FOOTPRINT ECOLOGY

Analysis of Thames Basin Heaths 2016 people counter data

Chris Panter

FOOTPRINT ECOLOGY, FOREST OFFICE, BERE ROAD, WAREHAM, DORSET BH20 7PA
WWW.FOOTPRINT-ECOLOGY.CO.UK
01929 552444

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Contents

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1. Introduction

The Thames Basin Heaths SPA

1.1 The Thames Basin Heaths (TBH) Special Protection Area (SPA) covers an area of approximately 8,400 ha and was classified under the Birds Directive in 2005. The area consists of 13 Sites of Special Scientific Interest (SSSI) distributed across three counties (Surrey, Berkshire and Hampshire) and 11 local authorities. About half (ca 4000 ha) is within the Ministry of Defence Training Estate, with the remainder owned and managed by Local Authorities, Conservation NGOs, Forestry Commission and private landowners.

1.2 The SPA includes areas of dry and wet heathland, mire, oak and birch woodland, gorse scrub and acid grassland, plus conifer plantation. UK southern heathlands, an open habitat found on poor, acid soils and dominated by heathers and gorse (*Calluna vulgaris*, *Erica* ssp. and *Ulex* ssp.), have a very limited global distribution, and are among the most threatened habitats in Britain and Europe.

1.3 The TBH are located to the south west of London, along the M3 corridor, and this proximity to London has led to high pressure for development, which started in the mid-20th century and continues to the present day. Heathlands in southern England now occupy about a sixth of the area they formerly covered. In TBH it has been estimated that the decline in area was 53% between 1904 and 2003 with fragmentation of 52 main blocks to 192 smaller blocks during the same period (Land Use Consultants 2005).

1.4 The TBH SPA is classified for three species of birds, listed on Annex I of the Birds Directive: Nightjar *Caprimulgus europaeus*, Woodlark *Lullula arborea* and Dartford warbler *Sylvia undata*. All three species are ground nesting (or in the case of Dartford warbler, low nesting) species, and are therefore particularly vulnerable to disturbance.

1.5 A range of impacts to heathlands are particularly associated with the proximity to urban areas. These 'urban effects' (see Haskins 2000; Underhill-Day 2005 for review) include; increased fire incidence, trampling, fly-tipping, pollution, soil erosion, predation by cats, increased natural predators, and disturbance by humans and their dogs. Studies of the Annex I bird species show clear impacts of increased housing on both breeding success and numbers (Murison 2002; Liley & Clarke 2003; Liley *et al.* 2006; Mallord *et al.* 2007)

TBH SPA Area Delivery Framework and SAMM

1.6 As a result of growing evidence of the impacts from these urban effects, it was recognised that mitigation measures were necessary to ensure continued residential development did not adversely impact the TBH SPA. The local authorities, with Natural England, worked to produce a series of mitigation and avoidance measures. The background to these is discussed in detail in Burley's report on the TBH SPA draft delivery plan (2007) and details of the agreed approach set out in the Thames Basin Heaths Special Protection Area Delivery Framework (Thames Basin Heaths Joint Strategic Partnership Board 2009).

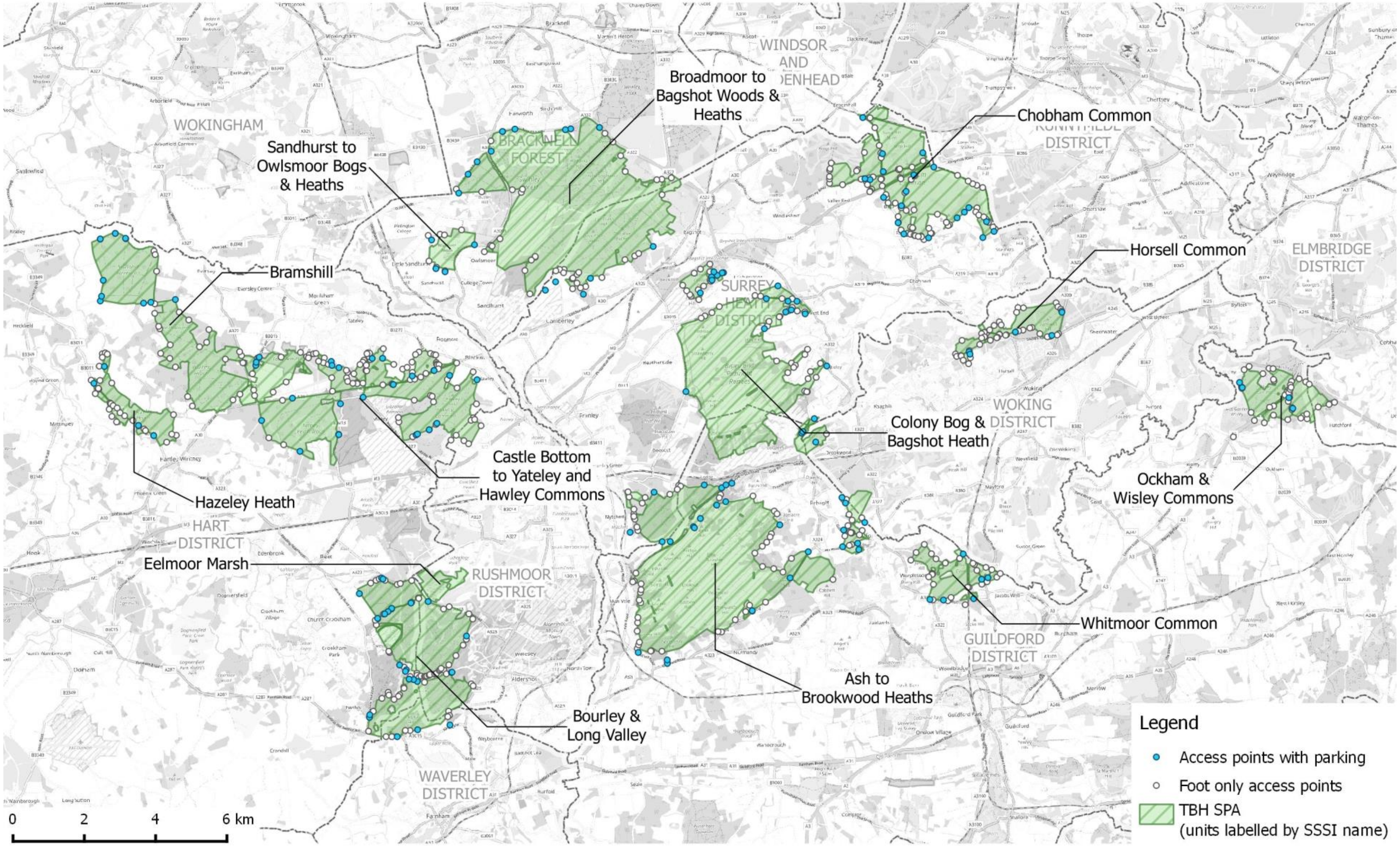
1.7 The Delivery Framework identifies a series of development zones around the SPA that inform where and how residential development can be taken forward, including the use of alternative sites, visitor access management and the accompanying monitoring. Key components of the Framework include::

- A 400m zone around the SPA boundary within which there is a premise of no net development.
- A zone of influence from 400m to 5km from the SPA boundary (up to 7km for large developments) within which any new residential development should provide or contribute to the provision of avoidance measures to mitigate the impacts of the new residents.
- Avoidance measures such as the provision of additional green space ('SANGs'– suitable alternative natural greenspace) and on-site access management ('SAMM' – strategic access management and monitoring).

