GREEN CANOPY COVER AND VISITOR ACTIVITY

Executive summary

About the research

The purpose of this analysis was to see if the change in visitor footfall or dwell times between a very hot day (30°C+) and a day with a normal/seasonal temperature is related to the amount of green canopy cover in an area.

Tree cover can reduce surface temperatures and provide some shelter from direct sun on hot days. As London will experience more frequent hot days in coming years, we want to understand whether tree cover affects Londoners' behaviour on hot days.

PRD supported the GLA with the analysis. Together we developed a series of questions to frame the approach.

Research questions & findings

Q1: Are visitor footfall, dwell times, and spending more resilient/sustained in town centres and high streets with higher green canopy cover during extreme hot weather?

People's behaviour in visiting town centres and high streets on very hot days (peak temperatures 30°C+) appears to be largely unaffected by green canopy presence. Correlations between footfall and green canopy, dwell times and green canopy, and spending and green canopy are weak and not significant.

19 July 2022 stands out as a day with more instances of significant (albeit weak) correlations between green canopy cover and other metrics, particularly for town centres. This was the record-breaking 39°C day and the analysis suggests that town centres with more green canopy cover may experience slightly less of a decline (or even a rise) in footfall versus the control day when compared to town centres with less green canopy cover.

Average visitor footfall and spending on the evening of 19 July 2022 was higher than the control day, which could reflect people taking official extreme heat warnings about that day seriously and choosing (where possible) to shift their town centre activities from the hotter daytime hours to the somewhat cooler evening hours.

It is worth noting that town centres with more green canopy cover may be associated with or located in/near more well-off areas. Of the 10 town centres with the most green cover, almost all are in/near places with low levels of deprivation (e.g. Hampstead, St John's Wood, Hornchurch, South Harrow, Pinner, Muswell Hill)—the only exception is Thamesmead. Londoners using these leafier town centres may be more socially or economically flexible in their shopping patterns, whereas Londoners in other areas might not have as much choice around when they leave home or use a town centre.

It is unclear why high streets don't have a similar pattern for 19 July, but it may be to do with different behaviours or ways Londoners use town centres compared to high streets. (We do note that there is some overlap of town centre and high street boundaries.)

Changes in footfall on 19 July compared to the control day may be linked to messaging urging people to stay indoors and avoid travelling that day as well as widespread disruptions to public transport.

Q2: Are visitor footfall and dwell times more resilient/sustained in smaller areas across London (350m hexagons) with higher green canopy cover during extreme hot weather?

In most cases, higher green canopy cover is associated with increased dwell time (but not necessarily footfall) on hot days—the leafier the hexagon, the longer people spent there, relative to the control days.

This could be due to people visiting parks on hot days, whether to take advantage of the weather or because depending on people's accommodation, hot days spent in places shaded by green canopy are more bearable than indoors.

The correlations point to green canopy cover being a small (5-6%) contributing factor to visitor dwell time. Other factors could include whether someone lives or works near an area with high green canopy cover, whether they have the time or ability to visit one, and the state of the route to the green area (is it shady, pleasant, direct, etc).

Visitor footfall in small areas appears to be largely unaffected by green canopy presence. Correlations between footfall and green canopy are generally weak and not significant.

Q3: Setting aside green canopy cover, is there a temperature after which footfall and dwell times in town centres and high streets tend to decrease?

On days above 35°C, visitor dwell times are above average (though footfall is below average – i.e. there are fewer people but they are staying longer).

Average footfall appears higher at lower temperatures, which may be due to higher volumes of visitor footfall in town centres and high streets during the December holiday season. Dwell times appear consistent through the high 20s.

However, correlations between temperature and change in footfall or dwell times are weak and it is not possible with the data available to identify a temperature after which footfall or dwell times start decreasing.

Future research

At the time of the research, we only had a small number of very hot days to investigate, which makes it difficult to reveal any useful patterns (or to trust the patterns we might see in the data). The heatwave in September 2023 and the near-certainty of additional hot days in summer 2024 may provide us with more robust data for re-running a similar analysis later in 2024.

Our methodology of using 'hot days' and 'control days' is also just one possible approach to Q1 and Q2. Alternative methodologies could yield different results. This work should at least provide a starting point for discussion and refining the methodology in the future.

The following pages provide more technical detail on the approach and findings. You can quickly navigate to the detailed findings by looking for the pages with a light blue background.

Project brief

The purpose of this analysis was to investigate any difference in footfall and spending in passively-cooled areas (i.e. those with higher green canopy cover) compared to ‘hot’ high streets (i.e. ones with little to no green canopy cover).

PRD supported the GLA with the analysis. Together we developed a series of questions to frame the approach:

Q1: Are visitor footfall, dwell times, and spending more resilient/sustained in town centres and high streets with higher green canopy cover during extreme hot weather?

Q2: Are visitor footfall and dwell times more resilient/sustained in individual hexagons* with higher green canopy cover during extreme hot weather?

Q3: Setting aside green canopy cover, is there a temperature after which footfall and dwell times in town centres and high streets tend to decrease?

We used BT Mobility and Mastercard Retail Location Insights data for this analysis along with green canopy data from the GLA.

*Note on hexagon data

The GLA and TfL use a standardised method for aggregating small-scale data across London. The method is based on apportioning London into 350 m wide hexagons using GIS (geographical information software). The hexagons cover all of London but do not overlap with one another. Each hexagon has a unique ID.

The hexagons can be roughly assembled into other geographies, for example to form the shape of local authorities, town centres, or parks.

Both the GLA’s green canopy cover estimates and BT’s footfall data are calculated to hexagon level.

Q1: Are visitor footfall, dwell time, and spending more resilient/sustained in town centres and high streets with higher green canopy cover during extreme hot weather?

Q1: Are visitor footfall, dwell times, and spending more resilient in town centres and high streets with higher green canopy cover during extreme hot weather?

Process

1. Select extreme hot days and control days for comparison

Hot day	Peak day temp	Control day	Peak day temp
Sun 11 June 2023	31°	Sun 4 June 2023	21°
Sun 25 June 2023	30°	Sun 4 June 2023*	21°
Mon 11 July 2022	31°	Mon 4 July***	23°
Tue 19 July 2022**	39°	Tue 5 July***	22°

* Last most seasonable weather for the same day of week
** Data will be affected by severe train disruptions
*** Data for Wimbledon will be affected by tennis

Data time periods:
Daytime: 12 to 15 block ('day')
Evening: 18 to 21 block ('eve')

2. Extract footfall, dwell, and spend data for hot/control days for high streets, town centres, BIDs
a. Filter GLA BT and Mastercard data to the specific dates and times above
b. Filter GLA BT data to only show observations where footfall is >= 50

3. Estimate the proportion of green cover in each high street, town centre, and bid
a. Join the GLA green canopy hex spreadsheet to the GLA hex lookup for different boundary types
b. Add up the total area of hexagons covering each boundary, the total area of green cover in the hexagons covering each boundary, then calculate the proportion of green cover across each cluster of hexes

