * 3.6663 = 214.16lbs. CO2 sequestered

This means trees at installation comes with 214.16lbs of CO2 already sequestered during their time at the nursery

A total of 1183 **Cinnamomum camphora,** were planted, resulting in a total CO2 sequestration at nursery of:

214.16lbs*704.00=175398.54 lbs

<u>Carbon Sequestration / Net</u>

In this calculation, we will substrat the pre-installation number from the total number projected over 10 years.

Total net

Per year net

- **Pterocarya stenoptera,***Pterocarya stenoptera C. DC.*

At 10 years old, a Pterocarya stenoptera tree can have a DBH 26.00 inch, and 37.00ft hight

W = 0.25D2H = 0.25(262)(37) = 6253 lbs. green weight above ground.

6253 lbs. * 120% = 7503.6lbs. green weight (roots included)

7503.6lbs. * 72.5% = 5440.11 lbs. dry weight

5440.11 lbs. * 50% = 2720.06 lbs. carbon

2720.06lbs * 3.6663 = 9972.54 lbs. CO2 sequestered

9972.54 lbs / 10 years =997.25 lbs. CO2 sequestered per year

<u>Carbon Sequestration / Pre-Installation</u>

According to the Planting Schedule CAD file, the specification for this tree at planting is a DBH of 20 cm and a height of 300-350 cm. We are taking an average of these numbers for calculation, which is DBH = 20 CM (7.87in) and Height = 325cm (10.66 ft)

For calculation, D uses INCHES as unit, and H uses FT as unit, the resulting number is in LBS

W = 0.25D2H = 0.25(7.872)(10.66) = 165.27 lbs. green weight above ground.

165.27 lbs. * 120% =198.33 lbs. green weight (roots included)

198.33 lbs. * 72.5% =143.79 lbs. dry weight

143.79 lbs. * 50% = 71.89 lbs. carbon

71.89 lbs * 3.6663 = 263.58 lbs. CO2 sequestered

This means trees at installation comes with 263.58 lbs of CO2 already sequestered during their time at the nursery

A total of 68 **Cinnamomum camphora** were planted, resulting in a total CO2 sequestration at nursery of:

17923.7 lbs

<u>Carbon Sequestration / Net</u>

In this calculation, we will subtract the pre-installation number from the total number projected over 10 years.

Total net = 660208.86

Per year net= 66020.89

- Ginkgo biloba,

Ginkgo biloba tree can have a height of around …….

W = 0.25D2H = 0.25(82)(15) = 240 lbs. green weight above ground.

240 lbs. * 120% = 288 lbs. green weight (roots included)

288 lbs. * 72.5% = 208.8 lbs. dry weight

208.8 lbs. * 50% = 104.4 lbs. carbon

104.4 lbs * 3.6663 = 382.8 lbs. CO2 sequestered

382.8 lbs / 10 years = 38.3 lbs. CO2 sequestered per year

- **Cinnamomum camphora,**

At 10 years old, a Cinnamomum camphora tree can have a height 27.07ft and DBH 4.92 in

https://journals.ashs.org/hortsci/view/journals/hortsci/50/5/article-p762.xml

W = 0.25D2H = 0.25(4.922)(27.07) = 163.88lbs. green weight above ground.

163.88lbs. * 120% = 196.66lbs. green weight (roots included)

196.66lbs. * 72.5% = 142.58lbs. dry weight

142.58 lbs. * 50% = 71.29 lbs. carbon

71.29 lbs * 3.6663 =35.64 lbs. CO_2 sequestered

35.64 lbs / 10 years = 3.56 lbs. CO_2 sequestered per year

<u>Carbon Sequestration / Pre-Installation</u>

According to the Planting Schedule CAD file, the specification for this tree at planting is a DBH of 15CM and a height of 300-350 cm. We are taking an average of these numbers for calculation, which is DBH = 15CM (5.91in) and Height = 325cm (10.66 ft)

For calculation, D uses INCHES as unit, and H uses FT as unit, the resulting number is in LBS

W = 0.25D2H = 0.25(5.912)(10.66) = 92.97 lbs. green weight above ground.

92.97 lbs. * 120% = 111.56 lbs. green weight (roots included)

111.56 lbs. * 72.5% = 80.88 lbs. dry weight

80.88 lbs. * 50% = 40.44 lbs. carbon

40.44 lbs * 3.6663 = 148.27 lbs. CO_2 sequestered

This means trees at installation comes with 148.27 lbs of CO_2 already sequestered during their time at the nursery

A total of 1183 **Cinnamomum camphora** were planted, resulting in a total CO_2 sequestration at nursery of:

148.27*1183=175398.54 lbs

<u>Carbon Sequestration / Net</u>

In this calculation, we will substrat the pre-installation number from the total number projected over 10 years.

Total net=-133231.21

Per year net=-13323.12

- **Zelkova serrata, *Taxodium distichum var. Imbricatum***

https://www.nature.com/articles/s41598-021-87129-7/tables/1

D=4.43 HEIGHT=5.85M 9 YEAR

At 10 years old, a Zelkova serrata tree can have a height of around 40.02 feet and a trunk diameter of around 10.42inches

W = 0.25D2H = 0.25(10.422)(40.02) = 1085.99lbs. green weight above ground.

1085.99llbs. * 120% = 1303.19lbs. green weight (roots included)

1303.19 lbs. * 72.5% = 944.81 lbs. dry weight

944.81 lbs. * 50% = 472.41lbs. carbon

472.41lbs * 3.6663 =1731.998lbs. CO_2 sequestered

1731.99 lbs / 10 years = 1731.99 lbs. CO_2 sequestered per year

Carbon Sequestration / Pre-Installation

According to the Planting Schedule CAD file, the specification for this tree at planting is a DBH of 22CM and a height of 700-800 cm. We are taking an average of these numbers for calculation, which is DBH = 22CM (8.6in) and Height = 750cm (24.6 ft)

For calculation, D uses INCHES as unit, and H uses FT as unit, the resulting number is in LBS

W = 0.25D2H = 0.25(8.62)(24.6) = 456.97206 lbs. green weight above ground.

456.97206 lbs. * 120% = 548.366472 lbs. green weight (roots included)

548.366472 lbs. * 72.5% = 397.5656922 lbs. dry weight

397.5656922 lbs. * 50% = 198.7828461 lbs. carbon

198.7828461 lbs * 3.6663 = 728.79 lbs. CO_2 sequestered

This means trees at installation comes with 728.79 lbs of CO_2 already sequestered during their time at the nursery

A total of 174 **Zelkova serrata** were planted, resulting in a total CO_2 sequestration at nursery of:

728.79*174=126810.7 lbs

Carbon Sequestration / Net

In this calculation, we will subtract the pre-installation number from the total number projected over 10 years.

Total net=29008686.65

Per year net=2900868.66

Sources:

Tree planting plan and breakdowns were provided by the landscape architect, Turenscape

Limitations:

- The major limitation in this method is that the tree size is an estimation of the plant based on the World Agroforestry database or other resources.
- We do not know the actual size of the tree when plants arrived at the site.

Social Benefits

Introduction

For social benefits, this study is interested in exploring the various aspects of the park's design, including ecological, spatial and aesthetic, and their role as a health device for the general public, improving mood, reducing stress, and improving perceptions and opinions. To achieve this, the team designed an intercept survey with a goal to examine differences in people's thoughts and moods in different natural sittings, in collaboration with Dr. Karina Schoengold, Agricultural Economics, and Dr. Anne Schutte, Psychology, at UNL. The intercept survey was conducted on site at Fish Tail Park, targeting park users aged 19 and above, which is the legal age of majority in the state of Nebraska where the research team is based.

The intercept survey was implemented by the research team from June 30 to July 22, 2023, at various locations within the park. Researchers were strategically positioned in different areas. The protocol for survey was designed to ensure no bias in how respondents were selected and approached. Research assistants approached each person walking through survey areas, and in cases where multiple potential respondents were present in a given area, the closest individual was chosen first. The initial period of implementation spanned from 10 a.m. to 9 p.m. each day, but after on-site testing, it was adjusted to 10 a.m. to 12 p.m. and 2 p.m. to 9 p.m. The exclusion of the 12 p.m. to 2 p.m. timeframe was based on low park usage and reduced participant willingness during very hot summer weather.

Conducting surveys in Fish Tail Park

Participants engaged in the survey by scanning a QR code using their personal mobile devices and completing an online questionnaire. For those unwilling or unable to use personal devices, researchers provided mobile devices for questionnaire completion. The QR code linked to the Qualtrics survey platform.

All personnel distributing the survey underwent training on intercept survey methodology and ethics. Prior to the commencement of the research, participants were presented with an informed consent form, allowing respondents the option to participate or withdraw at any point during the process. Approximately 3.8% of participants chose not to proceed after reading the informed consent form, while 88.2% of consenting participants fully completed the questionnaire. In total, the survey received 748 responses.

The team received approval from the Institutional Review Board at the University of Nebraska-Lincoln prior to commencement of survey implementation.

Supports social engagement, with 66% of 748 surveyed visitors reporting that they visit with family and/or friends.

Promotes return visits, with 46% of 748 surveyed visitors stating they visit the park with some frequency (at least once per month).

Background:

Fish Tail Park has both ecological and social benefits, serving as a landmark in the Nanchang High Tech Zone. Every day, hundreds of people visit the park for various activities including dining at the cafe or restaurant, fishing at the water ponds, walking, bird watching, sightseeing, and meeting with friends. The park is well-equipped with different facilities, including a viewing platform along the island in the center, an observation tower in the southeast corner, a sports ground for basketball and skating on the east side, as well as a restaurant, café, and public toilets. On weekends, the park sees even higher numbers of visitors.

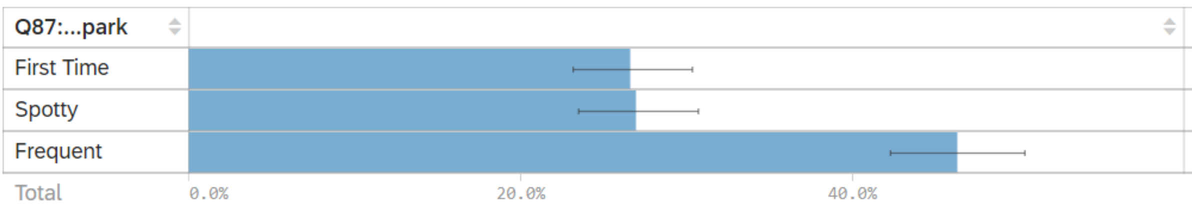
Method:

The survey involves questions to measure both use and special preferences as for use preference. To find out visitation frequency and return visitors, it asked a question of "How frequently do you use this park, with four choices: "first time", "few times per year", "a few times a month", and "a few times per week".

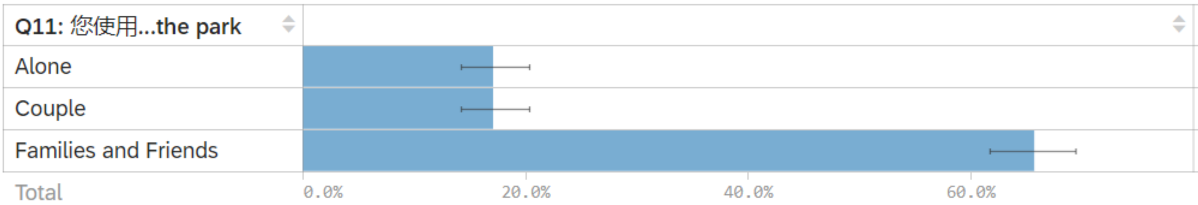
To find out the social setting under which visitors use the park, we asked a question: “What is the social setting when you use the park”, with four choices: "Alone", “As a couple”, and “Families and Friends”

Calculations:

To understand how many are now using the park frequently, we grouped the visitation frequency data into three categories, First Time, Spotty, and Frequent, where Frequent is a combination of the last two answers. 46.4% of the respondents visit the park frequently, at least once every month.



To understand the social setting, we looked at the results from this question which asks social setting directly. A clear pattern can be observed here, with 65.7% stating they are here with their family and/or friends, with the remaining roughly equally distributed between alone and couple.



Sources:

Intercept survey data

Limitations:

- Survey does not include park visitors at or under the age of 18

Supports mental health and well-being, with 56% of 748 surveyed visitors reporting they visit to enjoy nature and/or heal from daily pressure.

Promotes positive emotional responses through the presence of migrating birds, with 72% 748 of surveyed visitors displaying strong positive emotions towards birds on-site.

Background:

Fish Tail Park contributes significantly to emotional well-being and public health in the Nanchang High Tech Zone, acting as a serene retreat within the city. Daily, numerous individuals visit the park, engaging in activities that boost their mood and overall health. These include relaxing at the cafe or restaurant, looking afar at the edge of the lake, engaging in walking and bird watching, enjoying the scenic beauty, and socializing with friends. The park's design supports these health-promoting activities with its unique ecological aesthetics and design.

Method:

The team used an intercept survey to measure this benefit. The survey involves questions that seek to understand positive emotional responses, relieve from stress, and other outcomes.

The emotional benefits were surveyed and analyzed in several ways.

Direct

Some questions were asked directly, for example the purpose of visiting the park, with a list of choices including enjoying nature and its refreshing/healing effects.

Direct / Indexed

Some questions were statements of certain emotions, thoughts and feelings and people were asked to identify with. To understand these statements together, indexes are created to show them in an aggregate form, as follows:

The enchantment index is an index constructed from five yes or no statements for identifying with characteristic of thoughts while being in the park, intended to measure if people have switched into an abstract, emotional, imaginary, and positive mode of thinking, rather than rational thinking.

The egret index is an index which compiles people's emotional reactions to the idea of migratory birds, like poetic, imaginary, free, etc to understand how certain preferred species evoke positive feelings for park visitors.

Relationship / Causal

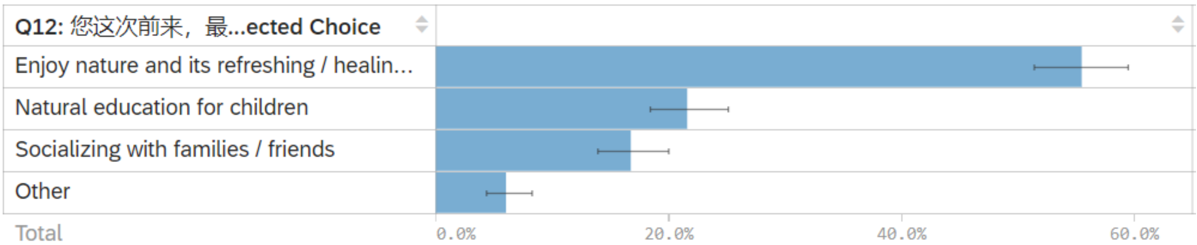
Some analysis focused on understanding explanatory factors and emotional / healing outcomes. For example, we explored how well the enchantment index and the feeling of getting away from daily concerns are coupled.

Calculations:

Some of the results were directly from survey questions. For those looking at relationships, we used Qualtrics for analysis.