1.8 Access management is coordinated strategically by Natural England working with the local authorities and partners, under the Thames Basin Heaths Partnership (TBHP). The TBHP is made up of 26 organisations, primarily the 11 local authorities, but also relevant government bodies and NGOs. The access management can include 'soft' measures, such as education and wardening, or 'hard' measures such as limiting car parking, managing path networks etc. Wardening staff, which have been on the ground since 2015, to promote appropriate behaviour on the SPA and encourage use of alternative sites, including the use of a website to detail alternative sites for visitors to use (http://www.tbhpartnership.org.uk/sites/).

1.9 The other part of SAMM is the monitoring of the mitigation measures. SAMM recognises that the continual monitoring is needed to evaluate the levels of recreational use on heaths and on SANGs. Monitoring should allow a check on the effectiveness of measures, act as an early warning and allow mitigation measures to be adjusted as necessary to reflect changes in access patterns, and types of use on both heathland and SANG mitigation sites.

Map 1: The location of the Thames Basin Heaths SPA and access point onto the sites.



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Automated counters

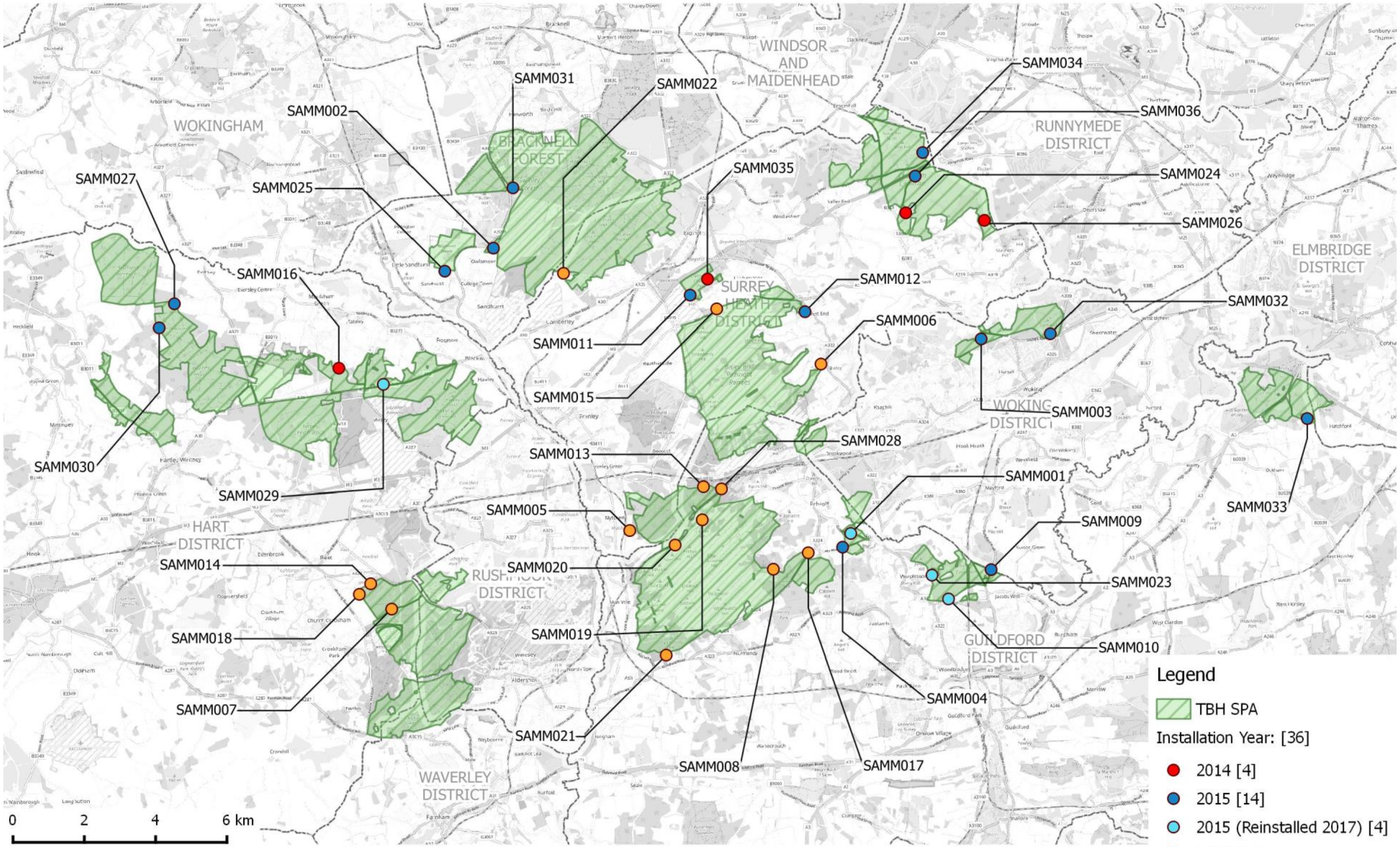
1.10 Access occurs widely across the SPA – see Map 1 – although access can often be constrained by other factors, such as private land ownership and military activities.

1.11 Monitoring data of visitor access, integral to SAMM, is collected in a range of ways, for example, through car park counts, or direct counts. However, these approaches can require considerable staff time to produce a large, robust dataset. The use of automated counters placed on access points to sites to record people provides a greater level of detail and does not involve lengthy fieldwork. These sensors require effort to be maintained, but provide an extremely large dataset across 24 hrs a day, which the staff time required to otherwise produce would be unrealistic.

1.12 These sensors can therefore be used to examine daily, weekly and monthly patterns at specific locations, and to also record long-term changes in access patterns across several years. These can be used as a baseline to examine the current access, and in the future to determine how these relate to SAMM actions, such as on site efforts of the SPA and the provision of SANGs. The distribution of all sensors which have been deployed across the TBH SPA is shown in Map 2.

1.13 This report serves to examine the data collected during 2016 from the network of automated counters, exploring the differences both temporally and spatially. The report also provides suggestions for improved data quality and calibration. Furthermore, we examine more widely the full list of current sensors to review the current network and any future considerations about coverage and deployment.

Map 2: The distribution of sensor locations across the TBH, categorised by the year of installation for each of the 36 sensor locations.