4. Join data on green canopy cover per boundary to footfall, dwell, and spend extract

5. Calculate the change in footfall, dwell, and spend between hot days and control days

6. Visualise and formally test correlation between green canopy cover and change in metrics (Pearson coefficient)

Visualisations

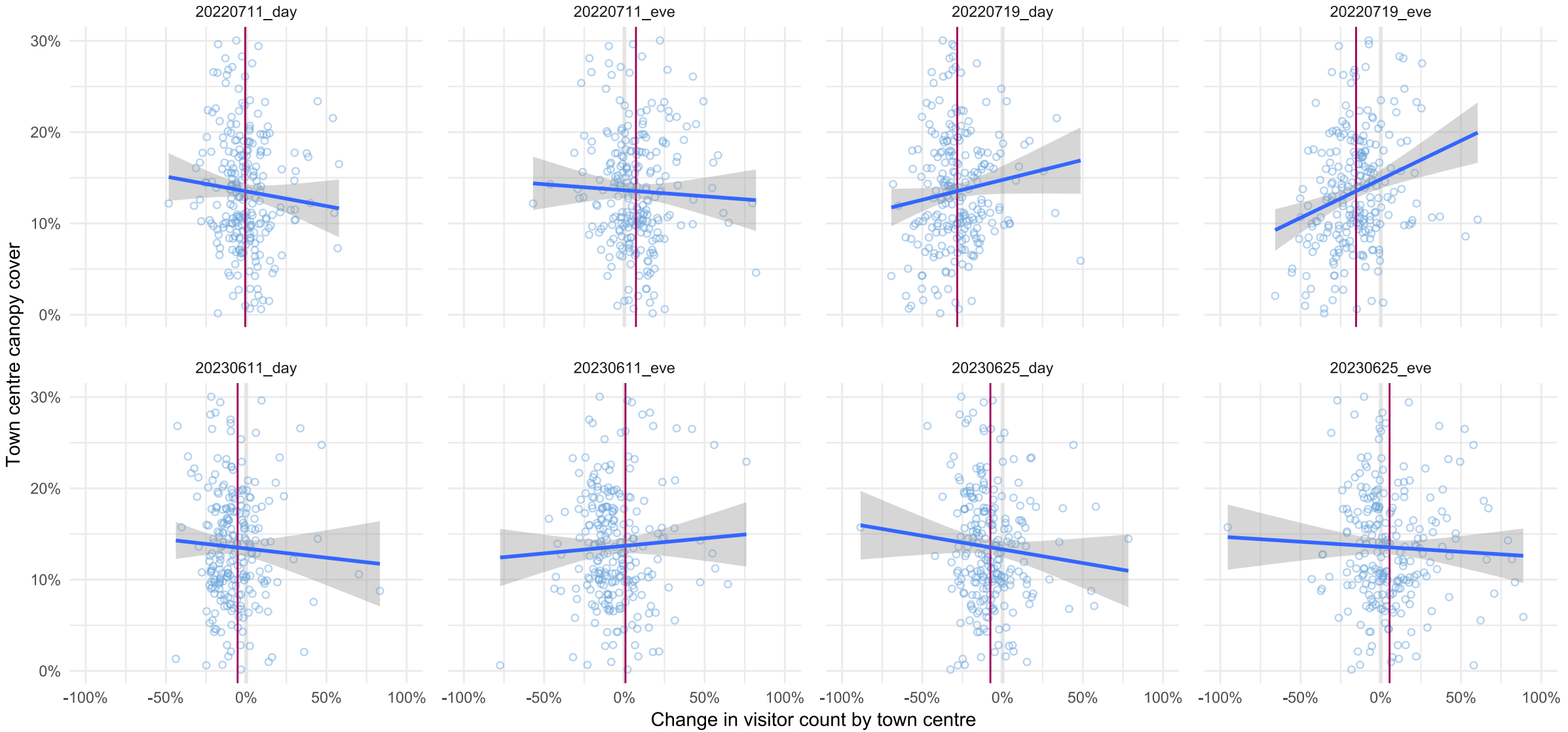
On the following pages, each dot represents a single town centre or high street. Its position within the plot denotes its green canopy cover and the change in visitor count, visitor dwell time, or spending between the hot day and control day.

The pink line shows the average change in visitor count, visitor dwell time, or spending across all town centres or high streets.

The blue line shows the relationship between x and y axis data. A grey shadow under the blue line indicates uncertainty about the relationship due to a lack of data (wider grey area = more uncertainty/unreliability of relationship).