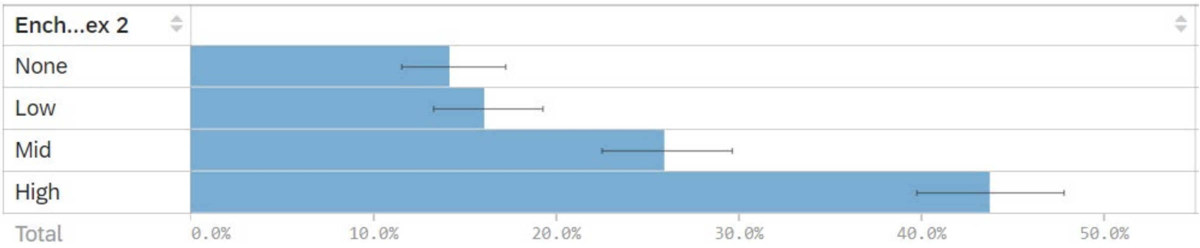
Healing (Direct)

55.5% surveyed indicated they are here to enjoy nature and/or heal from daily pressure, 22.4% indicated they brought their kids here for natural education.



Effects of feeling enchanted (Direct / Indexed, Relationship / Causal)

On the Enchantment Index (EI), constructed using five emotional statements, 43.8% displayed high index score while being at the park.

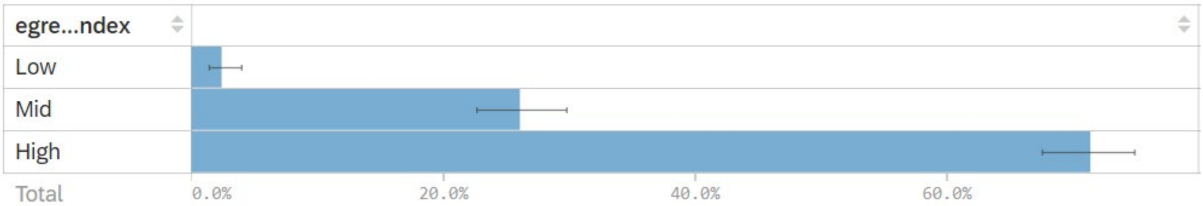


High index score in EI leads to increased likelihood of feeling away from everyday concerns

Enchantment Index 2	Q111: 您感觉自己远离了日常的烦恼吗? How much do you fe...otten away" from your every... 点没有 Not a...	2	3	4	5 = 完全远离了 Ver...
None	35.7%	23.7%	8.6%	13.6%	13.5%
Low	7.1%	13.2%	22.0%	16.6%	7.3%
Mid	10.7%	25.0%	26.3%	30.2%	22.9%
High	46.4%	38.2%	43.1%	39.6%	56.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

<u>Effects of preferred species (Direct / Indexed, Relationship / Causal)</u>

On an index constructed using eight emotional statements on egrets and other migratory birds, 71.5% displayed strong positive emotions towards them.



Healing Effect:

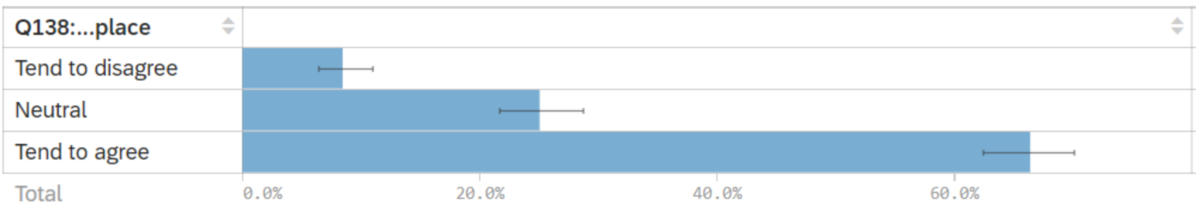
Statistically strong relationship can be observed between emotional responses to migratory birds on site, and how much they felt away from everyday concerns

egret index	Q111: 您感觉自己远离了日常的烦恼吗? How much do you...ten away" from your everyd... 1 = 一点没有 No...	2	3	4	5 = 完全远离了 ...
Low	25.0%	1.3%	2.4%	0.0%	1.0%
Mid	21.4%	50.0%	39.7%	11.2%	5.2%
High	53.6%	48.7%	57.9%	88.8%	93.8%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

<u>Place Recognition and Attachment (Direct / Indexed, Relationship / Causal)</u>

66.4% feeling migratory birds make the park unique and special.

Statistically strong and very clear relationship between emotional responses to migratory birds on site, and how much they felt they would choose Fish Tail Park as the place to take visitors to who have come from outside the city.



Supports positive public opinion towards management of the city and land, with 58% of 748 surveyed visitors agreeing that the park represents a more advanced example of land stewardship and 66% agreeing that it is in harmony with nature.

Background:

One type of social value from ecological parks is in improving public opinions and satisfaction towards management and development of the city. Fish Tail Park restored an urban brownfield and promoted habitat creation, migratory bird support, water purification, and many other environmentally beneficial interventions. The team is interested in seeing if and how well they help frame public opinions towards the park and management of the city.

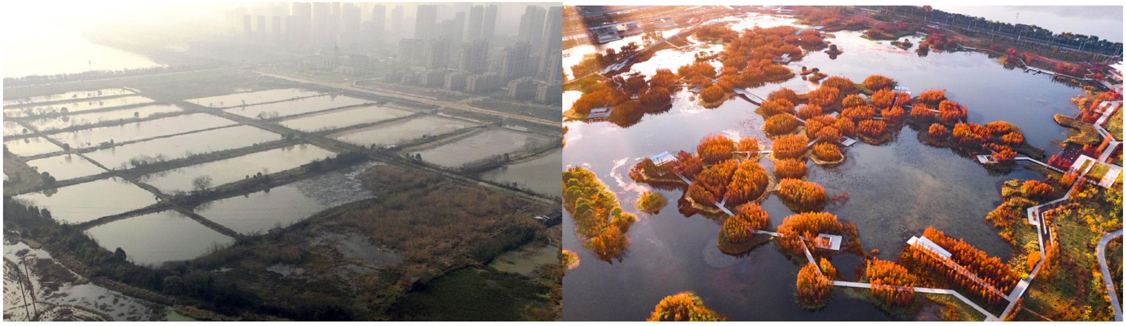


Image: Before and After.

Method:

The team used an intercept survey to measure this benefit. The survey involves questions that seek to understand how visitors perceive environment efforts and their attitudes.

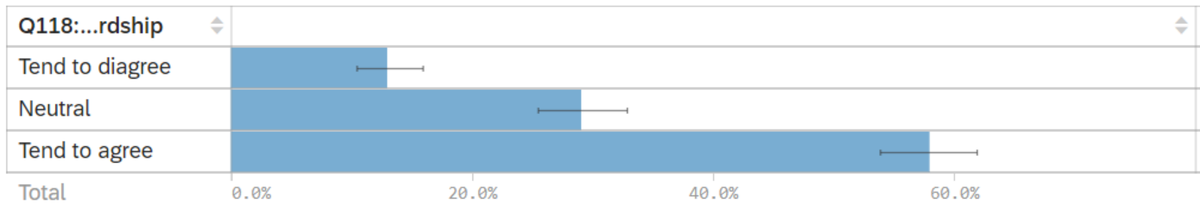
Calculations:

Some of the results were directly from survey questions. For those looking at relationships, we used Qualtrics for analysis.

The survey question has a total of 748 responses, Attitudes

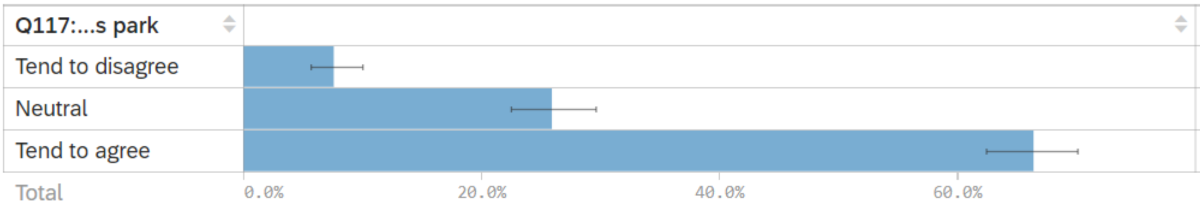
<u>Positive Land Stewardship:</u>

58.0% of surveyed believe that Fish Tail Park represents a more advanced way of land stewardship



<u>Harmony with Nature:</u>

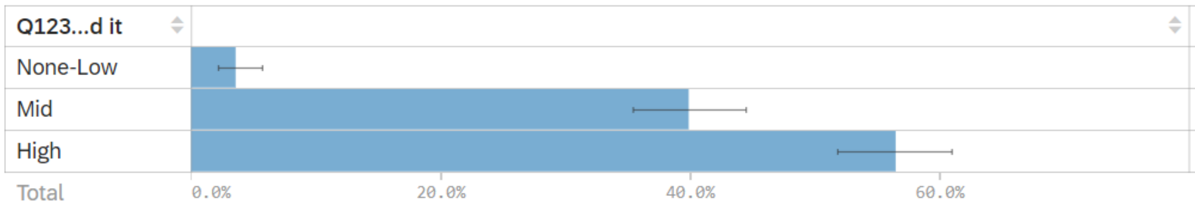
66.4% of surveyed believe that Fish Tail Park is harmonious with nature.



Return of the “good-old-days”

As China developed, sometimes a perception can be observed where the public feels the development is coming at the price of the environment, and a sentiment of missing the past relationship with nature exists. We were interested in seeing if this ecological approach to parks matches the desire of the public to return to a co-living with nature. We explored this by first asking if people believed the environment of the past was better; and then if they think Fish Tail Park represent a return to that past good environment on a 1-5 scale.

Of people who believed the environment in the past were more natural and better, 51.4% agree or strongly agree that Fish Tail Park represents a return to that natural past; only a very small percentage gave a 1 or 2, indicating either disagreement or weak agreement.



Improved public opinion leading to improved place attachment

Statistically strong relationship can be observed between how much in harmony people think this park is with nature, and if they would take their friends visiting from outside of the city to the park over other places in Nanchang.

	Q117: 您觉得这座公园与自然是和谐的吗? How...like we ...		
Q124: 如果您要带...rinc...	Tend to disagree	Neutral	Tend to agree
Tend to disagree	63.6%	25.3%	12.8%
Neutral	25.0%	48.7%	21.4%
Tend to agree	11.4%	26.0%	65.9%
Total	100.0%	100.0%	100.0%

Sources:

Intercept survey data

Limitations:

- Survey does not include park visitors at or under the age of 18

Decreases noise levels by an average of 10.8 decibels, a clearly noticeable change, between the road and the sunken area of the park immediately next to the road.

Background:

The economic and social development of Nanchang city has led to an increase in the flow of people and vehicles. The number of vehicles daily on the roads has increased by 28.24%, from 594,200 in 2022 to over 762,000 this year, according to The People's Government of Nanchang Municipality. The Fish Tail Park is situated in the Nanchang High-tech Zone, surrounded by urban fabric to the south, Aixihu North Road to the west, and Wugongmio Road to the east. The park is bordered by Mingshan Drainage to the north and east, as shown in Figure 34.

The research team collected data to determine how well the park reduces noise levels emitted by busy roads and urban fabric.

Figure 34 Fish Tail Park’s geographic location

Method:

The team sampled points within three categories in the park, as follows. These are identical to what was measured to evaluate thermal comfort.

Figure 35: Locations of sampling categories

In the park, 19 points were identified and selected as data collection points for noise levels as shown in Figure 36. Identified points have an average 100 m spacing from each other.

Figure 36 Distribution of sampling points for noise level data collection.

Cat 1: Sidewalk

This type of space can be found along the periphery of the park. It is 3 meters wide, paved using unit pavers and has street trees alongside planted at approx. 3 meter intervals, but is otherwise directly adjacent to asphalt paved slow / car lanes. If slow lane is present, the slow lane is 5 meters wide, followed by a green buffer with street trees planted at 5.5m intervals, before reaching car lanes. Based on the orientation of sunlight, it may have some limited shading from street trees.

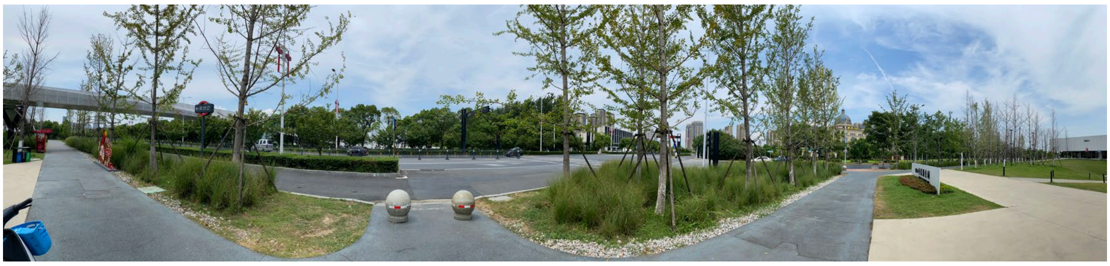


Figure 37 photo of point 1 located on the southwest corner of Fish Tail Park

Figure 38 photo of point 12 located along Wugongmio Road

Cat 2: Belt-landscape

This type of space is inside the park and in a belt-like configuration running along the periphery. Tree planting in this area is inconsistent. Some areas have trees spaced 5m apart, and in others trees are scattered. In general, the shading in this area categorically similar to Cat 1 and is limited. However, distinctively, this area is defined by a stepping down of elevation totaling to about 3 meters from city road level towards the water. If any major difference is found here, elevation may be a primary explanatory factor.

Figure 39 photo of point 9 showing the elevation change towards the water

Cat 3: Aqua-forest Islands

The third type is the forested islands, located at the center of the park and surrounded by various sizes of water bodies. It is characterized by densely planted metasequoia trees along with aquatic plants, with the exception of a few open platforms and two raised arc bridges. It would be interesting to observe the performance of this deliberate gesture of high density planting, and how humidity and wind speed changes within these denser pockets of landscape, while some of the open areas may help isolate the effectiveness of water area from shade.