2. Methodology for 2016 data processing

2.1 The full counter list installed at any point cover a total of 36 counters current or previously in use on the TBH SPA, as shown in Map 2. However, some of these sensors were only installed in 2017 and therefore data for 2016, to be analysed in this report, was provided for only 21 sensors – see Table 1.

Table 1: Summary table of the locations of the 21 sensors for which data were provided. Sorted by SSSI then by ID.

SSSI Name	Sensor ID	Name
Ash to Brookwood Heaths	SAMM001	Bullswater Common - North Corral
	SAMM004	Bullswater Common - South Corral
Bramshill	SAMM027	Heath Warren Wood - St. Neots Road
	SAMM030	Heath Warren Wood - Bramshill Depot
Broadmoor to Bagshot Woods & Heaths	SAMM002	Broadmoor Bottom - Owlsmoor
	SAMM031	Crowthorne - Devils Hwy
Castle Bottom to Yateley and Hawley Commons	SAMM016	Yateley Common - Vigo Lane
Chobham Common	SAMM024	Chobham Common - Clearmount
	SAMM026	Chobham Common - Fishpool
	SAMM034	Chobham Common - Burma Rd
	SAMM036	Chobham Common - Staple Hill
Colony Bog & Bagshot Heath	SAMM011	Lightwater Country Park - Viewpoint
	SAMM012	Brentmoor Heath
	SAMM035	Lightwater Country Park - Leisure Centre
Horsell Common	SAMM003	Horsell Common - Horsell Common Rd
	SAMM032	Horsell Common - Near 6-ways car park
Ockham & Wisley Commons	SAMM033	Ockham Common
Sandhurst to Owlsmoor Bogs & Heaths	SAMM025	Wildmoor Heath - Thibet Rd
Whitmoor Common	SAMM009	Whitmoor - A320 Guildford Rd
	SAMM010	Whitmoor Common - Salt Box Rd side
	SAMM023	Whitmoor Common - Path to St. Mary's Church

Data reformatting

2.2 The raw data provided by the TBHP staff consisted of 160,124 data rows from the 21 sensors (as listed in Table 1). This single dataset from these sensors collated all the individual data files which were downloaded from the sensors on a regular basis (every two to three months). The combined data set from all 21 sensors detailed:

- The sensor unit name,
- Data point id (id column which consecutively counts the number of data rows from each ‘file’ – each file being a separate data download),
- A date-time column;
- The number of events per hour; and
- Any data handling notes.

2.3 Into these raw data were inserted a series of columns used for the data analysis; date, day of month; month-year, and hour. The normal format for the sensors was for each data row to detail the total number of events (an ‘event’ being a recorded pass) for the given hour. Although, for two sensors the data was organised differently, with a row being given for each event (recorded pass). These two sensors were treated differently and the data were processed as follows.

2.4 This main issue required a reformatting of the data, and was restricted to the 1st files for SAMM0016 (1,627 data rows, 01/01/2015-25/01/2016) and SAMM0027 (131 rows, 01/01/2015-15/01/2016). These data were organised as single passes, with a single row for each pass, rather than the standard which detailed the total passes per hour (both were Schmidt units). Unusually each event row was recorded twice with a row of the number of passes as 1, and a subsequent new row with same information and passes always given as 0. For these data rows, the extra 0 count rows were removed, and event data reformatted into hourly total values. This reformatting removed the incorrect data and replaced the rows with 590 and 351 rows for SAMM016 and SAMM027 respectively, resulting a corrected database of 159,307 rows.

2.5 Table 2 shows a summary of the completeness of raw data recording following the initial data reformatting, but not data cleaning.

Table 2: Monthly summary of raw data recording each sensor, values indicate the estimated number of days the sensor was collecting data for. Values in brackets indicate the percentage of hours for which the sensor was recording data out of the total hours in the month.

Sensor ID	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SAMM001	7 (22.6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SAMM002	0 (0)	11.3 (39.1)	31 (100)	30 (100)	31 (99.9)	20.3 (67.5)	19.5 (62.9)	31 (100)	30 (100)	31 (100)	30 (100)	31 (100)
SAMM003	31 (100)	29 (100)	31 (100)	30 (99.9)	31 (100)	30 (100)	30.9 (99.7)	31 (100)	30 (99.9)	31 (100)	30 (100)	31 (100.1)
SAMM004	21.3 (68.5)	29 (100)	31 (100)	30 (100)	30.9 (99.7)	30 (100)	31 (100)	31 (100)	30 (99.9)	31 (100)	30 (100)	13.5 (43.4)
SAMM009	0 (0)	28.6 (98.6)	31 (100)	30 (100)	31 (99.9)	30 (100)	31 (100)	31 (100)	30 (100)	31 (100)	30 (100)	31 (100)
SAMM010	3.3 (10.6)	28.6 (98.7)	31 (100)	30 (100)	31 (99.9)	30 (100)	31 (99.9)	31 (100)	30 (100)	31 (100)	30 (100)	31 (100.1)
SAMM011	0 (0)	20.5 (70.8)	31 (100)	30 (100)	31 (99.9)	30 (100)	31 (100)	31 (100)	30 (100)	31 (100)	30 (100)	31 (100.1)
SAMM012	31 (100)	29 (100.1)	31 (100)	30 (100)	31 (99.9)	30 (100)	31 (99.9)	31 (100)	30 (100)	31 (100)	30 (100)	31 (100.1)
SAMM016	31 (100)	29 (100)	31 (100)	30 (100)	26.9 (86.7)	30 (100)	31 (100)	31 (100)	30 (99.9)	31 (100)	30 (100)	31 (100)
SAMM023	17.4 (56.2)	29 (100)	31 (100)	30 (100)	31 (99.9)	30 (100)	31 (100)	31 (100)	30 (99.9)	31 (100)	30 (100)	31.1 (100.3)
SAMM024	2.3 (7.5)	29 (100)	31 (100)	30 (99.9)	31 (100)	30 (100)	31 (99.9)	31 (100)	30 (100)	31 (100)	30 (100)	31 (100)
SAMM025	12.4 (39.9)	29 (100)	31 (100)	30 (100)	31 (99.9)	30 (100)	31 (99.9)	31 (100)	30 (99.9)	31 (100)	30 (100)	31 (100)
SAMM026	31 (100)	29 (100)	31 (100)	30 (99.9)	31 (100)	30 (100)	31 (100)	31 (100)	30 (99.9)	31 (100)	30 (100)	31 (100)
SAMM027	31 (100)	29 (100)	31 (100)	30 (100)	4.6 (14.8)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SAMM030	31 (100)	29 (100)	31 (100)	30 (100)	31 (99.9)	30 (100)	31 (100)	31 (100)	30 (99.9)	31 (100)	30 (100)	31 (100)
SAMM031	31 (100)	29 (100)	31 (100)	30 (100)	31 (99.9)	30 (100)	31 (99.9)	31 (100)	30 (100)	31 (100)	30 (100)	31 (99.9)
SAMM032	30.8 (99.5)	29 (100)	31 (100)	29.8 (99.3)	31 (100)	30 (100)	30.8 (99.5)	31 (100)	30 (99.9)	31 (100)	30 (100)	31 (99.9)
SAMM033	3.6 (11.6)	29 (100)	31 (100)	30 (100)	31 (99.9)	30 (99.9)	31 (100)	31 (100)	19.7 (65.6)	0 (0)	1.4 (4.7)	31 (100)
SAMM034	30.6 (98.8)	0 (0)	0 (0)	2.3 (7.6)	31 (100)	30 (100)	31 (100)	31 (100)	30 (99.9)	31 (100)	30 (100)	31 (100)
SAMM035	31 (99.9)	29 (100)	31 (100)	30 (100)	31 (100)	30 (100)	31 (99.9)	31 (100)	30 (100)	31 (100)	30 (100)	31 (99.9)
SAMM036	30.8 (99.5)	29 (100)	31 (100)	29.8 (99.4)	31 (100)	30 (100)	31 (100)	31 (100)	30 (99.9)	31 (100)	30 (100)	31 (99.9)