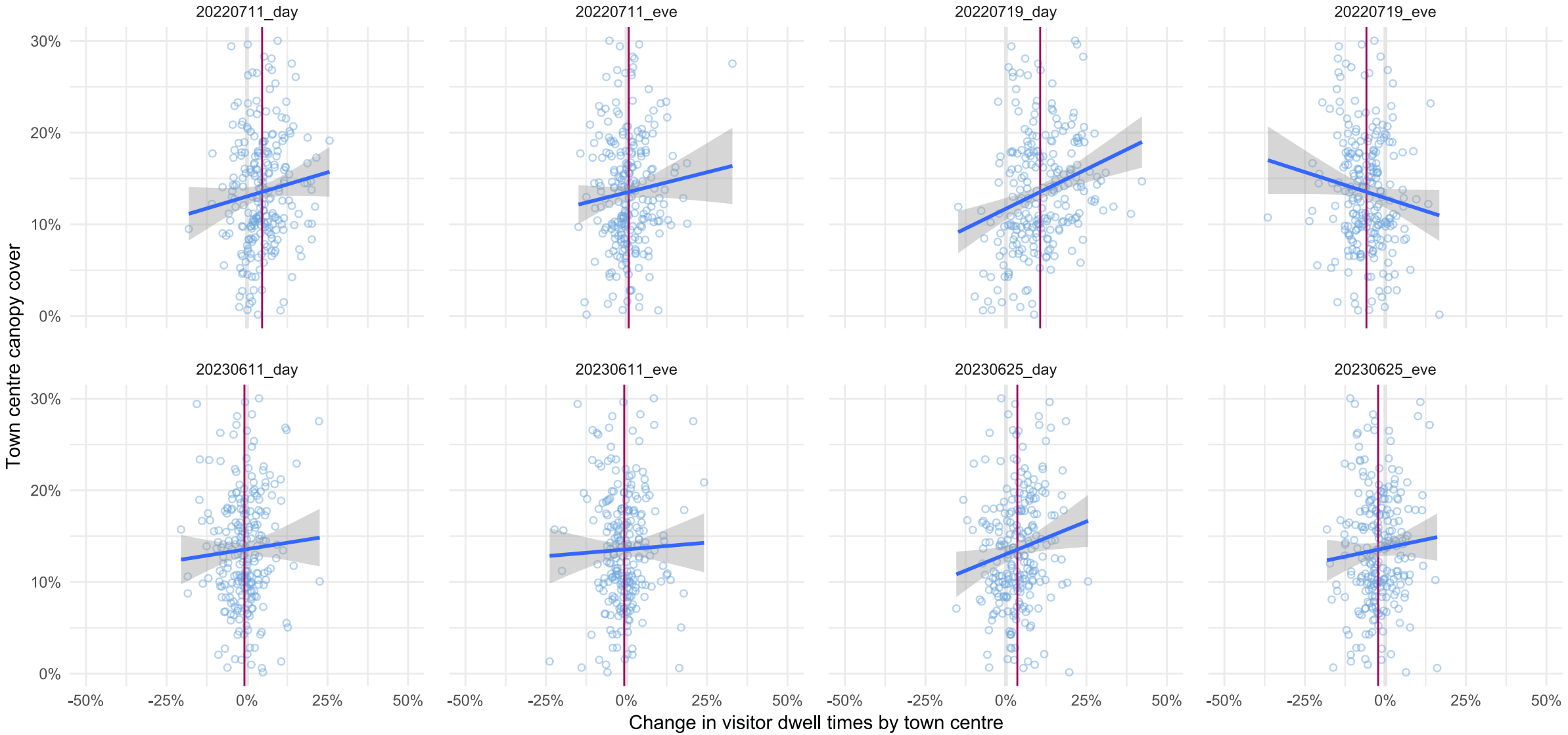
Town centres

Change in town centre visitor footfall, hot days vs comparator days



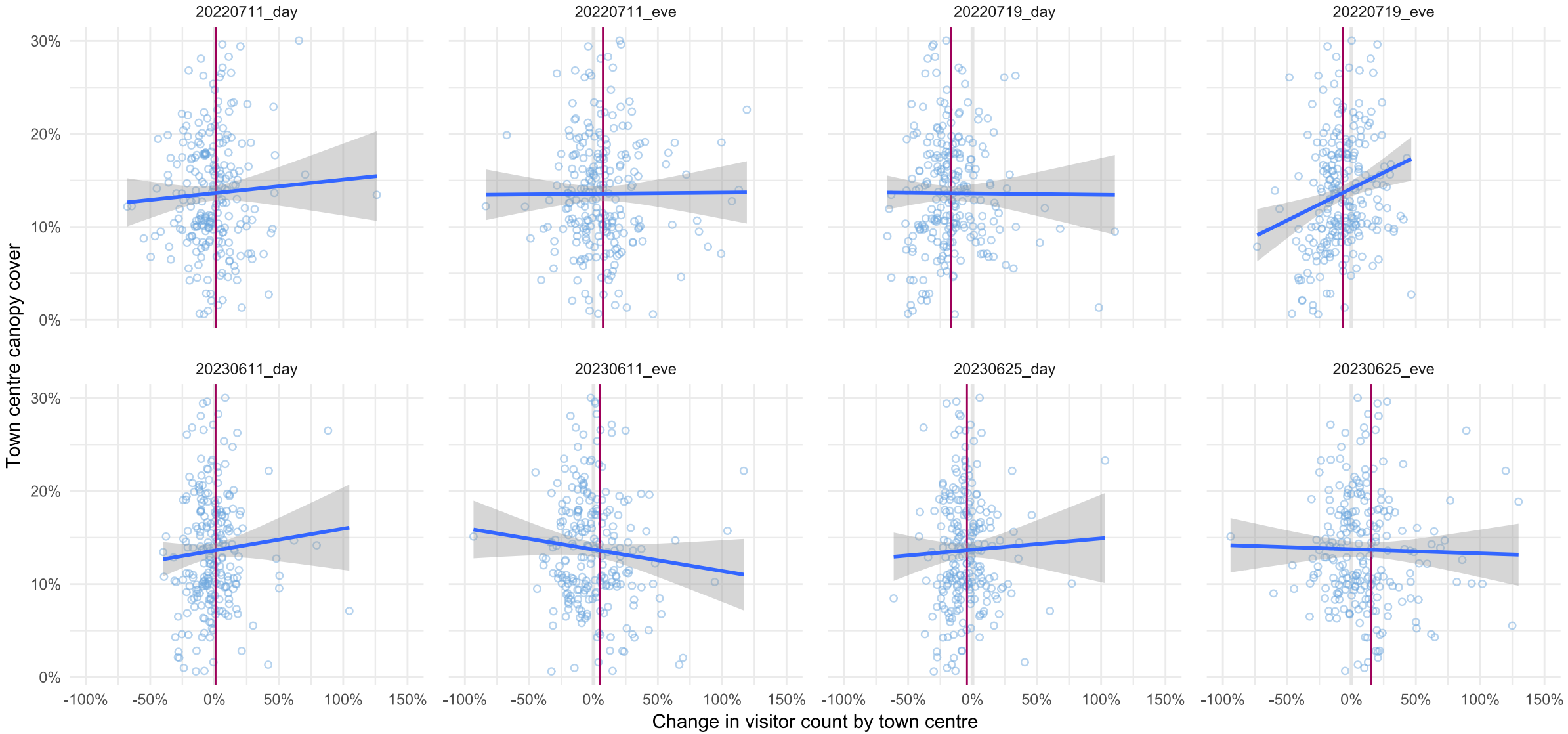
Town centres

Change in town centre visitor dwell times, hot days vs comparator days

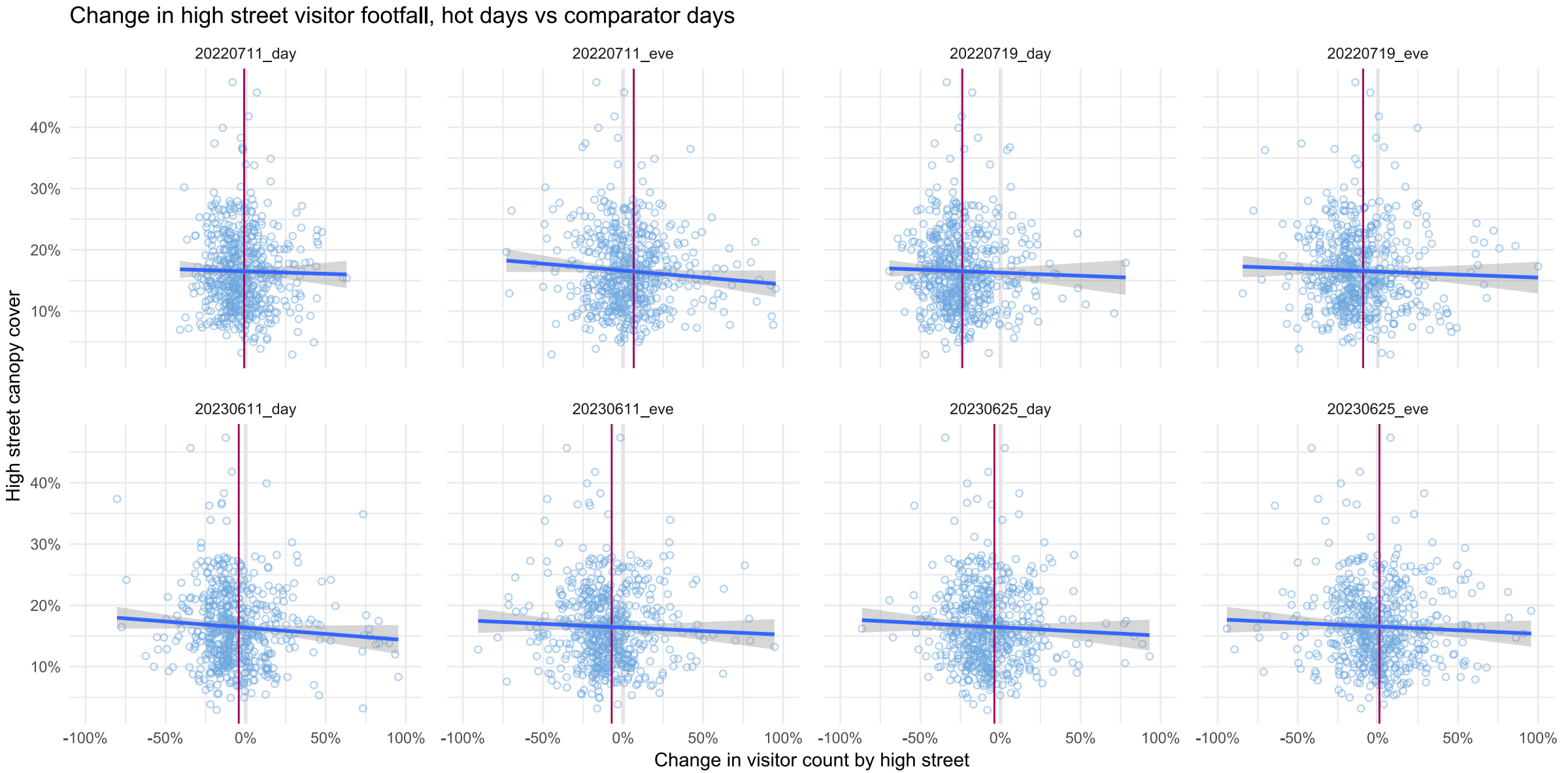


Town centres

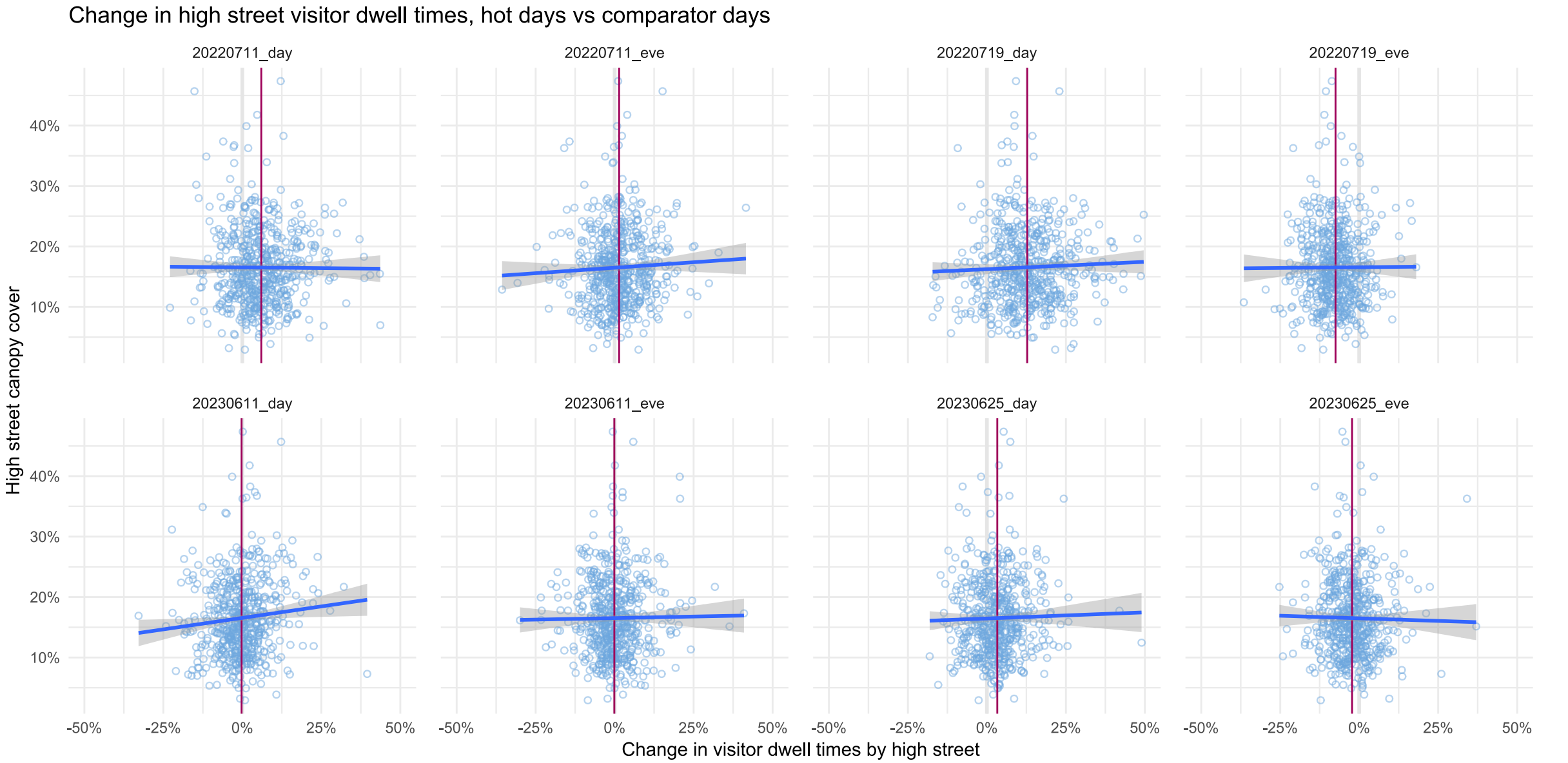
Change in town centre spend, hot days vs comparator days