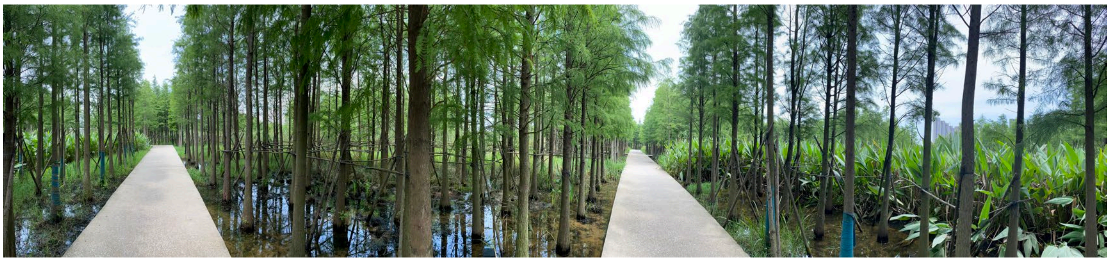


Figure 40 photo of point 15 showing densely planted metasequoia trees along with aquatic plants

Figure 41 photo of point 16 showing raised arc bridge

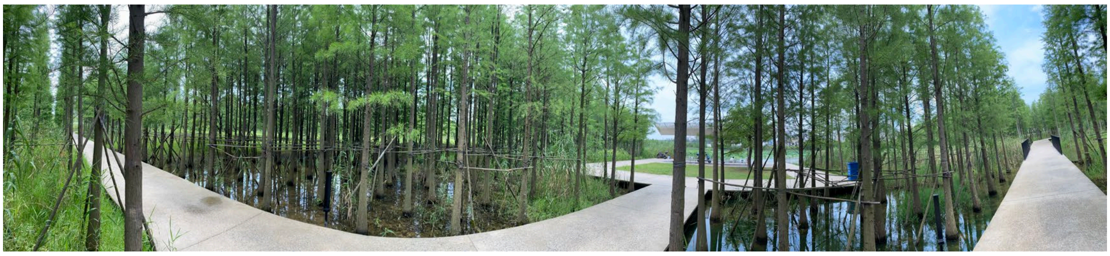


Figure 42 photo of point 18 showing open platform

Noise level measurements were conducted in summer 2023 from 05 to 22 July at 08:00 AM, 02:00 PM and 07:00 PM daily. Each day, the research team will utilize an online page to record the readings, which include the time, location, and data reading. By the end of the day, all the data records will be compiled and checked for any errors.

The App Decibel App, a noise meter app with a rate of 4.6 in the Apple store, was used on an iPhone 11 device to measure average noise levels (in unit of dB). The iPhone was placed during measurement about 1.5 meters above the ground and a continuous 30-second measurement was done to generate data reading for noise level at each location.

Each day, at 9AM, 2PM and 7PM, the weather condition and noise levels data were recorded at 19 locations in the park using the following form (Figure 43).

Yy5t | bbBFd3 | ds4L6O | cCJRFK | GgVYqx | vRkswl | oJhvVT

	A	B	C	D
1		Date & Weather Condition		
2		Noise Level		
3	Location	9 AM	2 PM	7 PM
4	1			
5	2			
6	...			

点击图片可查看完整电子表格

Figure 43 Example of noise level data records form.

Calculations:

This benefit is calculated using noise level data that was collected at different points in the park during the period from 05 to 20 July and three periods shown in Figure 44. The noise levels at Cat 1 locations were much higher than Cat 2 locations and Cat 3 locations, indicating that park landscape plays an important role in blocking noises that emitted from roads and urban fabric. However, the noise levels at some points (14 &16) in the park interior appeared relatively higher. Point 14 is situated on the edge of the island, across from the entrance cafe, and may be affected by noise. Point 16 is located on the bridge where there is significant wind noise. Furthermore, the noise level within the park may vary from day to another due to traffic impact.

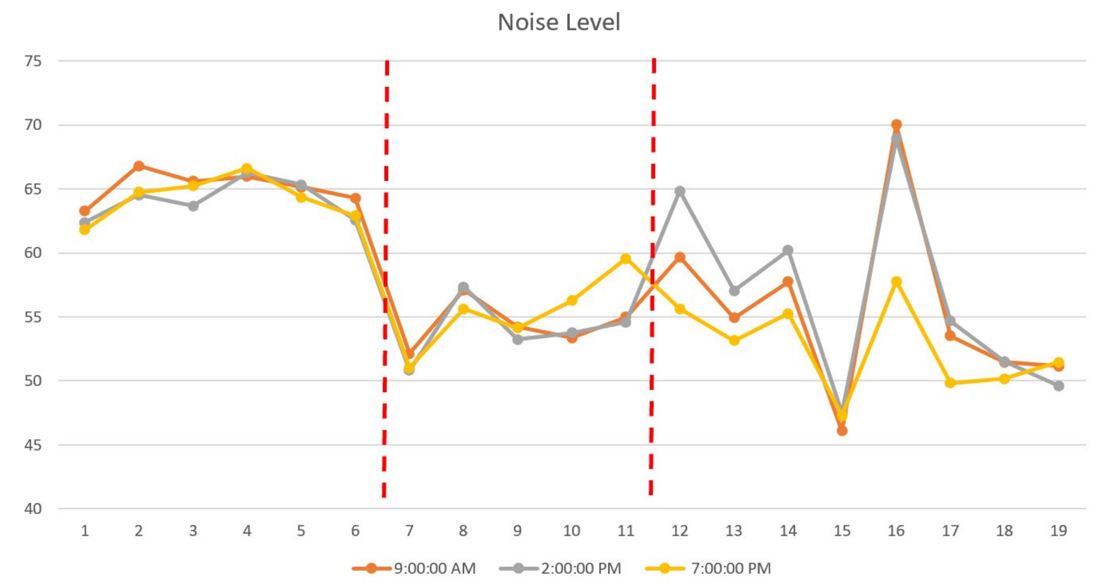


Figure 44 Average noise levels for the period 05 to 20 July, 2023

Figure 44 shows that the locations outside of the park tended to have higher average noise levels than the sunken location next to it during the daytime. At 9 am, Cat 1 locations had an average noise level of 65.1 dB, while Cat 1 locations had an average of 54.3 dB, indicating a difference of 10.8 dB which is maybe because Cat 1 locations were affected by a heavily trafficked road in the morning. At 2PM, the average is lower to 10.1 dB between the same locations. While locations 12-19 have a lower average noise level at night measures 52.5 db, because there are fewer people in the central part of the park during that time.

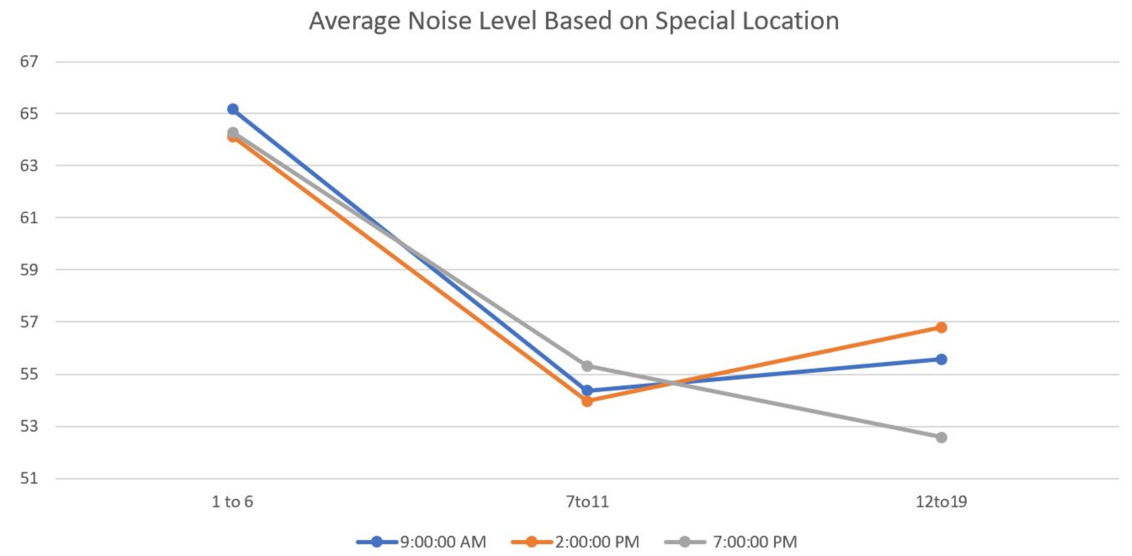


Figure 44 Average noise level from 05 to 20 July, 2023 for Point categories 1,2,3

Sources:

Nanchang Daily. (n.d.). 南昌二季度交通健康指数中部六省会排名第一. 南昌市人民政府 The People’s Government of Nanchang Municipality. http://www.nc.gov.cn/ncszf/jrnc/202307/b3eadbe383b64e3abdb7933f5aff65ce.shtml

Tashakkor, Shahla, Atefeh Chamani, Mozhgan Ahmadi Nadoushan, and Minoo Moshtaghie. "Acoustics in urban parks: Does the structure of narrow urban parks matter in designing a calmer urban landscape?." *Frontiers of Earth Science* 14 (2020): 512-521.

Limitations:

- The data measurements were conducted in the southwest part of the park due to feasibility considerations. Results may not represent the entire park.
- The activity of people affects noise level readings, but the sound from people's activity may not be negative.

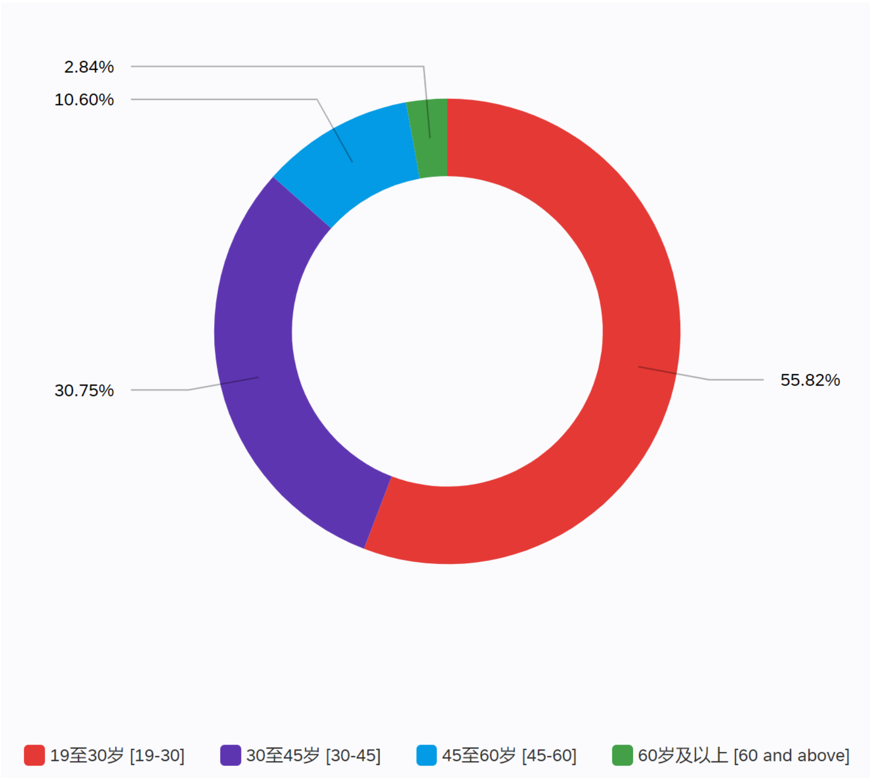
Serves visitors of multiple income levels, with 47% of visitors belonging to income categories at or under average income in Nanchang.

Background:

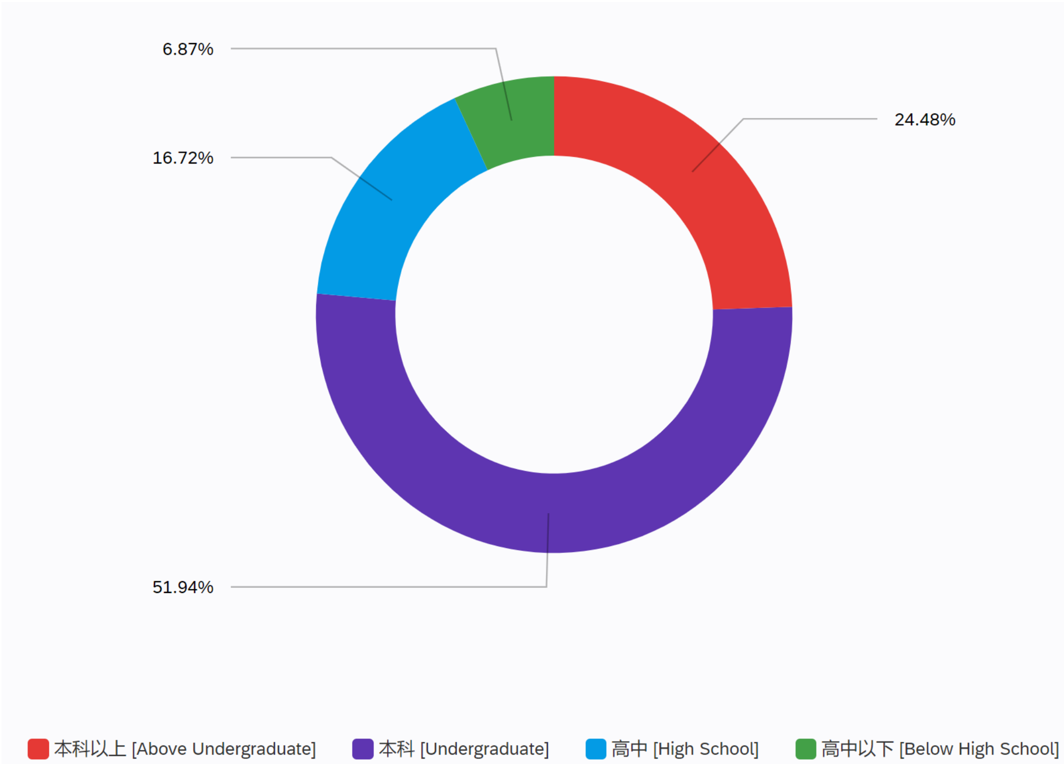
An ideal outcome of an urban park in terms of equality is that it serves a wide population where people of different gender, age, education, and income level feel welcomed and are able to access the park.

Method:

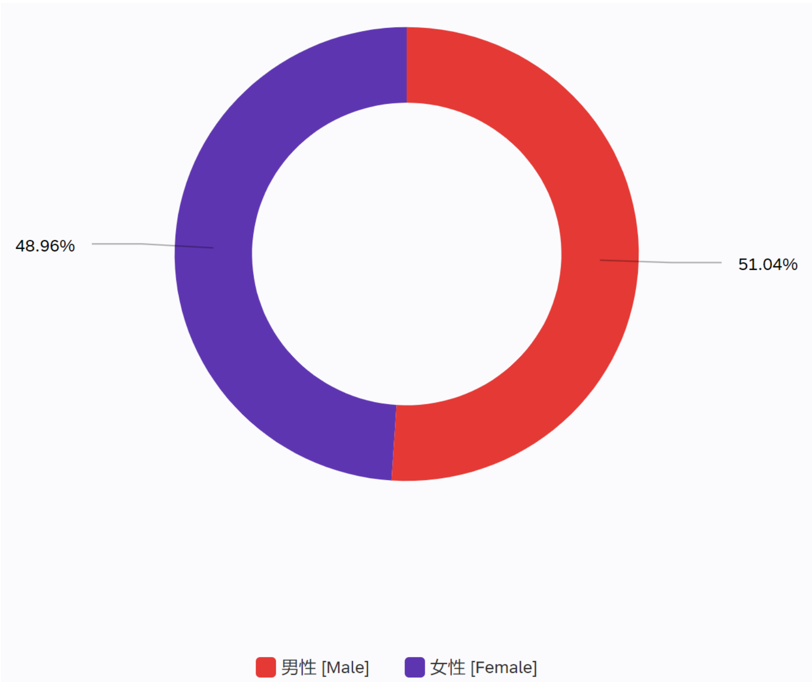
As the protocol of survey implementation was designed to ensure random selection of participants, the demographic profile of the respondents can be seen as representative of profile of park visitors.