Data cleaning

2.6 Manual cleaning of the data was required to remove data recorded which appears spurious or is completely lacking (e.g. false zeros).

2.7 The first data rows which were excluded were for four sensors;

- SAMM001 (01-19/01/16);
- SAMM004 (01-18/01/16);
- SAMM010 (01/01-01/02/16);
- SAMM024, (01/01-31/01/16);

2.8 These data rows were noted to have appeared to record data in the format of the exact hour minutes of pass, rather than hourly totals (noted from the data, based on variable minutes, seconds value). While we would usually have concluded these were single event rows rather than totals per hour, it was noted that for all data values when this was the case the count was zero. These erroneous values were related to discrete individual files (e.g. single downloads) and usually the first of the dataset, but this was not always the case. As data values were all zeros and potentially false zeros, the data was discarded.

2.9 Other continuous sections of data with zero values were also noted from some sensors. These were all found to relate to an issue in the whole file download, suggesting an issue on the initial set up that meant no data was recorded for the period. As these values were zeros, and clearly not genuine zero values when compared to other data files for the sensor, the data rows were therefore discarded. Discrete download files where all values were zeros were:

- SAMM003 (28/04- 05/07/16
- SAMM010 (01/01-01/02/16);
- SAMM011 (15/05 -11/7/16)
- SAMM024 (01/-31/01/16),
- SAMM025 (19/-31/01/16),
- SAMM032 (01/02-31/03/16),

2.10 Only one section of data with clearly inflated values, e.g. hourly values in the order of 1,000s, was noted. These values related to the sensor SAMM004 between 3/-14/12/16 and occurred because of known water damage to the sensor.

2.11 Furthermore, only one section of clearly low values was recorded, for SAMM033 between 01/01/16 and 13/06/16. During this entire period only three passes were recorded, and these are thought to be related to test passes when downloading data (observer notes state "*not working didn't record anything for a period*")

2.12 The final cleaning step was to eliminate data values for the first and last data rows for each sensor's individual files. These data relate to when the sensor was set up/downloaded. The sensor will have been off for a sometime while data was downloaded and when the sensor was set up again after download a series of test passes would often be conducted. As such these values for at least the hour would be incorrect and to be extra conservative the whole day was therefore excluded.

2.13 The above exclusion principles resulted in the removal of 12,286 data rows. However, to fully remove any possible errors in the data and allow more easily and accurate analysis we eliminated all data from the sensor for the whole day if any hourly values had been eliminated. This step resulted in a total of 14,851 rows excluded (inclusive of the above 12,286 rows), accounting for approximately 9% of data rows from total 159,307.

2.14 The timeline of data available and used for each sensor after cleaning is shown in Figure 1 and an examination of the percentage of data removed for each sensor and by month is shown in Table 3. In August the highest percentage of data across all sensors was removed, 15.4% of data, followed by January, with 13.7% of data.

2.15 For a single sensor, SAMM001, all data recorded were believed to be erroneous and therefore had to be removed. However, the impact of this decision for analysis was fairly limited as the sensor was only recording data for one month (see Table 2).

Data collection issues

2.16 Individual issues noted by staff when data was downloaded were reasonably limited. SAMM033 had a spider and frass stuck in the PIR tube and SAMM023 had a fly stuck inside. While both did not result in any obvious data issues, there were some data spikes recorded, but nothing extremely large and generally fitting with typical daily patterns. This does highlight the issue of the sensors with apertures which can be more prone to winter rain, frost, dirt and insects becoming stuck inside.

2.17 The main issue from data collection is the direct vandalism to the sensors which was recorded quite often. The exact events and types of incidents were not recorded, as this was usually not known. However, the vandalism is explored in more detail for individual sensors in the latter section in reference to the types of sensors used and their location.

2.18 The known data issues were noted during the initial data collection and processing by TBHP staff and relate strongly to the sensors for which there were data issues – see Map 3.