High streets

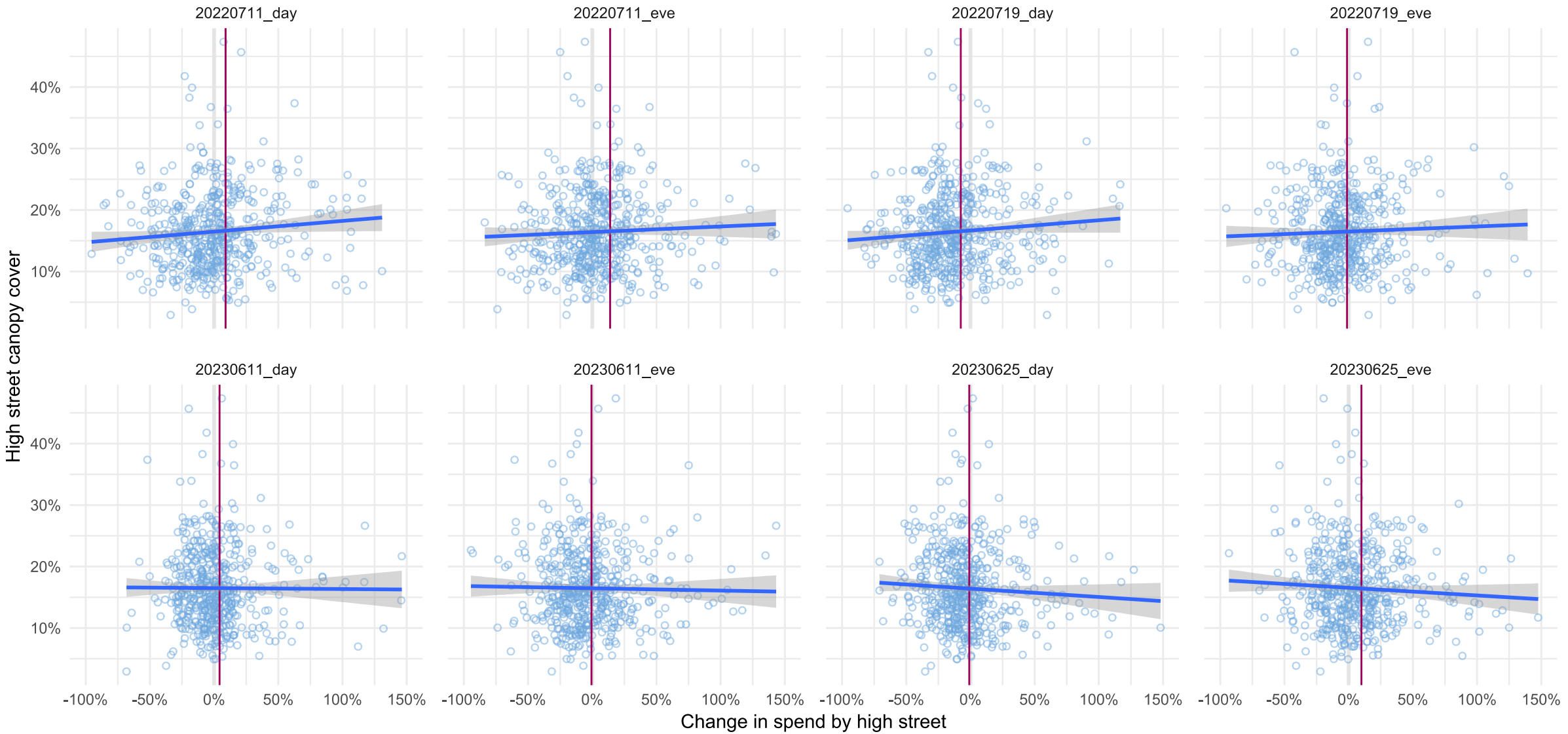


High streets



High streets

Change in high street spend, hot days vs comparator days



Q2: Are visitor footfall, dwell time, and spending more resilient/sustained in small areas (individual 350m hexagons) with higher green canopy cover during extreme hot weather?

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Process

1. Select extreme hot days and control days for comparison

Hot day	Peak day temp	Control day	Peak day temp
Sun 11 June 2023	31°	Sun 4 June 2023	21°
Sun 25 June 2023	30°	Sun 4 June 2023*	21°
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Tue 19 July 2022**	39°	Tue 5 July***	22°

* Last most seasonable weather for the same day of week
** Data will be affected by severe train disruptions
*** Data for Wimbledon will be affected by tennis

Data time periods:
Daytime: 12 to 15 block ('day')
Evening: 18 to 21 block ('eve')

2. Extract footfall and dwell data for hot/control days for individual hexagons
a. Filter GLA BT data to the specific dates and times above
b. Filter GLA BT data to only show observations where footfall is >= 50