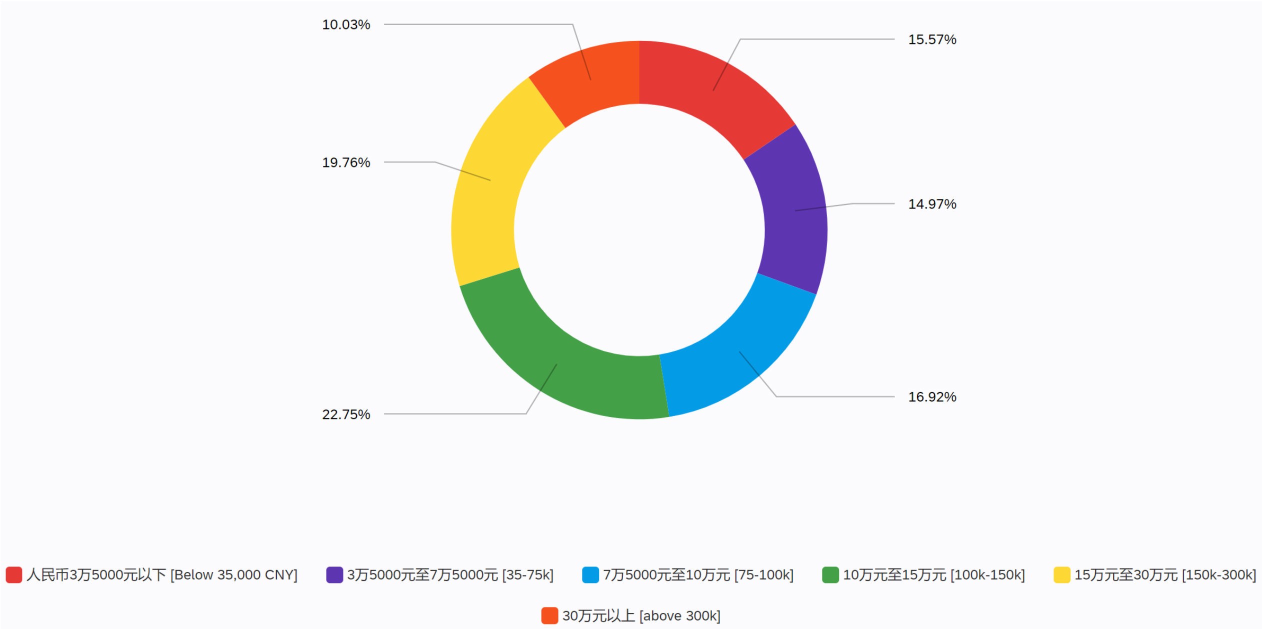
Age



Education



Gender



Annual household income

Gender

The survey had an almost equal number of male and female respondents. With 51.04% male and 48.96% female, or a gender ratio of 104.2 (Female = 100). Compared to Nanchang's urban population profile (Nanchang Bureau of Statistics, 2022) where gender ratio is 109.70, slightly more females are visiting the park than males.

Age

People are eligible to participate in the survey if they were older than 19, per IRB approval. Therefore, children are not included in the age profile calculations. The survey had 55.82% of respondents being between 19-30 years old, 30.75% of them being between 30-45 years old, 10.60% of them being 45-60 old, and 2.84% of them being 60 and above. The park is more popular among young and middle-aged groups.

Education

In terms of education, about 51.49 % respondents have an undergraduate degree, followed by 24.48 % respondents who hold a degree above college, 16.71% of respondents with high school degrees, and 6.78% of respondents lower than a high school degree, likely only finishing the required junior high school education.

Compared to overall urban population profile in education, undergraduate and above represents 27.5%. Notably the published education profile includes people of all ages and lists people with primary school, junior high, high school, and undergraduate and above levels of education, where the first category may be mostly consisting of children who are still attending school as a part of mandatory education. Since there is no way to differentiate, the next best estimate would be to exclude the category of primary school education, which yields a rate of 60.4% for undergraduate and above.

The park is overall balanced on education level in its visitor profile, although it leans slightly towards higher educated.

Income

We set our income distribution in 6 categories. Nanchang's average wage in 2022 was 101.8k CNY, and we have distributed our income categories with 100k being the middle point. The first three categories measure at or below average wage, and the latter three measure above average wage.

Distribution in income categories can be observed to be well-spread, with the biggest group being 100-150k at 22.75%, followed by 150-300k at 19.76%, then 75-100k at 16.92%, under 35k at 15.57%, and 35-75k at 14.97%, and finally 10.03% for above 300k. 47.46% of visitors belonging to income categories at or below average wage, showing a good level of inclusiveness for lower-income groups.

Since median income is typically lower than average income, it can be argued that the park still slightly favors those with higher income. No official median income data were found.

Characteristics of respondents	Percentage
Gender	
Male	48.96
Female	51.04
Age groups	
19-30	55.82
30-45	30.75
45-60	10.6
60+	2.84
Education level	
Below High School	24.48

High School	51.94
Undergraduate	17.72
Above Undergraduate	6.87

Demographic characteristic of respondents

Generates social media attention, with 104% more user diary posts and 187% more tags as compared to nearby Nanchang People's Park.

Background:

Fish Tail Park has become one of the most popular hotspots in Nanachang since it opened back May 2021. The park is supported by building facilities to meet its visitors' needs, including observation tower, restaurant, cafe, public toilets, pavilions, platforms, pedestrian bridges, outdoor cinema, and sports park (Figure 45). These facilities attract attention online, with an increase in search results and social media mentions.

Figure 45: Fish Tail Park provides facilities including (left) an observation tower and (right) outdoor cinema.

Method:

Xiaohongshu is an online life experience sharing platform, where users can find and interact with user-produced content by searching via an algorithm driven recommendation stream and following other users. Its content can be accessed primarily in two ways: 1) Direct Search, and 2) Tag View. The park's popularity can be measured by how much attention it has been getting on Xiaohongshu, and its performance can be understood by comparing it to other notable parks in Nanchang. For comparison, Ai'Xi Lake Wetland Park directly south of Fish Tail, built in 2007, and Nanchang People's Park, built in 1954, are used as comparisons.

Calculations:

To conduct this analysis, the team collected search results including number of published user diaries for name of the parks, and number of views under tags. Accuracy of data for number of published user diaries is to the hundreds and read count to the thousands.

As of end of July 2023, "Fish Tail Park" was present in 4,900 published user diaries, and the tag "Fish Tail Park" has 1,258,000 reading count. Comparatively, the term "Nanchang People's Park" is present in 2,400 published user diaries, and the tag "Nanchang People's Park" has 438,000 reading count; the term "Aixi Lake Wetland Park" is present in 8,300 published user diaries, and the tag "Aixi Lake Wetland Park" has 1,297,000 reading count.

Fish Tail Park's popularity performance is therefore +104% compared to Nanchang People's Park, -40% compared to Aixi Lake Wetland Park by user diary numbers, and +187% and -3% by tag read count respectively.

Sources:

Xiaohongshu

Limitations:

This is a preliminary look at how social media posts and tag read counts have aggregated over the years. Xiaohongshu is unique in that it's often used as a tips and guide platform, which should map reasonably well to popularity.

Xiaohongshu only reveals a limited resolution (number of published user diaries is to the hundreds and read count to the thousands) so the accuracy of our calculation is limited.

In addition, Xiaohongshu's user profile is predominantly people ages 18-35 and leans more towards female users, therefore does not reflect popularity across all user groups.

Attracts visitors through environmental features, with 60%of 748 surveyed visitors reporting that the forested islands are the primary reason why they would come to this park over others.

Background:

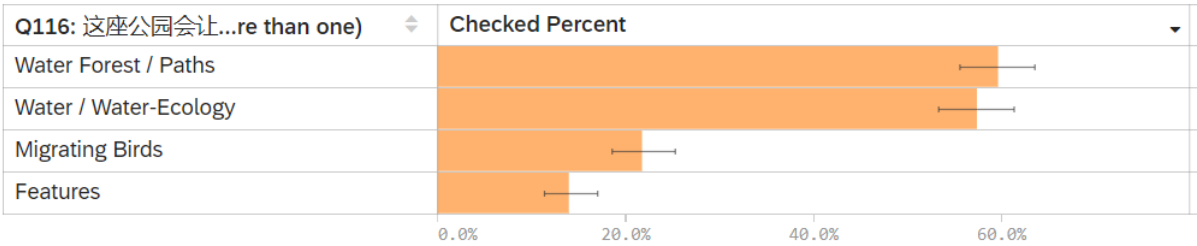
In the context of co-habitation where both social and ecological performance need to be at optimum, it is important to investigate how the unique design / form strategies have created not only a functional ecology on site, but also resonate with park visitors in creating attraction and identity.

Method:

The team used an intercept survey to measure this benefit. The survey included many questions measuring people's preference and place attachment. One of the questions asks: Select one or more from the list below why you may be more compelled to visit this park than any others, with the answers listing some of the prevailing features of the park. The result is taken to understand what echoed the best. Within the answers, the research team deliberately presented an answer for water/water-based ecology and an answer for water forest islands, to differentiate a general strategy of incorporating water in the park, from the unique design gesture at this park.

Calculations:

Results are taken directly from the survey dataset. Of the answers checked, 59.7% were the water forest / path. It can be observed that while water seems to be generally attractive for people, the unique design gesture stood out to people and created attachment to the park.



Sources:

Intercept survey data

Limitations:

- Survey does not include park visitors at or under the age of 18

Economic Benefits

Creates 20-30 maintenance and operational jobs, valued at $150,430 to $225,640 USD per year.

Background:

The establishment of a new public park brings new employment opportunities for the team of people managing and maintaining the park, adding value to the local labor market. We were interested in understanding how many jobs the park provides.

Method:

To answer this question, the research team developed several questions and interviewed the park maintenance workers and security personnel.

The interview revealed that there are 20 to 30 workers in the park for roles such as maintaining the lawn, removing trash, removing invasive plant species from the wetland, maintaining the trees in the park. Additionally, three individuals are on the park's safety team, with the primary responsibility of preventing certain activities in the park, such as swimming and fishing.

Calculations:

This is calculated by average maintenance and service role salary in Nanchang of CNY 53,670 for a total of CNY 1,073,400 to 1,610,100

20 (positions) * CNY 53,670 (average salary) = 1,073,400

30 (positions) * CNY 53,670 (average salary) = 1,610,100

These numbers are equivalent to USD 150,430 to 225,640.

Sources:

Interview conducted by the team during July 22, 2023

Limitations:

- Not all questions were answered, and the answers were in a range, not the exact number.
- Average salary is limited in accuracy, but we were unable to retrieve exact numbers directly from park management.

Provides stormwater retention capacity valued at an estimated $1.62 million USD.

Background:

Fish Tail Park is a park under the city's sponge city initiative, and it created significant stormwater retention capacity, which has already been utilized regularly during peak precipitation season. Reduction of flooding in cities clearly have economic value and the team investigated how the value can be calculated.

Method:

One way to attach dollar value to stormwater capacity is by looking at replacement cost – cost that would have incurred to build reservoir for retention of the same volume of water.

Calculations:

A 2012 study (Zhang et al.) estimated a replacement cost for stormwater retention value. We adjusted the amount for inflation and estimated a cost of CNY 61.63 per 1,000 gallons in 2023, equivalent of USD 8.64. For 188,016,433 gallons of retention capacity at Fish Tail Park, a total of USD 1,624,461 can be estimated.

Sources:

Zhang , et al. "The economic benefits of rainwater-runoff reduction by urban green spaces: A case study in Beijing, China - ScienceDirect." Journal of Environmental Management 100.10(2012):65-71.

Limitations:

This calculation is exploratory in nature.

Replacement cost is not the only method to estimate stormwater capacity value. Calculation of risk factor reduction may yield higher value.

Experimental/Inconclusive Benefits

Provides an estimated value of $4.96 million USD annually in educational and recreational value.

Method:

Research has been able to attach value through willingness to pay (WTP) studies for recreational and educational values of green stormwater infrastructure (GSI) per park visitor. With an estimation of unique visitors to the park every year, it is possible to estimate aggregate value for recreational and educational value yearly.

Calculations:

WTP study measured people’s WTP for recreational and educational service of GSI at 102.4 CNY/$14.8 yearly and 74.7 CNY/$10.8 yearly respectively. We estimate around 311,000 unique visitors come to the park on an annual basis. Therefore, a total of USD 4,602,800 yearly can be found for recreational value of the GSI; and USD 3,358,800 yearly for educational value of the GSI

Sources:

Zhang , et al. "The economic benefits of rainwater-runoff reduction by urban green spaces: A case study in Beijing, China - ScienceDirect." Journal of Environmental Management 100.10(2012):65-71.

Limitations:

This calculation is exploratory in nature.

Unique visitors are estimated by a percentage of urban population in Nanchang, and may have limited accuracy.

Creates a park experience valued by its users at an average amount of *CNY 50.64 per visit.*

Background:

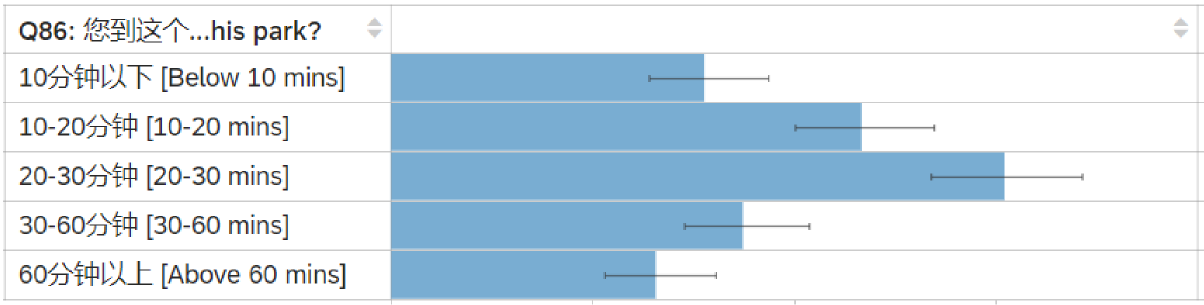
Urban parks can be differentiated by their level of attractiveness, with some mostly visited by people nearby, and others so attractive, that people are willing to travel out of their way to visit it. This can be translated into a monetary number. The team explored how much people value the Fish Tail Park’s unique design, experience and ecology places through a willingness to pay method.

Method:

Public parks in China have long ceased to charge entry fees to its users, which would have been a direct way to measure willingness to pay. It is still possible to indirectly estimate how much people are willing to pay for their visit, by looking at travel time, which translates to an opportunity cost based on the value of their time. In the intercept survey, visitors were asked about how long it took them to travel to Fish Tail Park.

Calculations:

The average annual income in Nanchang (Nanchang Bureau of Statistics, 2022) can be translated using standard 40-hour work week hours to an hourly average income of CNY 51.29. This number is then calculated with the time needed to make a return trip to the park. In the intercept survey, respondents selected one of the four time groups, 3 at 10 minutes interval, 1 at 30 minutes interval, and 1 for everything above an hour. For the purpose of this calculation, we used the medium for each time group and for the final group, we used 75 minutes. It can be calculated that on average, visitors value their experience at Fish Tail Park at CNY 50.64 per visit, with a medium value at CNY 42.74, and max at CNY 128.23.