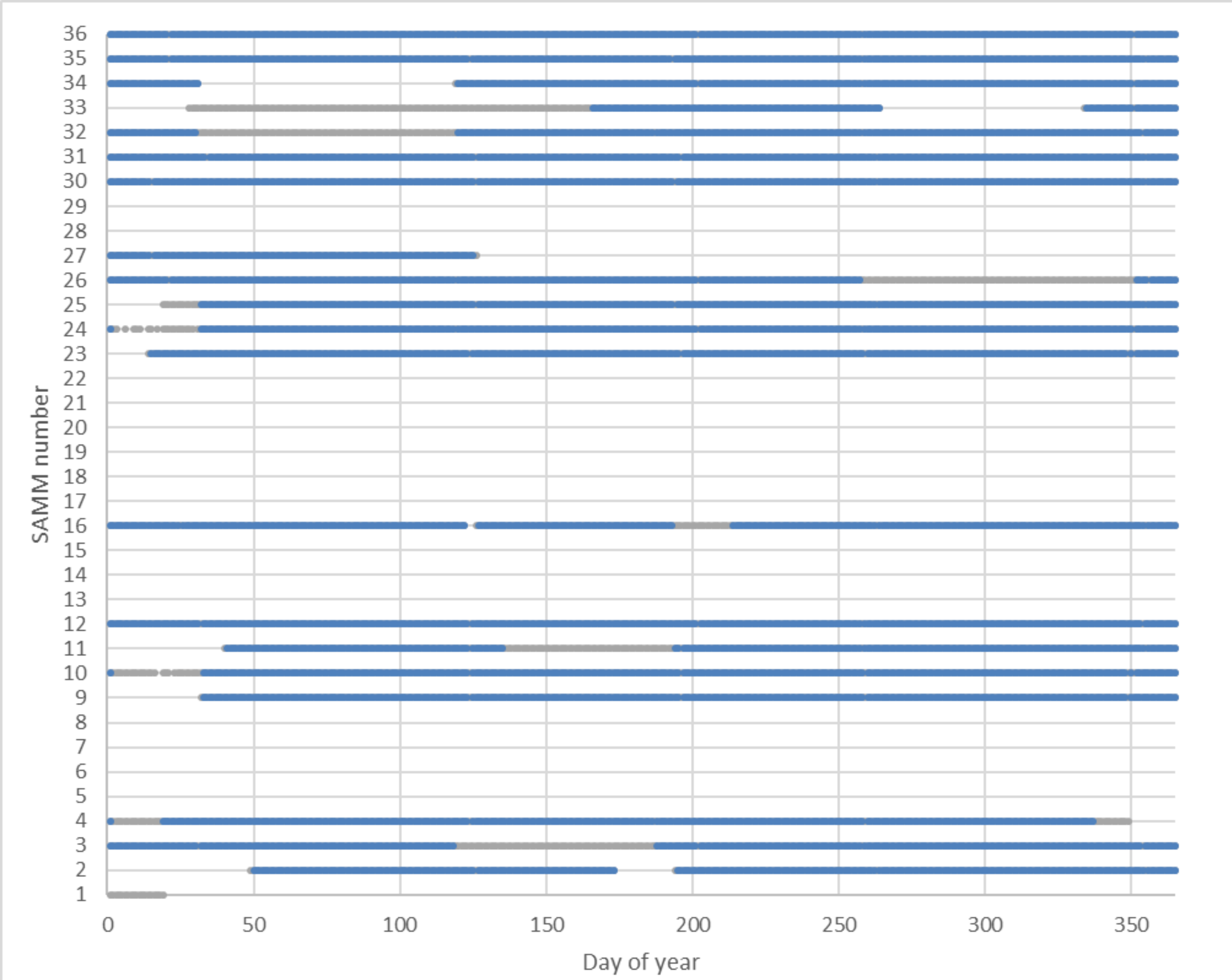
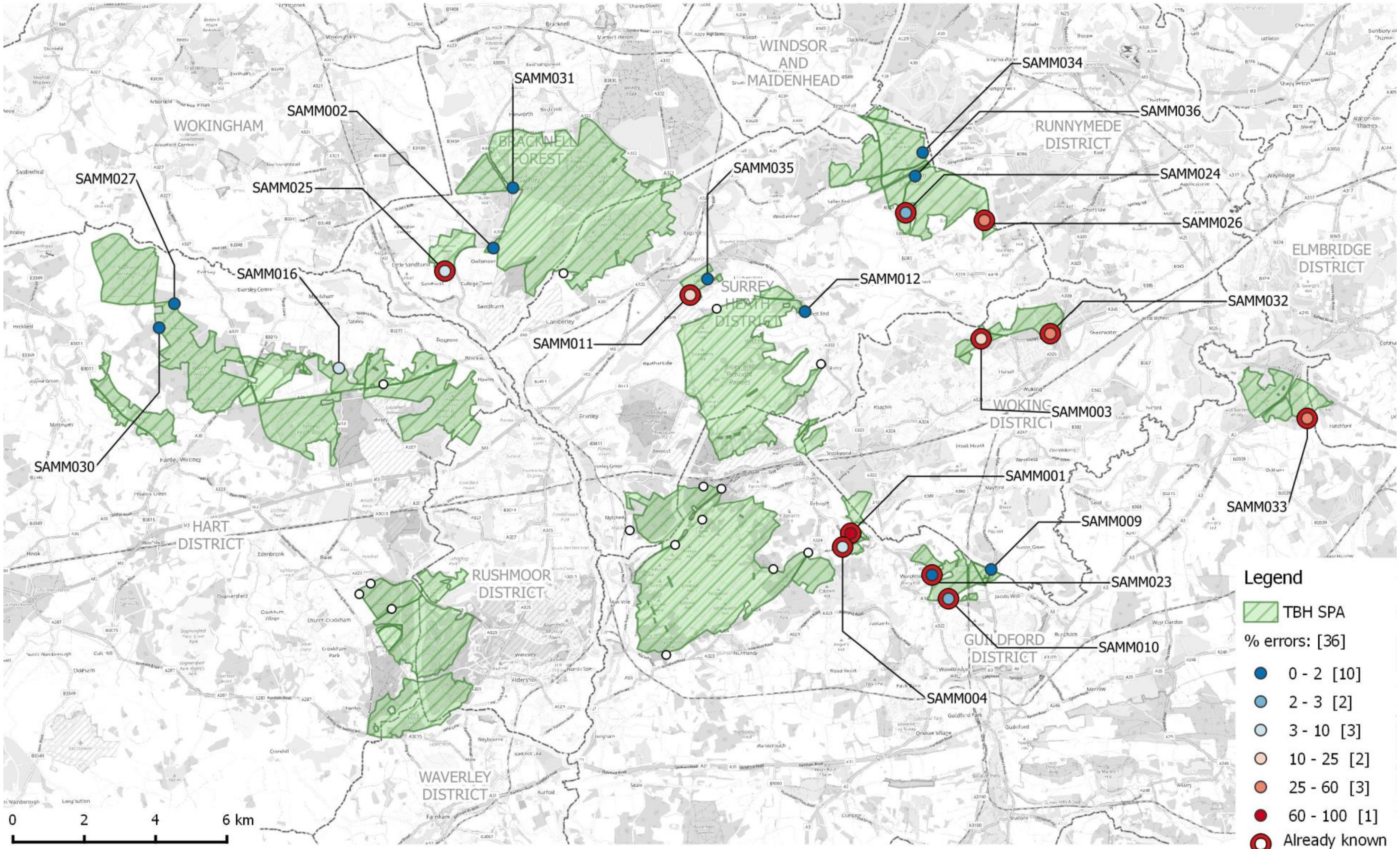


Figure 1 : Timeline of sensor data across the year. Blue markers indicate data recorded and used in analysis for the day. Grey markers indicate days for which data was recorded but discarded.

Table 3: Summary of percentage data rows of excluded during data cleaning.