3. Join green canopy data to footfall data

4. Calculate the change in footfall and dwell between hot days and control days for each hexagon

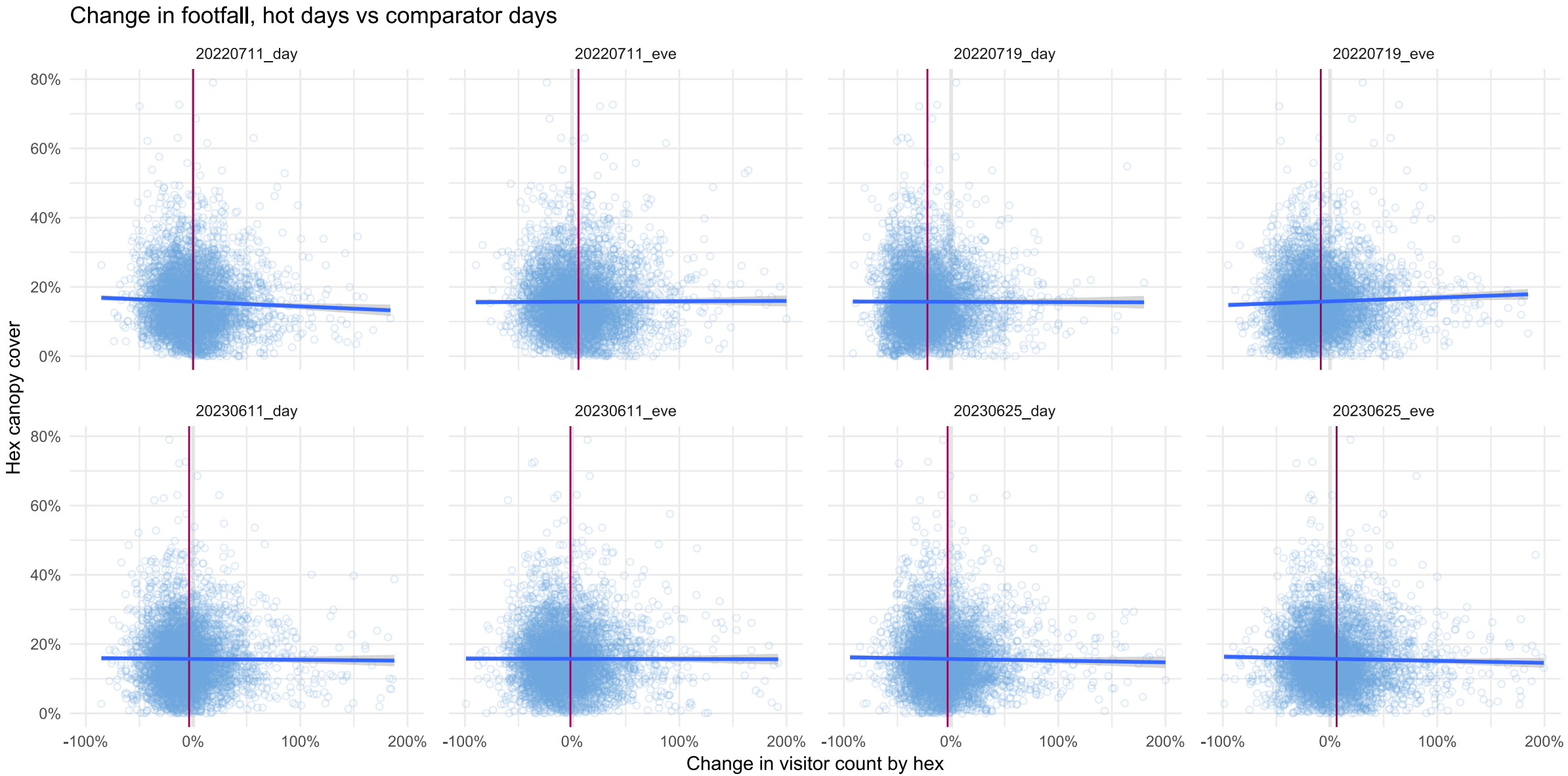
5. Visualise and formally test correlation between green canopy cover and change in metrics (Pearson coefficient)

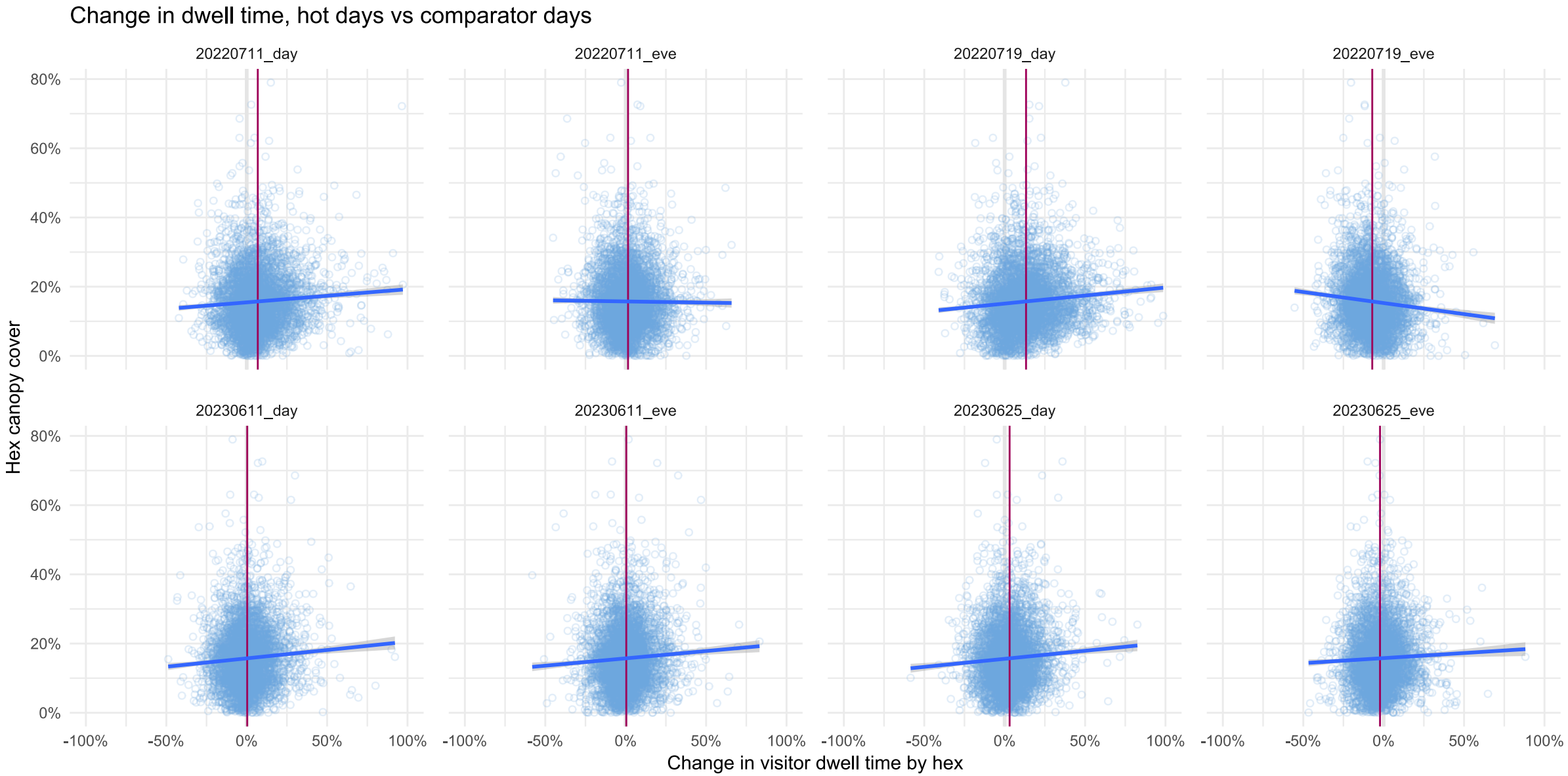
Visualisations

On the following pages, each dot represents an individual hexagon. Its position within the plot denotes its green canopy cover and the change in visitor count or dwell time between the hot day and control day.

The pink line shows the average change in visitor count or dwell time across all hexagons.

The blue line shows the relationship between x and y axis data. A grey shadow under the blue line indicates uncertainty about the relationship due to a lack of data (wider grey area = more uncertainty/unreliability of relationship).


Change in footfall, hot days vs comparator days
20220711_day
20220711_eve
20220719_day
20220719_eve
20230611_day
20230611_eve
20230625_day
20230625_eve
Hex canopy cover
80%
60%
40%
20%
0%
-100%
0%
100%
200%
Change in visitor count by hex


Change in dwell time, hot days vs comparator days
20220711_day
20220711_eve
20220719_day
20220719_eve
20230611_day
20230611_eve
20230625_day
20230625_eve
Hex canopy cover
80%
60%
40%
20%
0%
-100%
-50%
0%
50%
100%
Change in visitor dwell time by hex

Analysis

For the analysis, we calculated the Pearson correlation coefficient for each pair of variables (e.g. visitor footfall x green canopy, dwell time x green canopy). This gave us an initial idea of whether the correlation between green canopy and another metric is significant or not.

The Pearson correlation coefficient is a number between -1 and 1, where negative numbers denote a negative correlation (the more x goes up, the more y goes down) and positive numbers denote a positive correlation (the more x goes up, the more y goes up). Numbers at the extreme ends—towards -1 and 1—indicate a stronger correlation whereas numbers closer towards zero (e.g. 0.1, -0.2) indicate a weaker correlation.

The size of the correlation coefficient on its own does not tell us anything about its significance. It is possible that tree cover only contributes a tiny fraction of a percent to influencing human behaviour (compared to all the other possible variables).

To provide additional nuance, we then performed a 'shuffle test' or randomisation test, which involved shuffling the variable pairs 1000 times and generating another 1000 correlation coefficients, which we compared against the 'true' correlation coefficients.

The table below shows the true correlation coefficients. The ones marked in **bold blue** are those where the shuffle test indicated that the correlation is significant (i.e. the correlations are statistically meaningful even though they are weak).