Sources:

Intercept Survey

Limitations:

Respondents did not provide exact, to-the-minute travel time, but instead selected one of five time groups. Accuracy of calculation is limited by resolution of data. Calculation did not include time respondents spent at the park, rather only focused on travel time.

Appendix 1: Detailed Microclimate Data

Along imaginary N-S grid-lines

To further examine the microclimate data, we also became interested in comparing points which are roughly along the same North-South gridlines for both temp, humidity, windspeed, and thermal comfort comparison. This would allow us to isolate the influence of edge influences from the "sides" and see how data changes as it goes "up" into the park. We have selected the following groups of points to compare: points 3, 10, 14; points 4-9-15; 3-8-16(note: 16 is on bridge), and points 6-7-18.

A. Wind Speed

a) group 3-10-14

The average 9 am windspeed in point 3 measures 0.1, point 10 measures 0.3, point 14 measures 1.7

Point 3 to Point 10

Change % = (0.3 - 0.1) / 0.1= 2%

Point 10 to point 14

Change % = (1.7 - 0.3) / 0.3 = 4.6%

The average 2 pm windspeed in point 3 measures 0.5, point 10 measures 0.1, point 14 measures 2.1

Point 3 to Point 10

Change % = (0.1 - 0.5) / 0.5= -0.8%

Point 10 to point 14

Change % = (2.1 - 0.1) / 0.1 = 20%

The average 7 pm windspeed in point 3 measures 0.2, point 10 measures 0.2, point 14 measures 0.4

Point 3 to Point 10

Change % = (0.2 - 0.2) / 0.2= 0%

Point 10 to point 14

Change % = (0.4 - 0.2) / 0.2 = 1%

b) group 4-9-15

The average 9 am windspeed in point 4 measures 0.8, point 9 measures 0.8, point 15 measures 0.1

Point 4 to Point 9

Change % = (0.8 - 0.8) / 0.8= 0 %

Point 9 to point 15

Change % = (0.1 - 0.8) / 0.8 = -0.8%

The average 2 pm windspeed in point 4 measures 0.5, point 9 measures 0.8, point 15 measures 0.1

Point 4 to Point 9

Change % = (0.8 - 0.5) / 0.5= 0.6%

Point 9 to point 15

Change % = (0.1 - 0.8) / 0.8 = -0.8%

The average 7 pm windspeed in point 4 measures 0.5, point 9 measures 0.6, point 15 measures 0

Point 4 to Point 9

Change % = (0.6 - 0.5) / 0.5= 0.2%

Point 9 to point 15

Change % = (0 - 0.6) / 0.6 = -1%

c) group 3-8-16

The average 9 am windspeed in point 3 measures 0.1, point 8 measures 0.5, point 16 measures 3.1

Point 3 to Point 8

Change % = (0.5 - 0.1) / 0.1= 4%

Point 8 to point 16

Change % = (3.1 - 0.5) / 0.5 = 5.2%

The average 2 pm windspeed in point 3 measures 0.5, point 8 measures 0.6, point 16 measures 2.6

Point 3 to Point 8

Change % = (0.6 - 0.5) / 0.5= 0.2%

Point 8 to point 16

Change % = (2.6 - 0.6) / 0.6 = 3.3%

The average 7 pm windspeed in point 3 measures 0.2, point 8 measures 0.5, point 16 measures 1.2

Point 3 to Point 8

Change % = (0.5 - 0.2) / 0.2= 1.5%

Point 8 to point 16

Change % = (1.2 - 0.5) / 0.5 = 1.4%

d) group 6-7-18

The average 9 am windspeed in point 6 measures 0.05, point 7 measures 0.1, point 18 measures 0.8

Point 6 to Point 7

Change % = (0.1 - 0.05) / 0.05= 1%

Point 7 to point 18

Change % = (0.8 - 0.1) / 0.1 = 7%

The average 2 pm windspeed in point 6 measures 0.2, point 7 measures 0.09, point 18 measures 1.1

Point 6 to Point 7

Change % = (0.09 - 0.2) / 0.2= -0.55%

Point 7 to point 18

Change % = (1.1 - 0.09) / 0.09 = 11.2%

The average 7 pm windspeed in point 6 measures 0.2, point 7 measures 0.1, point 18 measures 0.3

Point 6 to Point 7

Change % = (0.1 - 0.2) / 0.2= -0.5%

Point 7 to point 18

Change % = (0.3 - 0.1) / 0.1 = 2%

B. Humidity

a) group 3-10-14

The average 9 am humidity in point 3 measures 64.5, point 10 measures 67.8, point 14 measures 68.7

Point 3 to Point 10

Change % = (67.8 - 64.5) / 64.5= 0.05%

Point 10 to point 14

Change % = (68.7 - 67.8) / 67.8 = 0%

The average 2 pm humidity in point 3 measures 55.3, point 10 measures 59.5, point 14 measures 61

Point 3 to Point 10

Change % = (59.5 - 55.3) / 55.3= 0.07%

Point 10 to point 14

Change % = (61 - 59.5) / 59.5 = 0.02%

The average 7 pm humidity in point 3 measures 71.9, point 10 measures 74.4, point 14 measures 74.4

Point 3 to Point 10

Change % = (74.4 - 71.9) / 71.9= 0.03%

Point 10 to point 14

Change % = (74.4 - 74.4) / 74.4 = 0%

b) group 4-9-15

The average 9 am humidity in point 4 measures 65.4, point 9 measures 66.8, point 15 measures 70

Point 4 to Point 9

Change % = (66.8 - 65.4) / 65.4= 0.02%

Point 9 to point 15

Change % = (70 - 66.8) / 66.8 = 0.04%

The average 2 pm humidity in point 4 measures 55.9, point 9 measures 61.6, point 15 measures 62.6

Point 4 to Point 9

Change % = (61.6 - 55.9) / 55.9= 0.1%

Point 9 to point 15

Change % = (62.6 - 61.6) / 61.6 = 0.01%

The average 7 pm humidity in point 4 measures 72.3, point 9 measures 74.6, point 15 measures 77.4

Point 4 to Point 9

Change % = (74.6 - 72.3) / 72.3= 0.03%

Point 9 to point 15

Change % = (77.4 - 74.6) / 74.6 = 0.02%

c) group 3-8-16

The average 9 am humidity in point 3 measures 64.5, point 8 measures 68.1, point 16 measures 67.1

Point 3 to Point 8

Change % = (68.1 - 64.5) / 64.5= 0.05%

Point 8 to point 16

Change % = (67.1 - 68.1) / 68.1 = -0.01%

The average 2 pm humidity in point 3 measures 55.3, point 8 measures 60.5, point 16 measures 58.9

Point 3 to Point 8

Change % = (60.5 - 55.3) / 55.3= 0.09%

Point 8 to point 16

Change % = (58.9 - 60.5) / 60.5 = -0.02%

The average 7 pm humidity in point 3 measures 71.9, point 8 measures 76.2, point 16 measures 74.7

Point 3 to Point 8

Change % = (76.2 - 71.9) / 71.9= 0.05%

Point 8 to point 16

Change % = (74.7 - 76.2) / 76.2 = -0.01%

d) group 6-7-18

The average 9 am humidity in point 6 measures 63, point 7 measures 67.7, point 18 measures 68.8

Point 6 to Point 7

Change % = (67.6 - 63) / 63= 0.07%

Point 7 to point 18

Change % = (68.8 - 67.6) / 67.6 = 0.01%

The average 2 pm humidity in point 6 measures 56.5, point 7 measures 60.9, point 18 measures 59.9

Point 6 to Point 7

Change % = (60.9 - 56.5) / 56.5= 0.07%

Point 7 to point 18

Change % = (59.9 - 60.9) / 60.9 = -0.01%

The average 7 pm humidity in point 6 measures 72.5, point 7 measures 76.9, point 18 measures 76.3

Point 6 to Point 7

Change % = (76.9 - 72.5) / 72.5= 0.06%

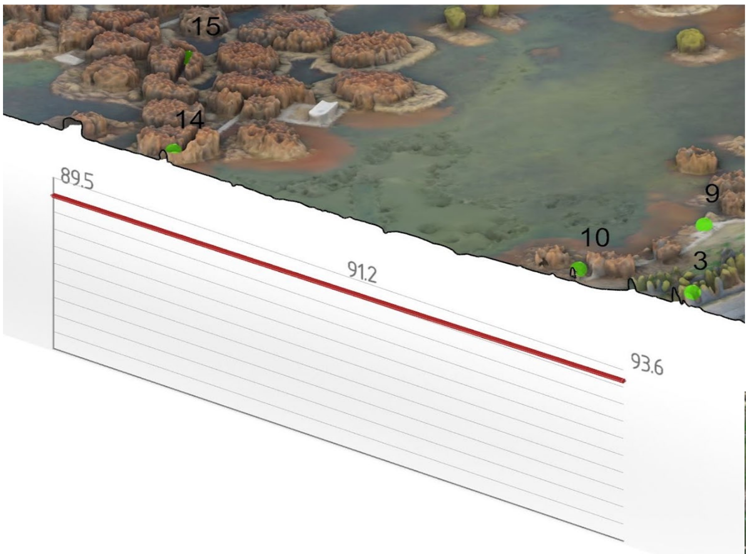
Point 7 to point 18

Change % = (76.3 - 76.9) / 76.9 = -0.07%

C. Temperature

a) group 3-10-14

The average 9 am temperature in point 3 measures 93.6, point 10 measures 91.2, point 14 measures 89.5



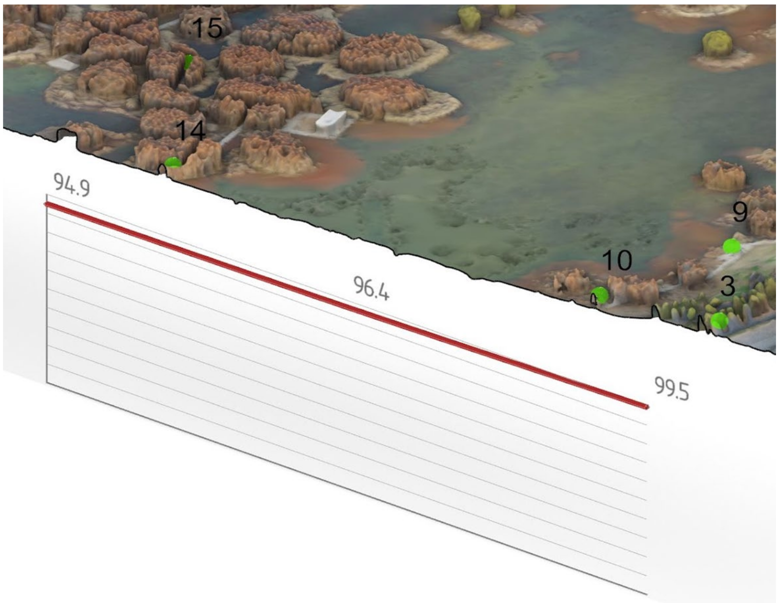
Point 3 to Point 10

Change % = (91.2 - 93.6) / 93.6= -0.02%

Point 10 to point 14

Change % = (89.5 - 91.2) / 91.2 = -0.01%

The average 2 pm temperature in point 3 measures 99.5, point 10 measures 96.4, point 14 measures 94.4



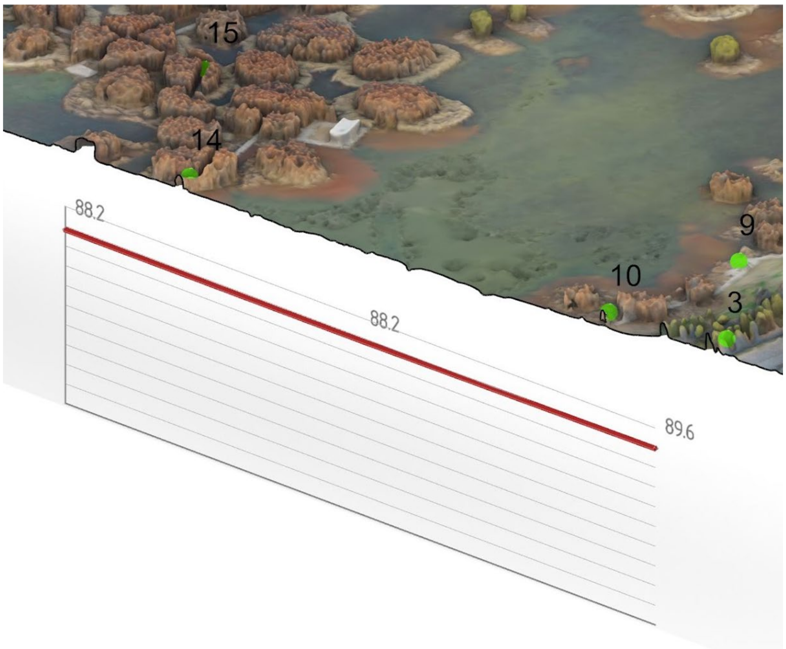
Point 3 to Point 10

Change % = (96.4 - 99.5) / 99.5= -0.03%

Point 10 to point 14

Change % = (94.4 - 96.4) / 96.4 = -0.02%

The average 7 pm temperature in point 3 measures 89.6, point 10 measures 88.2, point 14 measures 88.2



Point 3 to Point 10

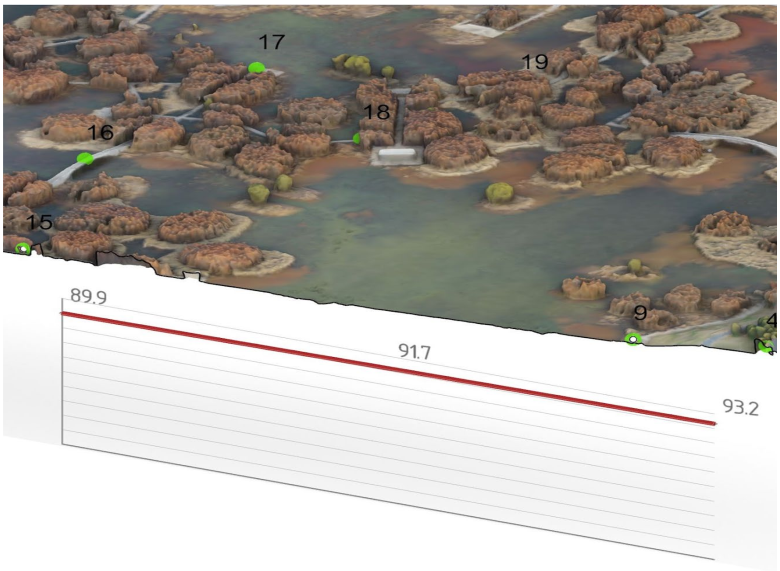
Change % = (88.2 - 89.6) / 89.6= -0.01%

Point 10 to point 14

Change % = (88.2 - 88.2) / 88.2 = %

b) group 4-9-15

The average 9 am temperature in point 4 measures 93.2, point 9 measures 91.7, point 15 measures 89.9