Sensor ID	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
SAMM001	100	-	-	-	-	-	-	-	-	-	-	-	**100**
SAMM002	-	0	0	6.5	2.9	0	0	3.1	0	2.6	0	3.3	**1.6**
SAMM003	6.5	0	0	6.6	0	0	9.9	100	100	19.1	0	3.2	**20.5**
SAMM004	38.8	0	0	85.1	0	0	0	3	0	3.2	0	3.2	**6.7**
SAMM009	-	0	0	6.5	2	0	0	3.1	0	3.2	0	3.3	**1.7**
SAMM010	100	0	0	9.8	2.2	0	0	3.1	0	3.1	0	3.3	**2.9**
SAMM011	-	0	0	6.6	2.6	0	0	58	100	38.7	0	3.3	**19.5**
SAMM012	3.2	0	0	6.6	3.6	0	0	3.1	0	3.1	0	3.3	**1.9**
SAMM016	6.5	0	0	6.5	0	0	0	1.6	0	64.5	0	3.2	**7.0**
SAMM023	2.4	0	0	9.9	0	0	0	3.1	0	3.2	0	3.2	**1.8**
SAMM024	100	0	0	6.5	0	0	3.2	0	0	3.1	0	3.3	**2.1**
SAMM025	100	0	0	6.5	0	0	0	3.1	0	3.1	0	3.2	**5**
SAMM026	6.5	100	100	58.1	0	0	3.2	0	0	3.2	0	56.6	**27.3**
SAMM027	6.5	-	-	-	0	0	0	12.7	-	-	-	-	**2.1**
SAMM030	6.5	0	0	6.5	0	0	0	3.1	0	3.2	0	3.2	**1.9**
SAMM031	3.2	0	0	6.3	3.4	0	0	3.1	0	3.1	0	3.3	**1.9**
SAMM032	5.9	0	0	6.3	100	100	93.3	0	0	2.7	0	3.2	**25.6**
SAMM033	100	-	29.4	6.5	100	100	100	100	43.3	0	0	0	**52.1**
SAMM034	3.3	0	0	6.5	-	-	12.7	0	0	3.2	0	3.2	**1.9**
SAMM035	6.3	0	0	6.3	0	0	0	3.2	0	3.1	0	3.3	**1.9**
SAMM036	5.9	0	0	3.1	0	0	2.8	0	0	3.2	0	3.2	**1.5**
Total	**13.7**	**5.6**	**5.6**	**11.3**	**11.9**	**10.5**	**11.2**	**15.4**	**13**	**9**	**0**	**6**	**9.3**

Map 3: Percentage of data which were errors for each sensor, and were subsquently removed as part of data cleaning.



Data analysis

2.19 Analyses were conducted involving a simple approach to the data, based on the raw pass values. These values approximate to, but are not directly equivalent to, the number of people. Detailed calibration of individual sensors would be required before these values presented could be converted into the number of people, rather than simply passes. Calibration is necessary as sensors may record people and groups in different ways or pick up on other passes (e.g. dogs), such that an approximation between passes and people is not consistent between sensors. This will also differ between the different types of locations, and types of sensor. Furthermore, the relative number of people entering and leaving will differ with the different traffic flows on sites. It cannot be assumed that the number of passes is double the amount of access (i.e. people passing in both directions, entering and leaving) as in some locations the flow may be predominantly unidirectional.

2.20 For this reason, the relative differences between individual sensors may not always be true and this could not be investigated in detail. However, within an individual sensor the changes over time are considered more reliable and are likely to be directly comparable.

3. Automated visitor counters

Current counter distribution

3.1 The full list of counters on the TBH SPA provides 36 sensors which are given by area in Table 4, and as already shown on Map 2. This includes all sensors for the site, both those for which we have 2016 data for and which were installed after this period.

3.2 The distribution of these sensors is categorised by the number deployed on each of the named SSSI areas which make up the SPA (Table 4). Sites with a high number of sensors are usually those which are larger, but this is not always the case and is often, in part, due to the amount of the site which are accessible to the public. Two of the SSSI shown in Map 1 lack any sensors; Eelmoor Marsh (c. 70 ha) and Hazeley Heath (c. 180 ha). Eelmoor has no public access and Hazeley is a relatively rural and an RSPB reserve. It is predominantly open access as it is common land.

3.3 Table 5 also shows sensors categorised by local authority (i.e. which authority they fall within). Most are located in Surrey Heath and Guildford Districts. No counters are present in Rushmoor which contains roughly half of Bourley & Long Valley and a small part of Castle Bottom to Yateley and Hawley Commons. There are also none in Waverley, which contains small part of Bourley & Long Valley or in Elmbridge which includes a small part of Ockham & Wisley Commons.

Table 4: Summary of the distribution of counters across TBH SPA listed for each SSSI name.

SSSI name	Approx. area (ha)	Number of counters
Ash to Brookwood Heaths	1570	10
Bourley & Long Valley	820	3
Bramshill	670	2
Broadmoor to Bagshot Woods & Heaths	1690	3
Castle Bottom to Yateley and Hawley Commons	920	2
Chobham Common	650	4
Colony Bog & Bagshot Heath	1130	5
Eelmoor Marsh	70	0
Hazeley Heath	180	0
Horsell Common	180	2
Ockham & Wisley Commons	220	1
Sandhurst to Owlsmoor Bogs & Heaths	90	1
Whitmoor Common	170	3
Total		**36**

Table 5: Summary of the distribution of counters across TBH SPA listed by local authority.

Local authority	Number of counters
Bracknell Forest	3
Guildford District	12
Hart District	7
Surrey Heath District	11
Woking District	3
Elmbridge	0
Rushmoor	0
Waverley	0
	36

Types of counters in use

3.4 The types of counters used have covered four different sensor types from three different companies. The four different types of sensors and their deployment across the years are summarised in Table 6Table 1. Chamber's RadioBeam units make up the current highest proportion of sensors used. Initially Passive Infra Red units were most commonly used, but there was a shift towards using the RadioBeam technology (produced by Chambers). The types of sensors used in 2016, and therefore of relevance to the data examined in this report are shown in Map 4.

3.5 The different types of units and their features are discussed below:

1. Schmidt Pressure Pad:
    - Works best on narrow paths or at gateways (standard pad sizes are 50 x 100 cm - options for wider paths can be available but often at greater costs)
    - USB data logger
    - Requires initial path works and has potential implications for future path disturbance
    - Ongoing path erosion/compaction or resurfacing issues can alter data
    - Buried sensor and loggers means no visible equipment to be vandalised.

2. Schmidt Passive Intra Red Counter:
    - No path disturbance or implications for future path erosion/compaction or resurfacing issues
    - Visible aperture – can attract vandalism, as a result of "being spied upon"
    - Some debate as to whether these can be affected by temperate or sunlight
    - 4 meter detection range – suitable for most paths, but can have limited range on wide paths/gateways
    - USB data logger