Pearson correlation coefficients for changes between hot/control days and green canopy cover >= 50 people per boundary	Footfall by hex	Dwell time by hex	Footfall by town centre	Footfall by high street	Dwell time by town centre	Dwell time by high street	Spend by town centre	Spend by high street
	% change in footfall between hot date and control date	*% change in average dwell time between hot date and control date*	*% change in footfall between hot date and control date*	*% change in footfall between hot date and control date*	*% change in average dwell time between hot date and control date*	*% change in average dwell time between hot date and control date*	*% change in spending between hot date and control date*	*% change in spending between hot date and control date*
11 July 2022 (day)	**-0.041**	**0.064**	-0.079	-0.015	0.108	0.006	0.043	0.039
11 July 2022 (eve)	-0.001	-0.009	-0.039	-0.074	0.089	0.033	0.049	0.061
19 July 2022 (day)	0.005	**0.089**	0.120	-0.030	**0.251**	0.021	-0.005	0.037
19 July 2022 (eve)	**0.033**	**-0.085**	**0.247**	**-0.089**	-0.122	-0.010	**0.175**	0.008
11 June 2023 (day)	-0.017	**0.060**	-0.048	-0.020	0.055	0.084	0.075	-0.044
11 June 2023 (eve)	**-0.026**	**0.053**	-0.051	-0.015	0.030	0.012	**-0.152**	-0.023
25 June 2023 (day)	-0.027	**0.064**	-0.084	-0.022	**0.146**	0.026	0.022	-0.030
25 June 2023 (eve)	-0.021	**0.038**	-0.041	-0.072	0.071	-0.019	-0.057	-0.068

Q1: Are visitor footfall, dwell times, and spending more resilient in town centres and high streets with higher green canopy cover during extreme hot weather?

Visitor footfall

On the whole, the correlation between visitor footfall and green canopy cover is *weak and not statistically significant* (i.e., any change in visitor footfall on hot days is not related to the amount of green canopy cover on a town centre or high street).

Exceptions are the evenings of **19 July 2022** and **11 June 2023** with significant correlations of 0.247 in town centres (hot-day footfall change was 25% *positively* correlated with canopy cover) and -0.089 in high streets (hot-day footfall change was 9% *negatively* correlated with canopy cover), respectively.

Visitor dwell times

On the whole, the correlation between visitor dwell times and green canopy cover is *weak and not statistically significant* (i.e., any change to visitor dwell times on hot days is not related to the amount of green canopy cover on a town centre or high street).

Exceptions are the daytimes of **19 July 2022** and **25 June 2023** in town centres with significant correlations of 0.251 (hot-day dwell change was 25% positively correlated with canopy cover) and 0.146 (hot-day dwell change was 15% positively correlated with canopy cover), respectively.

Spending

On the whole, the correlation between spending and green canopy cover is *weak and not statistically significant* (i.e., change in spending on hot days is not related to the amount of green canopy cover).

Exceptions are the evenings of **19 July 2022** and **11 June 2023** in town centres with significant correlations of 0.175 (hot-day spend change was 18% positively correlated with canopy cover) and -0.152 (hot-day spend change was 15% negatively correlated with canopy cover), respectively.

Summary

- 19 July 2022 stands out as a day with more instances of significant (albeit weak) correlations between green canopy cover and other metrics, particularly for town centres. This was the record-breaking 39°C day and the analysis suggests that town centres with more green canopy cover may experience slightly less of a decline (or even a rise) in footfall versus the control day when compared to town centres with less green canopy cover.
- The visitor footfall and spending on the evening of 19 July 2022 could reflect people taking official extreme heat warnings about that day seriously and choosing (where possible) to shift their town centre activities from the hotter daytime hours to the somewhat cooler evening hours.
- Town centres with more green canopy cover may be associated with or located in/near more well-off areas (e.g., Hampstead and St John's Wood town centres have among London's highest green canopy cover and are in/near more affluent areas). Londoners using these leafier town centres may be more socially or economically flexible in their shopping patterns, whereas Londoners in other areas might not have as much choice around when they leave home or use a town centre.
- It is unclear why high streets don't have a similar pattern for 19 July, but it may be to do with different behaviours or ways Londoners use town centres compared to high streets. (We do note that there is some overlap of town centre and high street boundaries.)

Q2: Are visitor footfall and dwell times more resilient in small areas (individual 350m hexagons) with higher green canopy cover during extreme hot weather?

Visitor footfall

On the whole, the correlation between visitor footfall and green canopy cover is *weak and not statistically significant* (i.e., any change in visitor footfall on hot days is not related to the amount of green canopy cover in an individual hex).

Exceptions are 11 July 2022 daytime (low but significant -0.041), 19 July 2022 evening (low but significant 0.033), and 11 June 2023 evening (low but significant -0.026).

Visitor dwell times

On the whole, the correlation between visitor dwell times and green canopy is *weak and statistically significant*: almost all hot days showed a positive correlation between dwell times and green cover except the evening of 11 July 2022 (not significant) and evening of 19 July 2022 (significant negative correlation).

Summary

- In most cases, increased green canopy cover is associated with increased dwell time on hot days—the leafier the hexagon, the longer people spent there, relative to the control days.
- This could be due to more people visiting parks on hot days, whether to take advantage of the weather or because depending on people's accommodation, hot days spent in places shaded by green canopy are more bearable than indoors.
- The correlations point to green canopy cover being a small (5-6%) contributing factor to visitor dwell time. Other factors could include whether someone lives or works near an area with high green canopy cover, whether they have the time or ability to visit one, and the state of the route to the green area.

Q3: Is there a temperature after which footfall and dwell times in town centres and high streets tend to decrease?

Q3: Is there a temperature after which footfall in town centres and high streets tend to decrease?

Process 1

Calculate the average footfall or dwell time for each town centre and then calculate what percent of average footfall or dwell time is at a given temperature

1. Collect peak daily temperature data for London for May 2022 to present (coinciding with the same period for which we have BT footfall data)

2. Filter 12 to 15 and 18 to 21 hour blocks from BT footfall data

3. Calculate the average footfall and dwell time per 3-hour block across all boundaries (e.g. average footfall during 12:00 to 15:00 across all town centres on 14 August)

4. Calculate the difference between footfall and dwell time on each day vs the average (e.g. difference between actual footfall and average footfall during 12:00 to 15:00 across all town centres on 14 August)

5. Join temperature data to the filtered and averaged footfall spreadsheet

6. Visualise and formally test for correlation

Visualisations

On the following page, each blue bar comprises data on the average footfall or dwell time at a given temperature point:
The ‘box’ (in the centre of the bar) is the data falling between the 25th and 75th percentiles

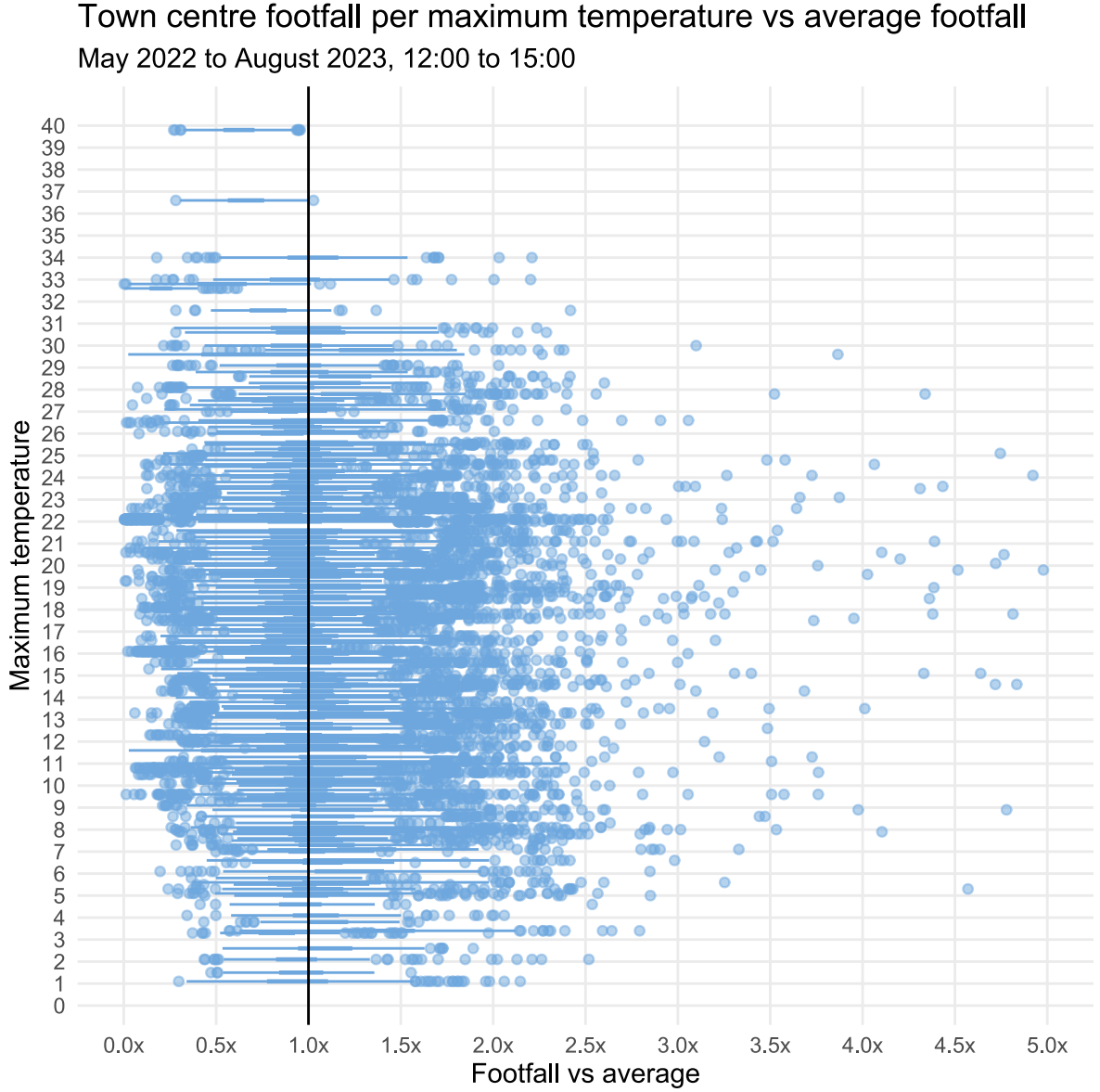
- The ‘whiskers’ (the thin lines either side of the box) are the data outside the central 50% of the box
- The ‘outliers’ (the dots) are the most ‘extreme’ data