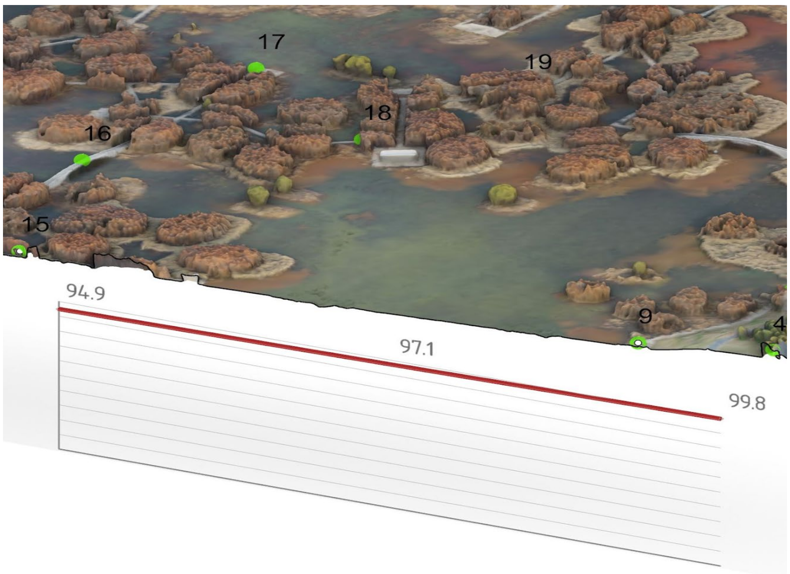
Point 4 to Point 9

Change % = (91.7 - 93.2) / 93.2= -0.01%

Point 9 to point 15

Change % = (89.9 - 91.7) / 91.7 = -0.01%

The average 2 pm temperature in point 4 measures 99.8, point 9 measures 97.1, point 15 measures 94.9



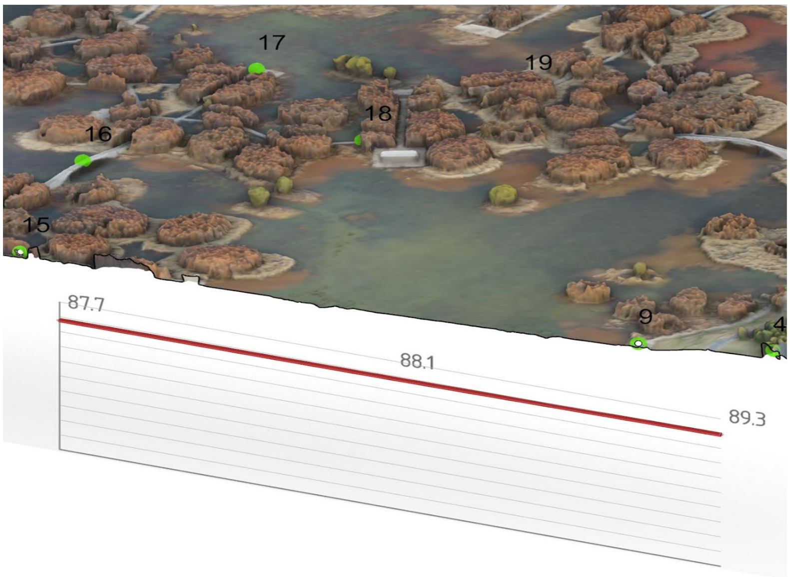
Point 4 to Point 9

Change % = (97.1 - 99.8) / 99.8= -0.02%

Point 9 to point 15

Change % = (94.9 - 97.1) / 97.1 = -0.02%

The average 7 pm temperature in point 4 measures 89.3, point 9 measures 88.1, point 15 measures 87.7



Point 4 to Point 9

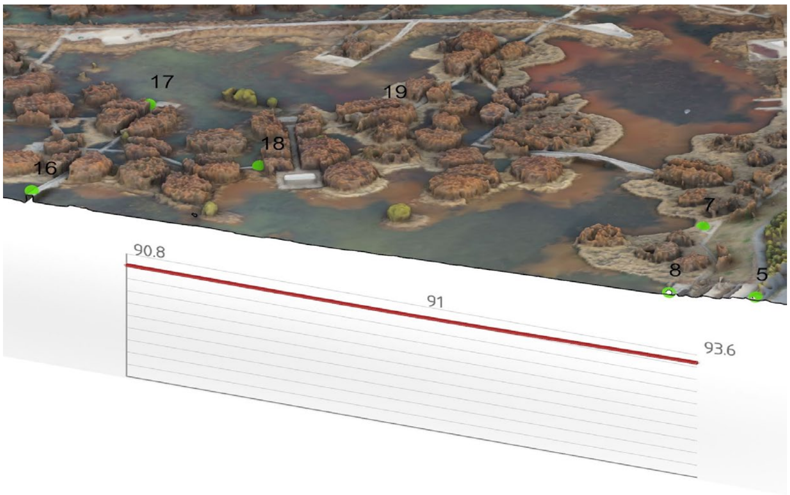
Change % = (88.1 - 89.3) / 89.3= -0.01%

Point 9 to point 15

Change % = (87.7 - 88.1) / 88.1 = -0.04%

c) group 3-8-16

The average 9 am temperature in point 3 measures 93.6, point 8 measures 91, point 16 measures 90.8



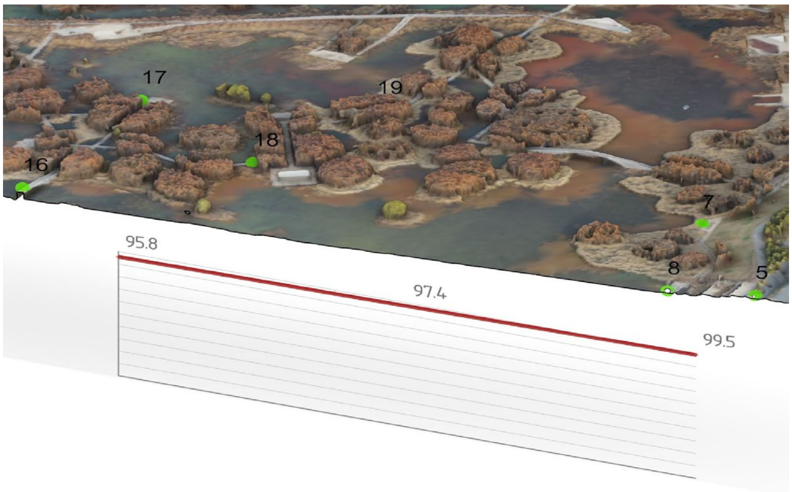
Point 3 to Point 8

Change % = (91 - 93.6) / 93.6= -0.02%

Point 8 to point 16

Change % = (90.8 - 91) / 91 = -0.02%

The average 2 pm temperature in point 3 measures 99.5, point 8 measures 97.4, point 16 measures 95.8



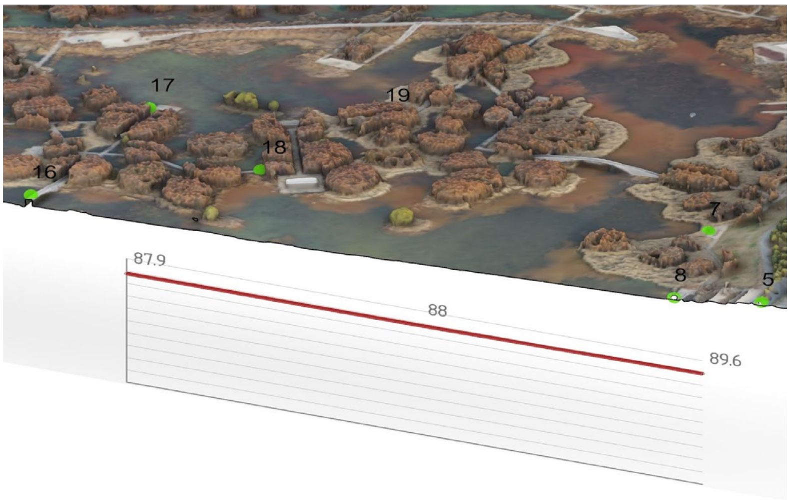
Point 3 to Point 8

Change % = (97.4 - 99.5) / 99.5= -0.02%

Point 8 to point 16

Change % = (95.8 - 97.4) / 97.4 = -0.01%

The average 7 pm temperature in point 3 measures 89.6, point 8 measures 88, point 16 measures 87.9



Point 3 to Point 8

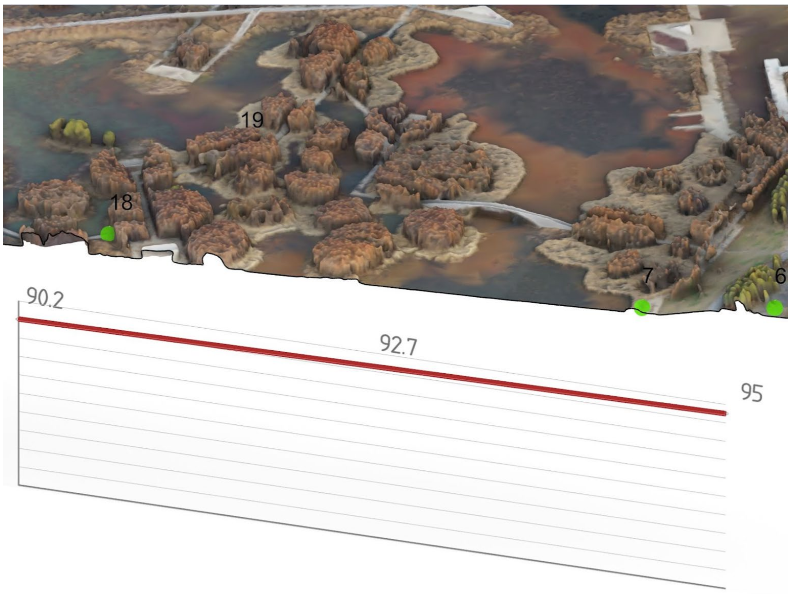
Change % = (88 - 89.6) / 89.6= -0.01%

Point 8 to point 16

Change % = (87.9 - 88) / 88 = -0.01%

d) group 6-7-18

The average 9 am temperature in point 6 measures 95, point 7 measures 92.7, point 18 measures 90.2



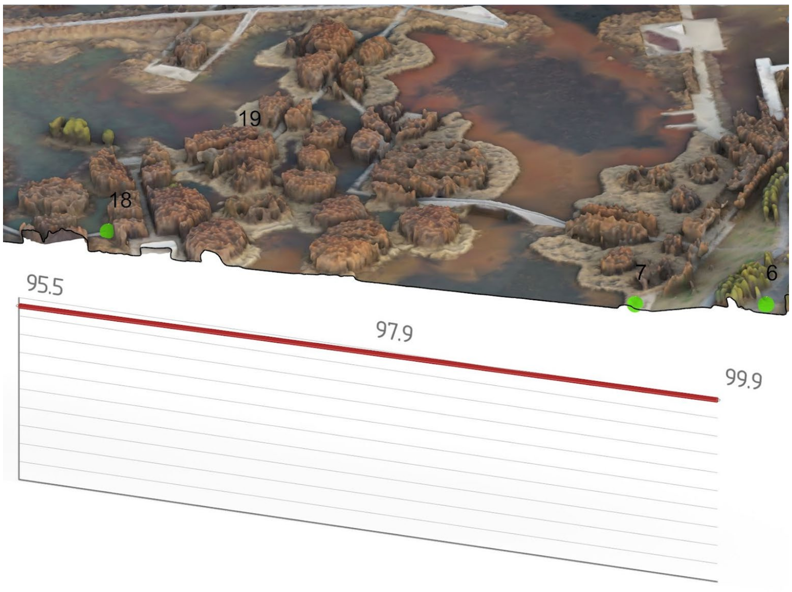
Point 6 to Point 7

Change % = (92.7 - 95) / 95= -0.02%

Point 7 to point 18

Change % = (90.2 - 92.7) / 92.7 = -0.02%

The average 2 pm temperature in point 6 measures 99.9, point 7 measures 97.9, point 18 measures 95.5



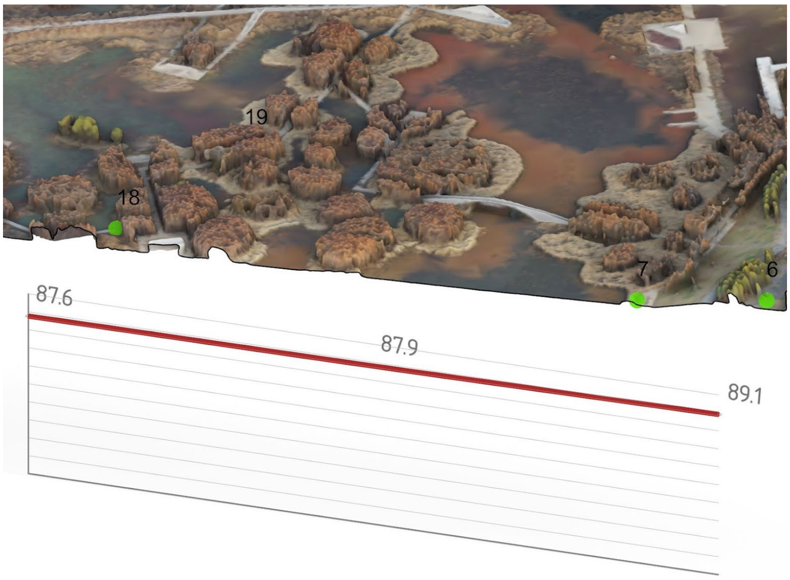
Point 6 to Point 7

Change % = (97.9 - 99.9) / 99.9= -0.02%

Point 7 to point 18

Change % = (95.5 - 97.9) / 97.9 = -0.02%

The average 7 pm temperature in point 6 measures 89.1, point 7 measures 87.9, point 18 measures 87.6



Point 6 to Point 7

Change % = (87.9 - 89.1) / 89.1= -0.01%

Point 7 to point 18

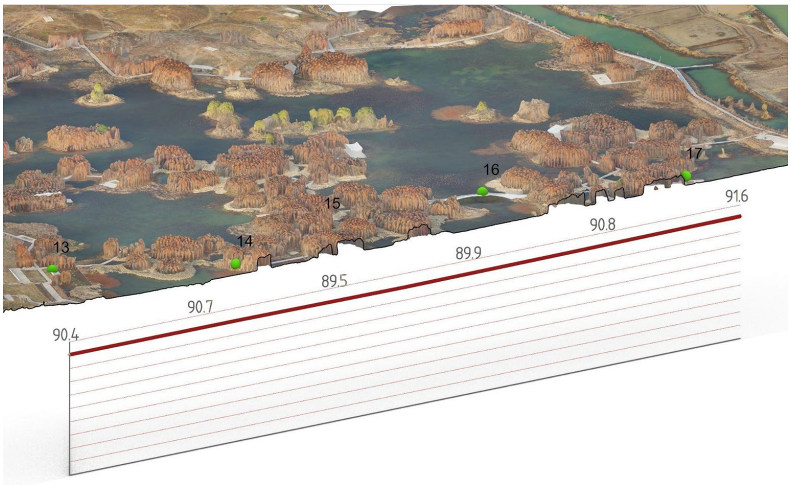
Change % = (87.6 - 87.9) / 87.9 = -0.03%