3. Linetop: Passive Intra Red Counter:

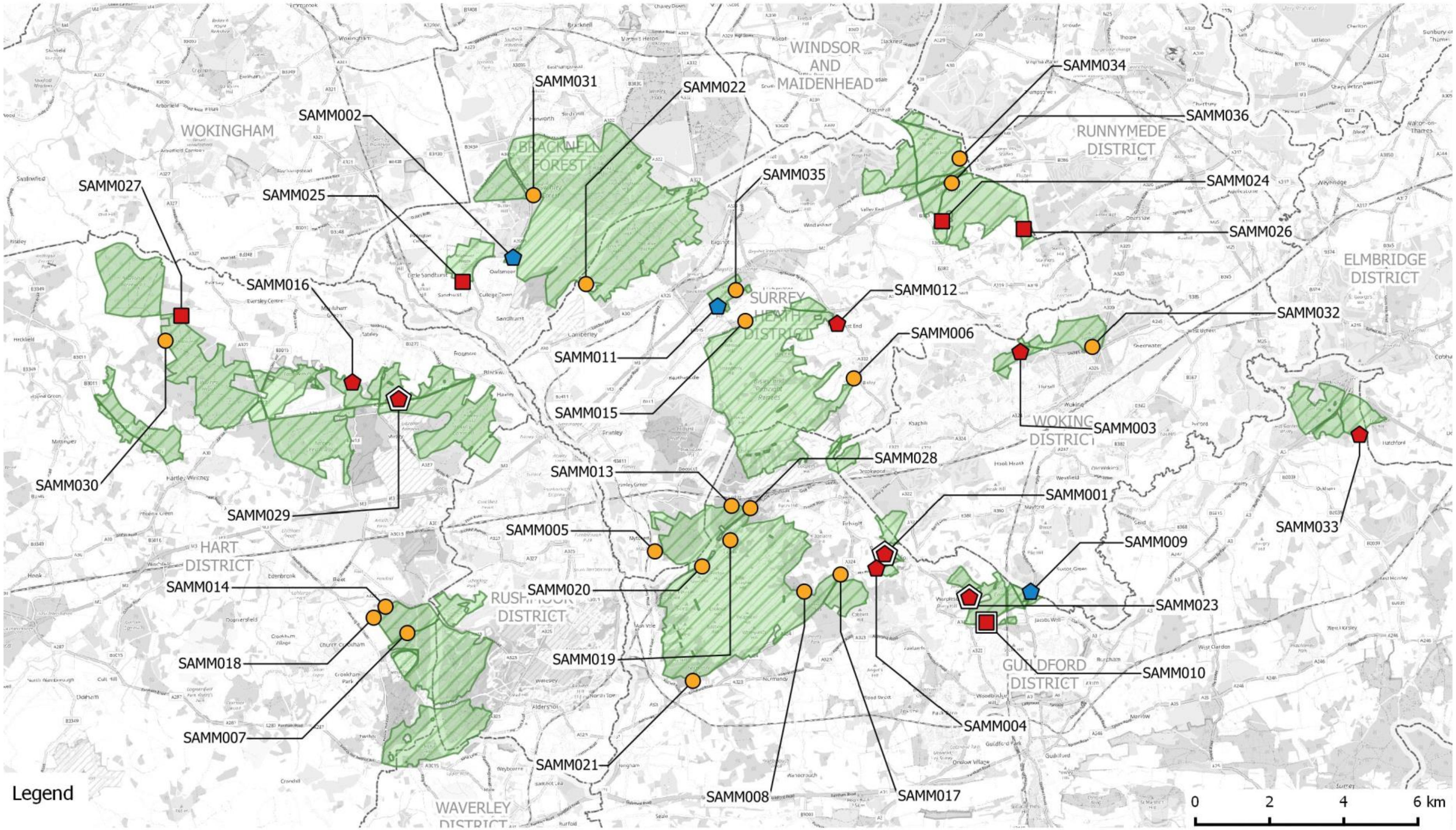
- No path disturbance or implications for future path erosion/compaction or resurfacing issues
- Visible aperture – can attract vandalism, as a result of “being spied upon”
- Some debate as to whether these can be affected by temperate or sunlight
- Some short range (e.g. 2 m), some longer range (up to 4m) – still can have limited range on wide paths/gateways.
- ‘Cube’ data loggers (require ‘cube’ memory readers)

4. Chambers RadioBeam units:
   - There is no external cables, indicators or aperture in housing or posts
   - Potentially more reliable in bad weather conditions or temperate changes
   - Narrow beam gives good discrimination. Some wide angle beams (as can be with some PIRs) may record multiple hits for a single pass (depending on distance from sensor).
   - RadioBeam system requires two units (transmitter and receiver) to be installed as posts, and therefore can be hard to find suitable locations.
   - Some counters can be set to exclude cars and directional movements (resolving entering/leaving issues in count data)

Table 6: Total number of sensors installed across the years. The four re-instalments are replacements of PIR/Pressure pad sensors with RadioBeam units.

Year of first installation	PIR	Pressure pad	RadioBeam	Total
2014	1	2	1	4
2015	10	3	5	18
2017			14	14
2017 (reinstalls of 2015)			4	4
Total	**11**	**5**	**20**	**40**

Map 4: Types of sensor deployed in 2016.



Legend

TBH SPA | PIR (Linetop) | PIR (Schmidt) | PIR (Schmidt) - later replaced | Pressure pad (Schmidt) | Pressure pad (Schmidt) - later replaced | Radiobeam (Chambers)

Advantages and disadvantages of types of sensors

3.6 All the types of sensors used have some advantages and disadvantages, alluded to in discussion on the types of sensors. Most issues are universal, but there are differences between sensors. The key points are the effect the issues have on staff time, financial costs and data quality. Financial costs will arise from replacement of faulty or broken parts and the main way this will occur is from vandalism. The vandalism and effects on data quality are the focus of the discussion and summarised by types of sensor in Table 7.

3.7 Vandalism is one of the key factors affecting data quality and therefore the covert nature of the sensors is an important point to note. The more obvious a sensor is to the public, we would assume the more likely the sensor is to be vandalised. Sensors with an aperture (e.g. PIR) can attract vandalism or non-malicious tampering (e.g. waving, walking back and forth). In other areas (outside the TBH), we are aware of incidents where certain PIR regularly had their aperture smeared with mud. Sensors which appear as nothing more than posts may be more discrete, but can of course, still be vandalised (just one incident of vandalism for this type has been recorded in TBH). Buried pressure pads, with the recording box also buried, are arguably the most unobtrusive and undetectable. Map 5 shows the location of sensors which have been vandalised.

3.8 Data quality is also affected by weather conditions and how prone sensors are to the issues of water/frost damage or water logging. This will be influenced by the individual sensors local environment and citing, which may mean it is more prone to wet/frost than an identical sensor in another location. Also, the time on site will be a factor, some sensors have been in site for a few years and may have already started to deteriorate.