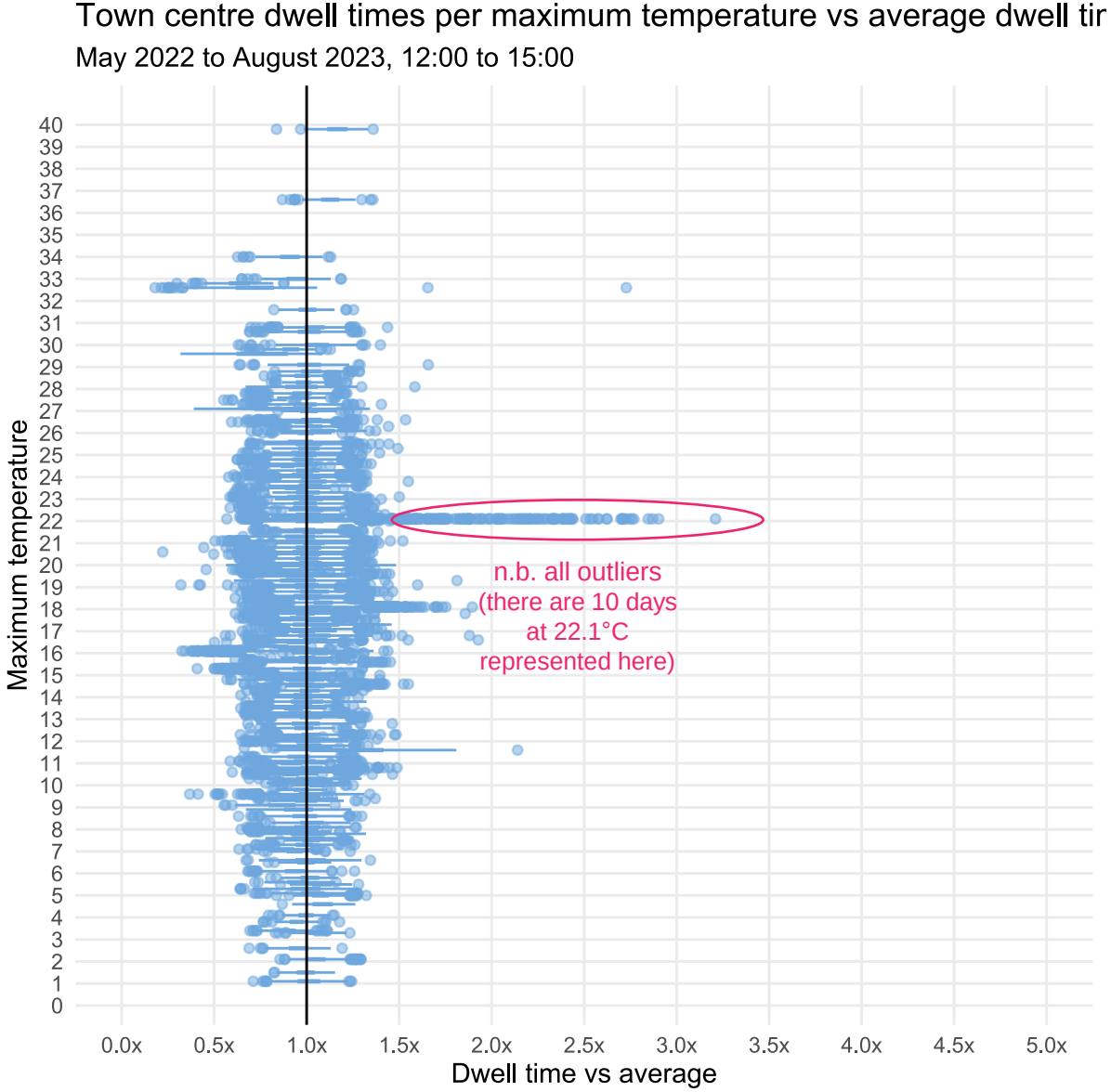
A very long bar or bar element (e.g. long whiskers, long box) indicates a wide, varying range of footfall or dwell time averages. A short bar or bar element indicates a smaller range of footfall or dwell time averages.

n.b. visualisations provided for town centres only

Findings/summary

- From 31°C onwards footfall appears to drop below average for most town centres, aside from the day of 34°C.
- On days above 35°C, dwell time is above average (though footfall is below average – i.e. there are fewer people but they are staying longer).
- The correlation coefficient between temperature and change in footfall or dwell time is very weak (<0.1).
- It is likely we need more data for 30°C+ days to be able to run a more reliable analysis.


Town centre footfall per maximum temperature vs average footfall
May 2022 to August 2023, 12:00 to 15:00
Maximum temperature
Footfall vs average
0.0x
0.5x
1.0x
1.5x
2.0x
2.5x
3.0x
3.5x
4.0x
4.5x
5.0x


Town centre dwell times per maximum temperature vs average dwell tir
May 2022 to August 2023, 12:00 to 15:00
Maximum temperature
Dwell time vs average
n.b. all outliers
(there are 10 days
at 22.1°C
represented here)
0.0x
0.5x
1.0x
1.5x
2.0x
2.5x
3.0x
3.5x
4.0x
4.5x
5.0x

Q3: Is there a temperature after which footfall in town centres and high streets tend to decrease?

Process 2

Generate temperature bins and calculate the average footfall and dwell time across all town centres/high streets for a particular temperature. Can we say 'for each degree above 30, average town centre footfall decreases by x amount'?