4. Along imaginary E-W grid-lines

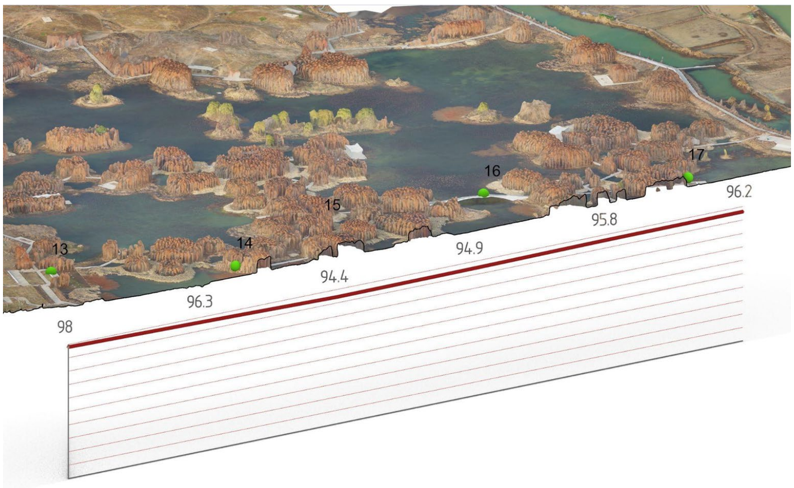
In addition, we also became interested in comparing points which are roughly along the same East-West gridlines for both temp, and thermal comfort comparison. This would allow us to isolate the influence of edge influences from the "sides" and see how data changes as it goes "up" into the park.

e) group 12-13-14-15-16-17

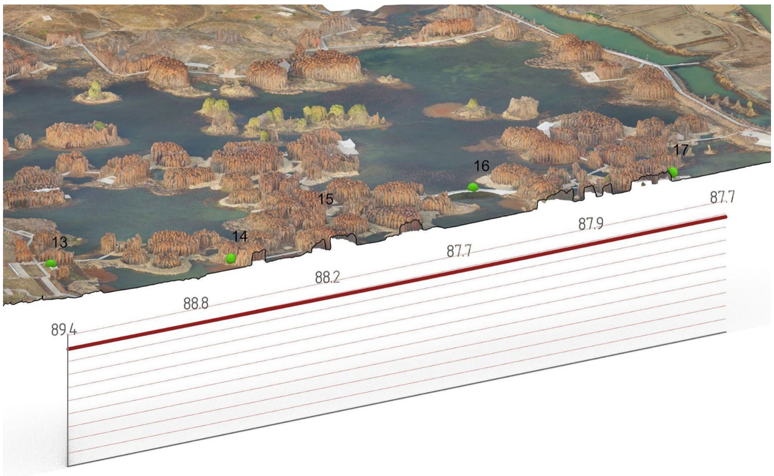
The average 9 am temperature in point 12 measures 90.4, point 13 measures 90.7, point 14 measures 89.5, point 15 measures 89.9, point 16 measures 90.8, point 17 measures 91.6.



The average 2 pm temperature in point 12 measures 98, point 13 measures 96.3, point 14 measures 94.4, point 15 measures 94.9, point 16 measures 95.8, point 17 measures 96.2.



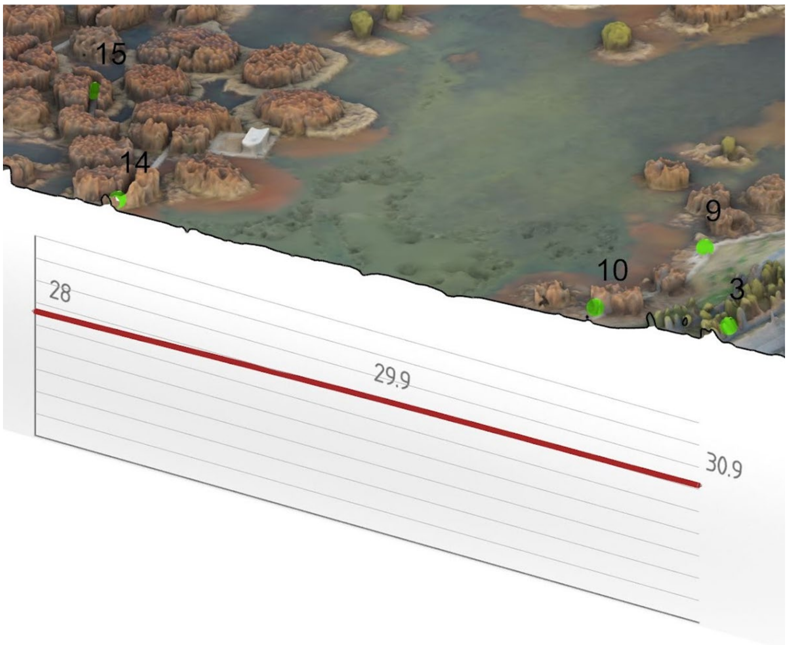
The average 7 pm temperature in point 12 measures 89.4, point 13 measures 88.8, point 14 measures 88.2, point 15 measures 87.7, point 16 measures 87.9, point 17 measures 87.7.



D. Thermal Comfort

a) group 3-10-14

The average 9 am thermal comfort in point 3 measures 30.9, point 10 measures 29.9, point 14 measures 28



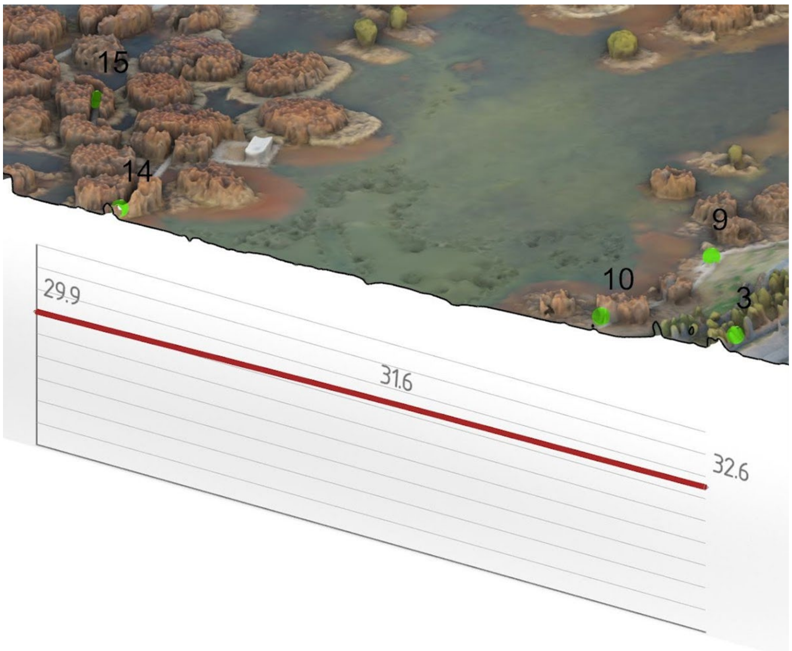
Point 3 to Point 10

Change % = (29.9 - 30.9) / 30.9= -0.03%

Point 10 to point 14

Change % = (28 - 29.9) / 29.9 = -0.06%

The average 2 pm thermal comfort in point 3 measures 32.6, point 10 measures 31.6, point 14 measures 29.9



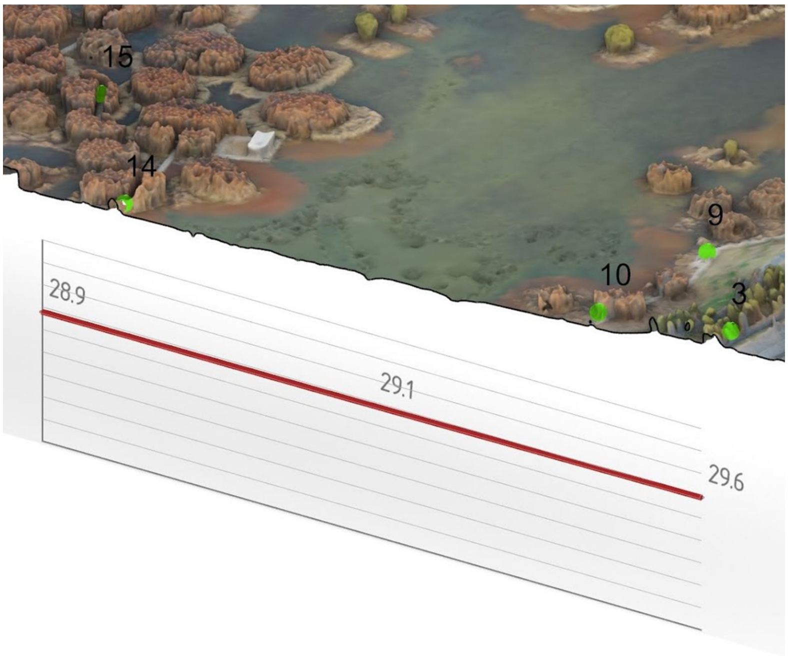
Point 3 to Point 10

Change % = (31.6 - 32.6) / 32.6= -0.03%

Point 10 to point 14

Change % = (29.9 - 31.6) / 31.6 = -0.05%

The average 7 pm thermal comfort in point 3 measures 29.6, point 10 measures 29.1, point 14 measures 28.9



Point 3 to Point 10

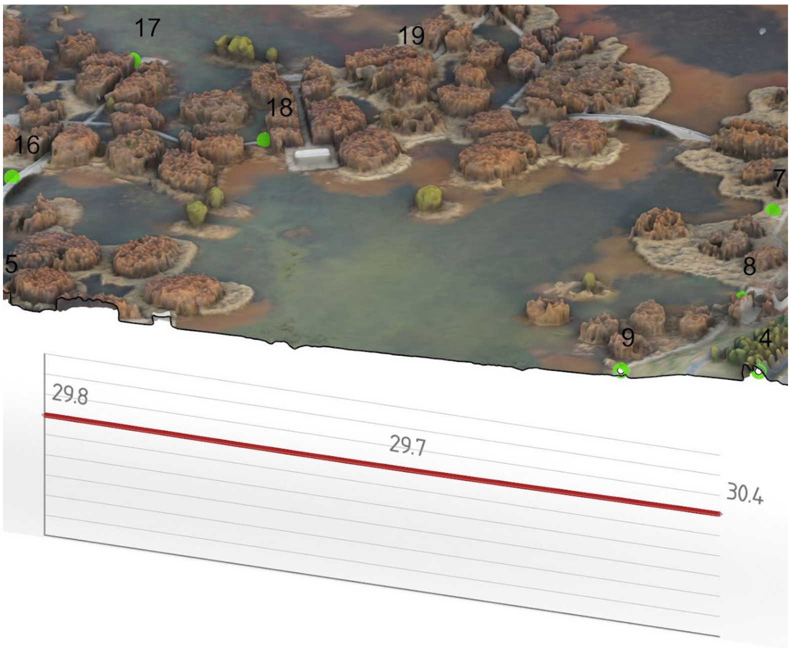
Change % = (29.1 - 29.6) / 29.6= -0.01%

Point 10 to point 14

Change % = (28.9 - 29.1) / 29.1 = -0.06%

b) group 4-9-15

The average 9 am thermal comfort in point 4 measures 30.4, point 9 measures 29.7, point 15 measures 29.8



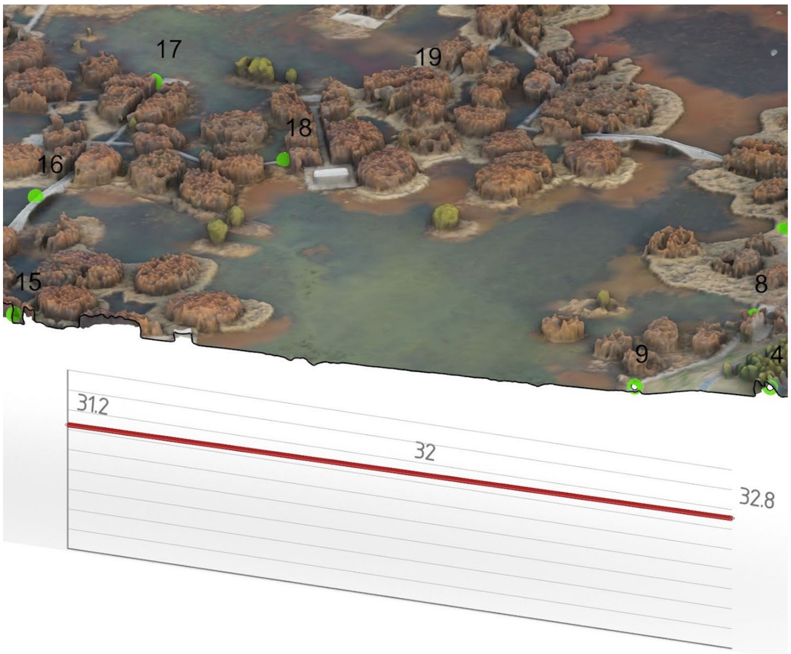
Point 4 to Point 9

Change % = (29.7 - 30.4) / 30.4= -0.02%

Point 9 to point 15

Change % = (29.8 - 29.7) / 29.7 = 0.03%

The average 2 pm thermal comfort in point 4 measures 32.8, point 9 measures 32, point 15 measures 31.2



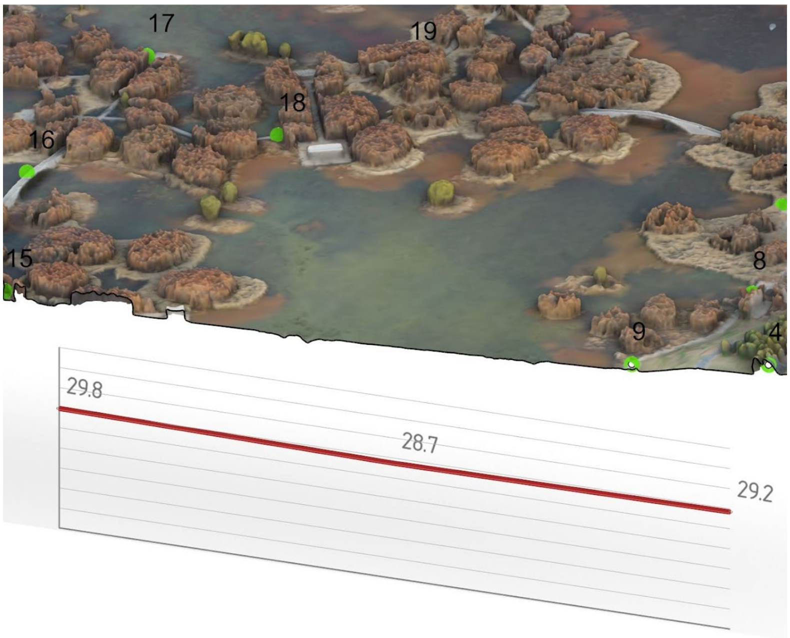
Point 4 to Point 9

Change % = (32 - 32.8) / 32.8= -0.02%

Point 9 to point 15

Change % = (31.2 - 32) / 32 = -0.02%

The average 7 pm thermal comfort in point 4 measures 29.2, point 9 measures 28.7, point 15 measures 29.8



Point 4 to Point 9

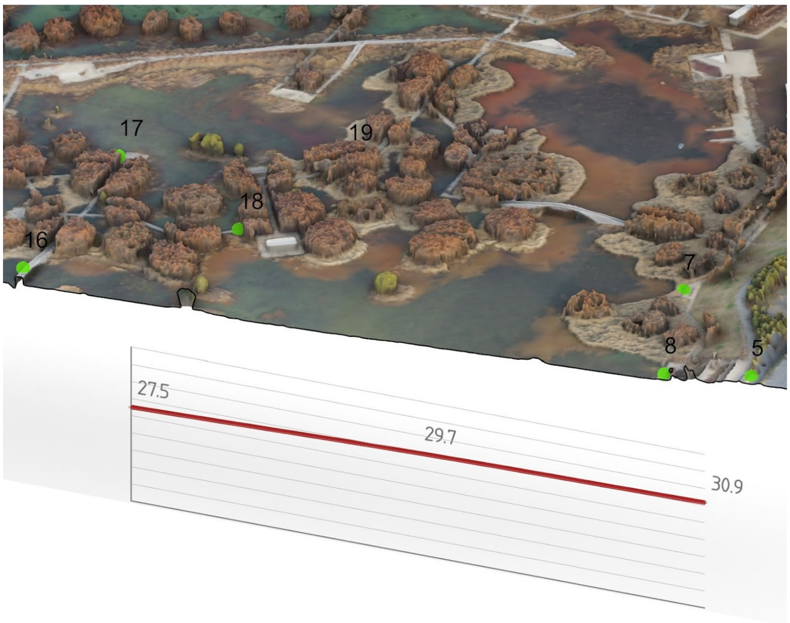
Change % = (28.7 - 29.2) / 29.2= -0.01%

Point 9 to point 15

Change % = (29.8 - 28.7) / 28.7 = 0.03%

c) group 3-8-16

The average 9 am thermal comfort in point 3 measures 30.9, point 8 measures 29.7, point 16 measures 27.5



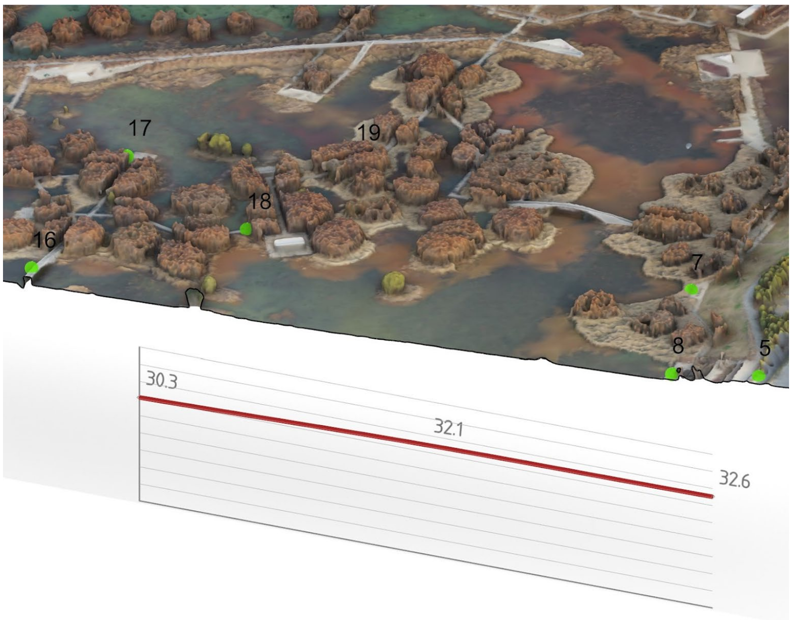
Point 3 to Point 8

Change % = (29.7 - 30.9) / 30.9= -0.03%

Point 8 to point 16

Change % = (27.5 - 29.7) / 29.7 = -0.07%

The average 2 pm thermal comfort in point 3 measures 32.6, point 8 measures 32.1, point 16 measures 30.3



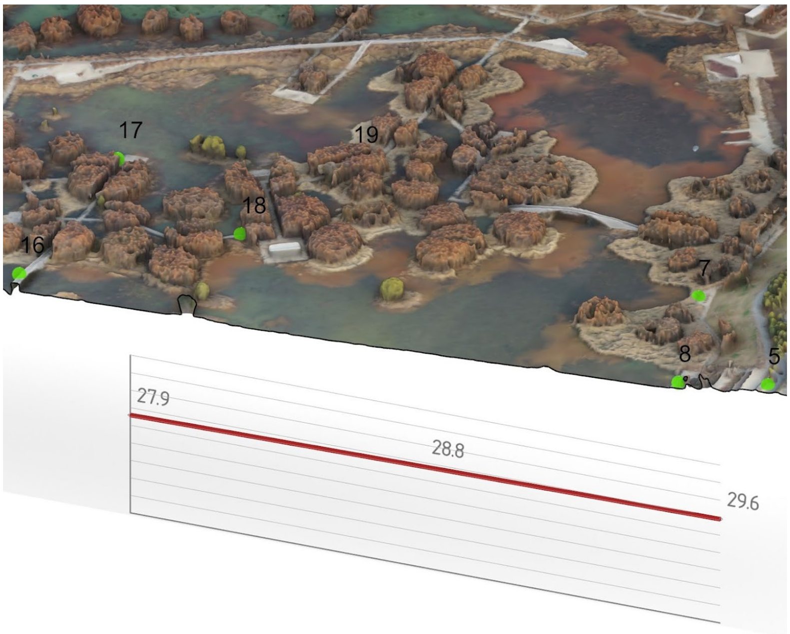
Point 3 to Point 8

Change % = (32.1 - 32.6) / 32.6= -0.01%

Point 8 to point 16

Change % = (30.3 - 32.1) / 32.1 = -0.05%

The average 7 pm thermal comfort in point 3 measures 29.6, point 8 measures 28.8, point 16 measures 27.9



Point 3 to Point 8

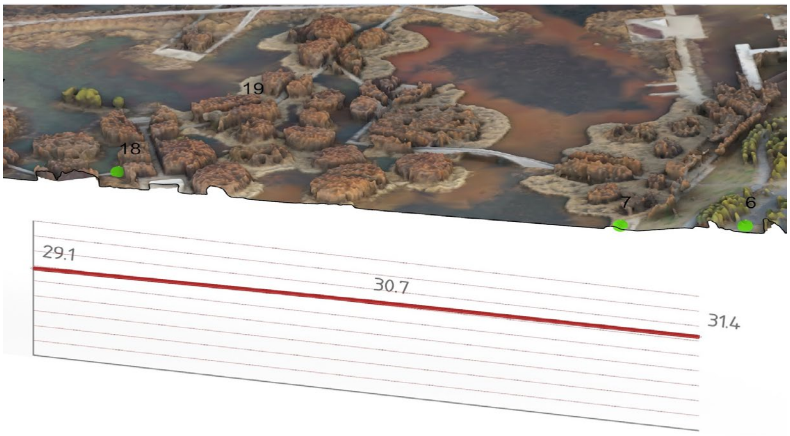
Change % = (28.8 - 29.6) / 29.6= -0.02%

Point 8 to point 16

Change % = (27.9 - 28.8) / 28.8 = -0.03%

d) group 6-7-18

The average 9 am thermal comfort in point 6 measures 31.4, point 7 measures 30.7, point 18 measures 29.1



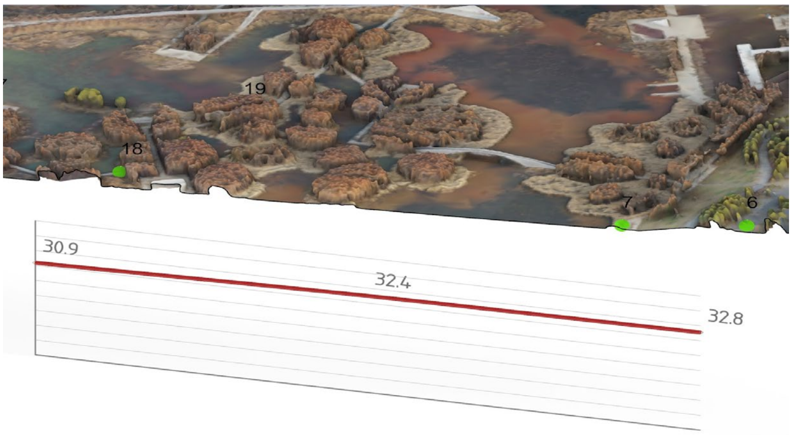
Point 6 to Point 7

Change % = (87.9 - 89.1) / 89.1= -0.01%

Point 7 to point 18

Change % = (87.6 - 87.9) / 87.9 = -0.03%

The average 2 pm thermal comfort in point 6 measures 32.8, point 7 measures 32.4, point 18 measures 30.9



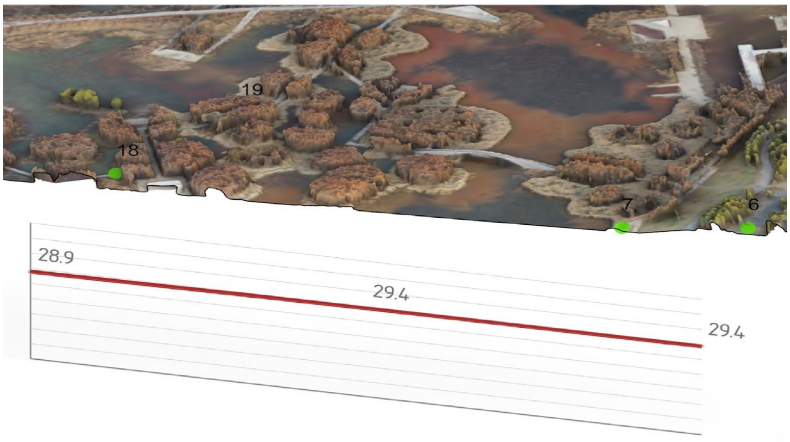
Point 6 to Point 7

Change % = (32.4 - 32.8) / 32.8= -0.01%

Point 7 to point 18

Change % = (30.9 - 32.4) / 32.4 = -0.04%

The average 7 pm thermal comfort in point 6 measures 29.4, point 7 measures 29.4, point 18 measures 28.9



Point 6 to Point 7

Change % = (29.4 - 29.4) / 29.4= 0%

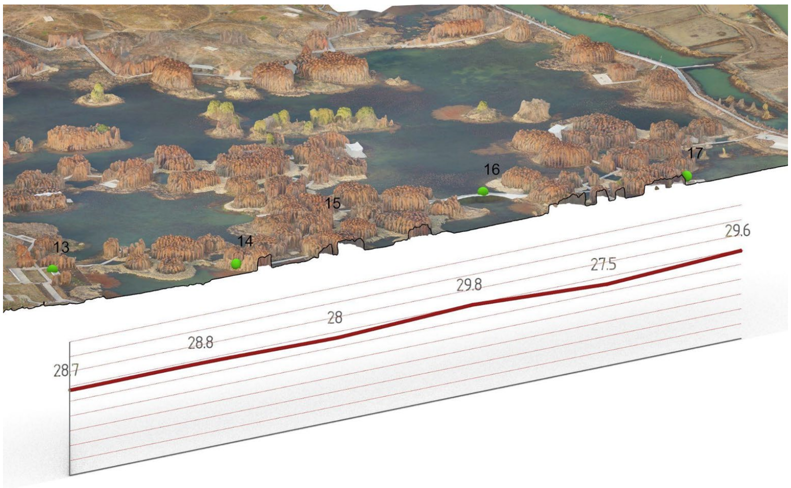
Point 7 to point 18

Change % = (28.9 - 29.4) / 29.4 = -0.01%

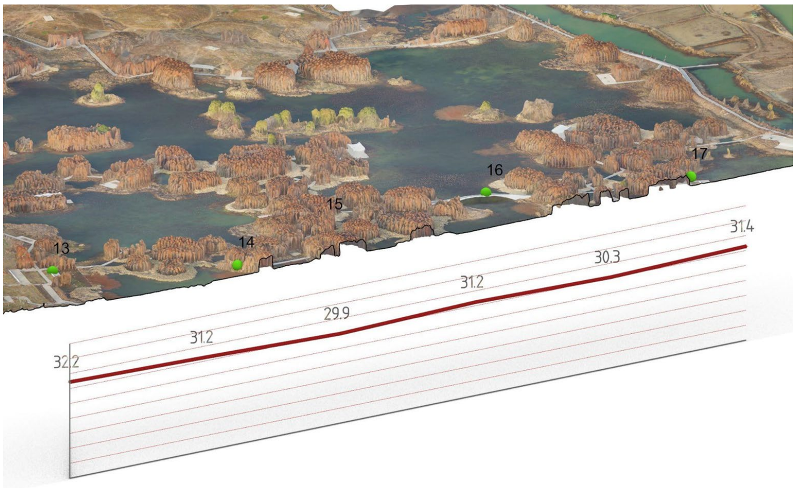
Along E-W direction

e) group 12-13-14-15-16-17

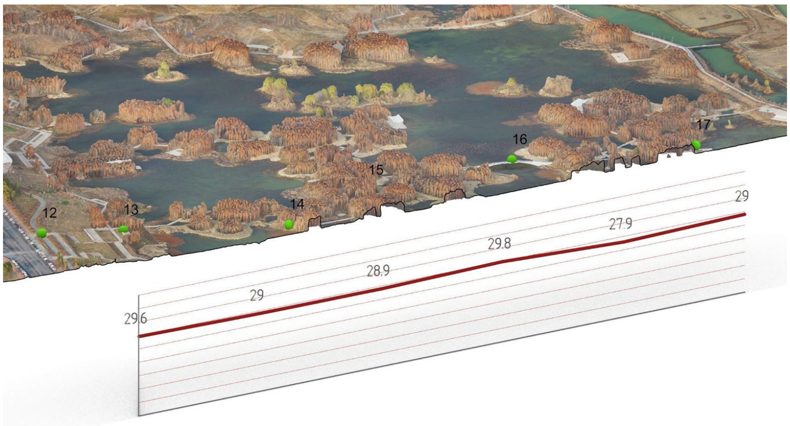
The average 9 am thermal comfort in point 12 measures 28.7, point 13 measures 28.8, point 14 measures 28, point 15 measures 29.8, point 16 measures 27.5, point 17 measures 29.6.



The average 2pm thermal comfort in point 12 measures 32.2, point 13 measures 31.2, point 14 measures 29.9, point 15 measures 31.2, point 16 measures 30.3, point 17 measures 31.4.



The average 7pm thermal comfort in point 12 measures 29.6, point 13 measures 29, point 14 measures 28.9, point 15 measures 29.8, point 16 measures 27.9, point 17 measures 29.



12
13
14
15
16
17
29.6
29
28.9
29.8
27.9
29