1. Collect peak daily temperature data for London for May 2022 to present (coinciding with the same period for which we have BT footfall data)

2. Filter 12 to 15 and 18 to 21 hour blocks from BT footfall data

3. Calculate the average footfall and dwell time per 3-hour block across all boundaries (e.g. average footfall during 12:00 to 15:00 across all town centres on 14 August)

4. Join temperature data to the filtered and averaged footfall spreadsheet

5. Group the data into temperature 'bins' (e.g. 21 = everything from 21 to 21.9°, 22 = 22 to 22.9°)

6. Calculate the average footfall or dwell time per temperature bin

7. Visualise and formally test for correlation

Visualisations

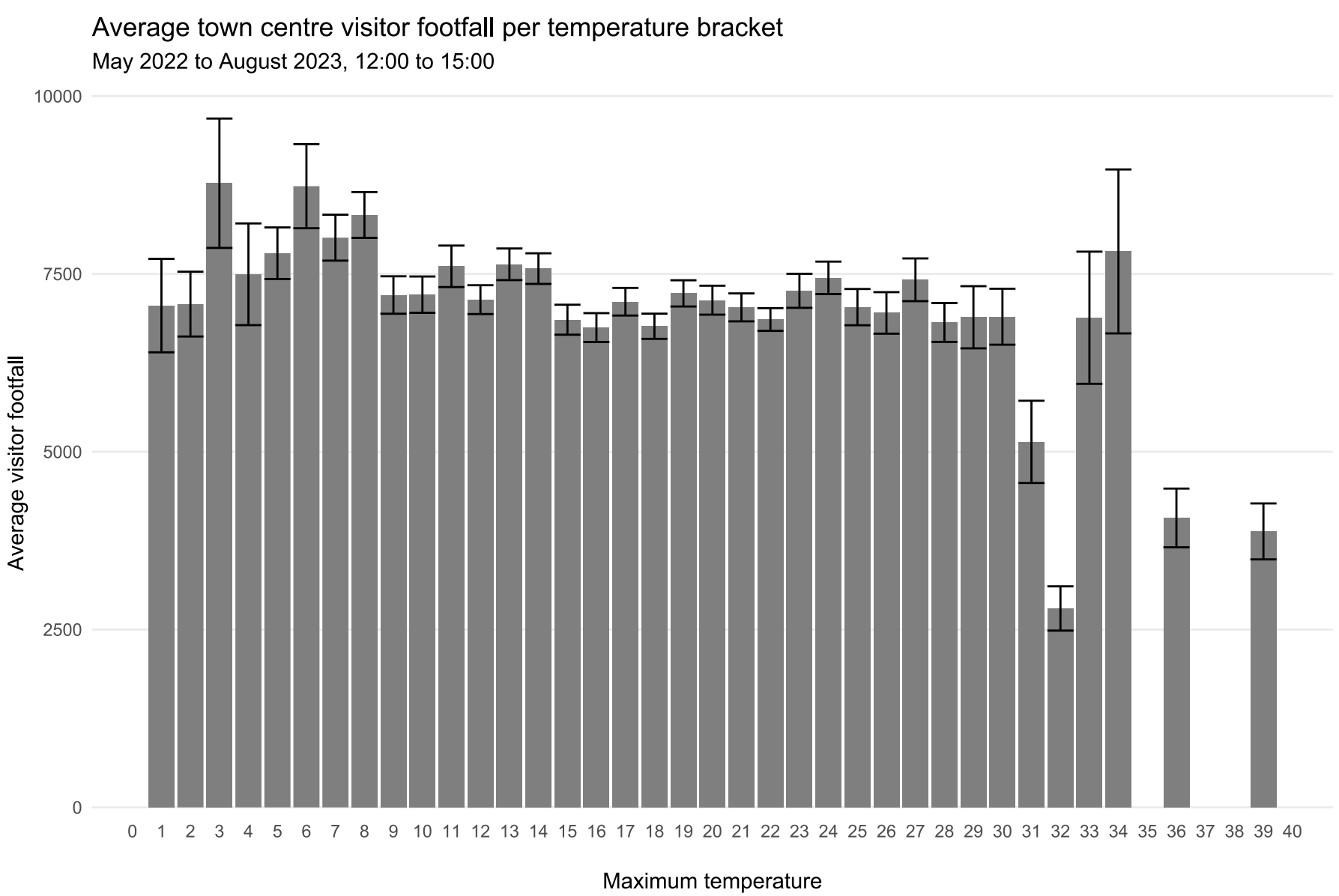
On the following pages, the grey bars indicate average footfall across all town centres for a given temperature bracket. The grey bar does not indicate the number of days the average is based on, which will be higher for London's more 'normal' temperature range (which will yield more reliable data) and much lower for 30°+ days (less reliable data).

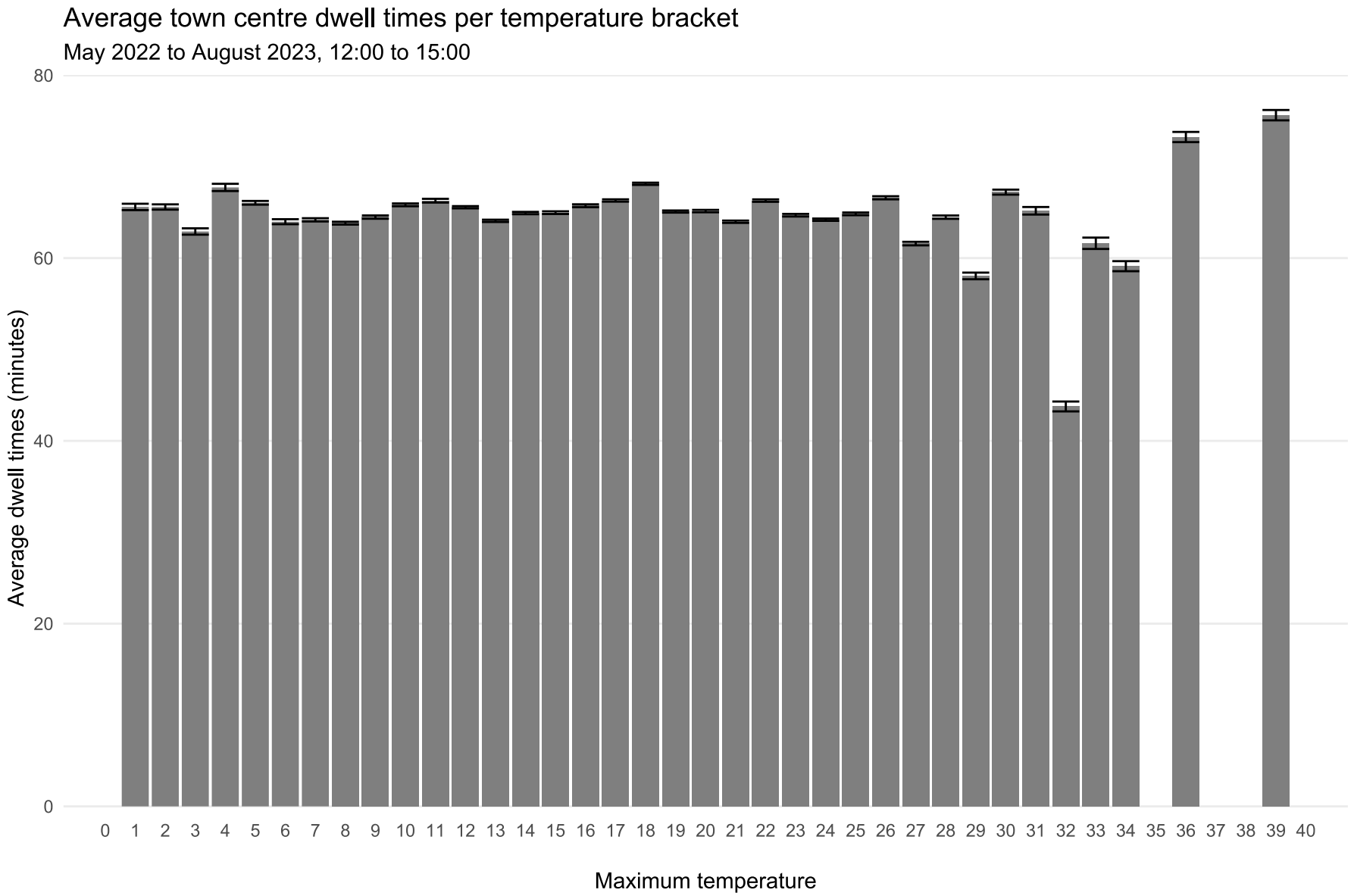
The black `I` shaped bars are error bars, representing uncertainty or variation of for data in each temperature bracket (based on the standard error). A shorter bar indicates data is clustered closer to the average and a longer bar indicates a wider spread of data from the average.

n.b. visualisations provided for town centres only

Findings/summary

- On days above 35°C, visitor footfall is below average and dwell time is above average (there are fewer people but they are staying longer).
- Average footfall appears higher at lower temperatures, which may be due to higher volumes of visitor footfall in town centres and high streets during the December holiday season. Dwell times appear consistent through the high 20s.
- It is likely we need more data for 30°C+ days to be able to run a more reliable analysis on extreme heat days.


Average town centre visitor footfall per temperature bracket
May 2022 to August 2023, 12:00 to 15:00
Average visitor footfall
10000
7500
5000
2500
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
Maximum temperature


Average town centre dwell times per temperature bracket
May 2022 to August 2023, 12:00 to 15:00
Average dwell times (minutes)
80
60
40
20
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
Maximum temperature