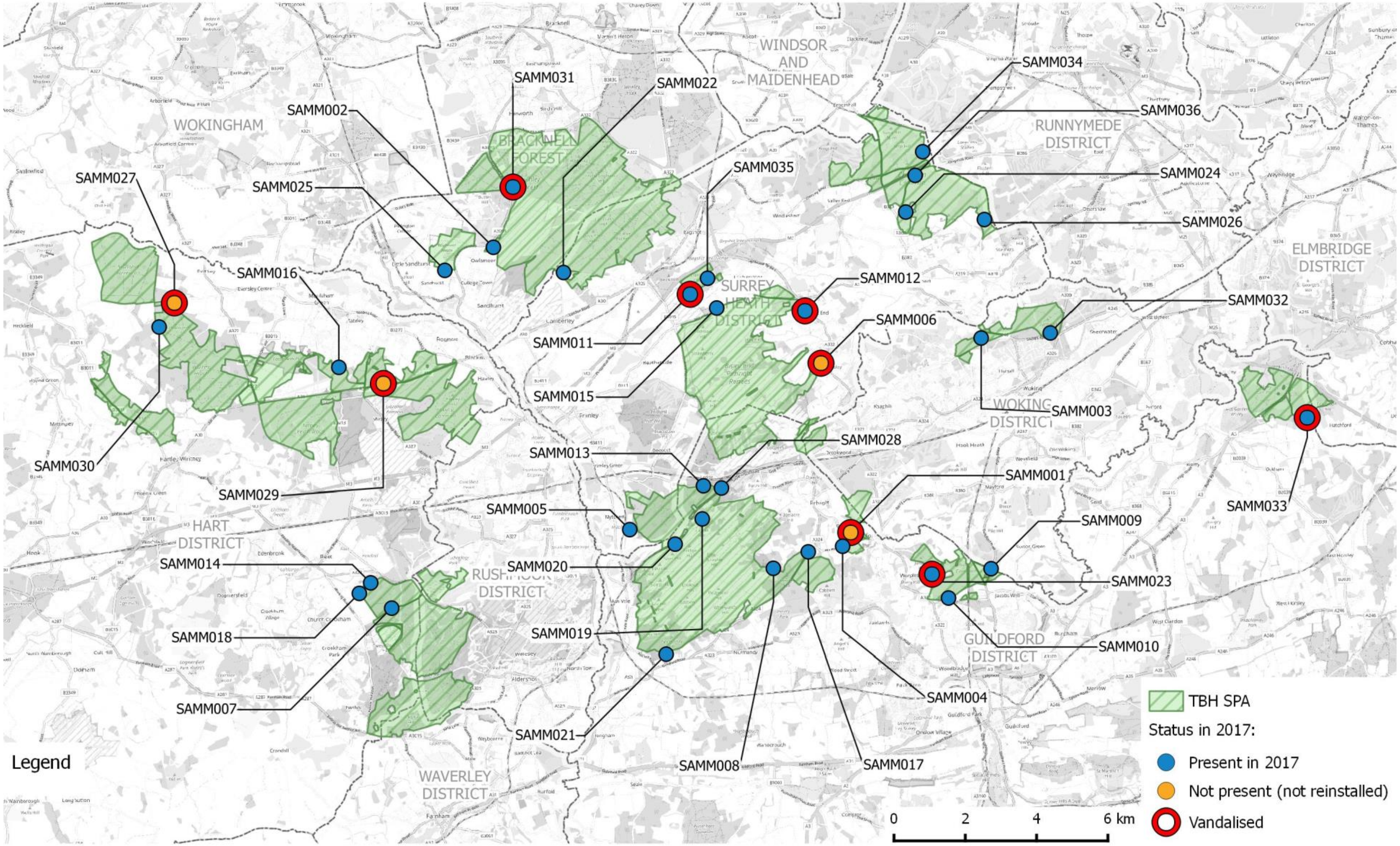
3.9 Finally, regardless of the types of sensors, all can have the limitation of people avoiding the sensors, depending on the placement. For example new desire lines or short-cuts can form which mean people change their routes and bypass the sensor over time.

3.10 The quality of data from the different types of sensor is shown in Table 7. This shows the data from all 36 'deployments', as multiple types of sensor could be used at a single location as part of replacements (usually the result of vandalism). From this table it would appear pressure pads have had particular issues with data, possibly due to ground issues such as compaction and waterlogging. The PIR sensors, as expected, are the most vulnerable to being vandalised and can also have some data quality issues. From Table 7 it would appear that the RadioBeam units collect the best data, however most units of this type had only been on site for less than year and therefore could be less likely to have data issues or be vandalised.

Table 7: Summary of the quality of data and vandalism recorded from the different types of sensor.

Sensor type	Number of sensors (all years)	% of sensors vandalised (all years)	% of sensors with data issues (all years)	Number of sensors (only sensors recording data in 2016)	Average of % of errors in each unit for 2016 data
PIR	11	50.4	54.5	11	21.3
Pressure pad	5	20	80	5	7.6
RadioBeam	20	10	5	6	5.8
Total	**36**	**25**	**30.5**	**22**	**13.6**

Map 5: The present status of sensors on sites (in 2017) and the distribution of vandalism to sensors.



4. Results of counter data

4.1 After data cleaning, the 2016 dataset consisted of 20 sensors which collected 14,456 data rows, i.e. hours of data. For a single sensor, SAMM001 which had only recorded data for January, all data was discarded. The number of data rows for individual sensors in this cleaned data set ranged from 2,640 (SAMM027, equivalent to c. 110 days) to 8,640 (SAMM036, equivalent to c. 360 days), although most sensors collected a reasonable amount of data, with a mean value of 7,179 hours per sensor (equivalent to c. 299 days).

4.2 One of the key considerations for the results of the data examined is the coverage across the year. The results examined in this report will be influenced by the coverage across the year and therefore the omission of certain time periods could potentially skew data. For example, considering sensors which are missing data more in a particular season will result in different patterns of use over the 24hr period, due to differences in day length.

4.3 The average number of passes per hour is shown for months of the year by individual sensors in Table 8. The cell values in Table 8 have been coloured to easily show the peaks and lows across individual sensors over time, and also the data gaps. SAMM027 has the largest data gap across the year, with seven months missing data. Although data used covers January to May, which still provides reasonable seasonal coverage.

4.4 Table 8 and Figure 2 show an overall peak during the summer, as might be expected. Some sensors (such as SAMM035, SAMM036 and to an extent SAMM004) do however show peaks in the winter months.

4.5 It should be noted that the red to green cell colouring in the table shows the ranking of cells, yet the actual scale of difference between cells can be very different. The degree of variation between monthly values is shown in the ratios and standard deviation values presented in Table 8. The largest of these was observed for SAMM016 (standard deviation on values 5.9) where lowest winter month values (1.5 passes per hour in February) were almost one fifteenth that of the summer peak (23.2, July). This value of 23.2 passes per hour as a mean for the month was also the largest value recorded across all sensors and months in the data recorded.

Table 8: Average number of passes per hour in each month for the individual sensors, with cells coloured red to green for low to high values for each sensor. The final columns express the ratio of the minimum monthly value divided by the maximum monthly value and the Standard Deviation of monthly values.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual Mean	Ratio of Min/ Max	SD
SAMM002	-	1.8	1.8	1.9	2	2.1	2.1	2.2	1.7	1.8	1.7	1.9	1.9	0.77	0.2
SAMM003	1.1	1.5	1.4	1.3	-	-	1.7	1.7	1.5	1.4	1	1.2	1.4	0.59	0.2
SAMM004	0.3	0.4	0.3	0.4	0.5	0.4	0.2	0.2	0.4	0.5	0.9	0.8	0.4	0.22	0.2
SAMM009	-	0.2	0.2	0.2	0.3	0.4	0.4	0.4	0.2	0.8	0.5	0.3	0.4	0.25	0.2
SAMM010	-	0.1	0.1	0.4	0.9	1.2	1.5	1.8	1.5	0.5	0.2	0.8	0.8	0.06	0.6
SAMM011	-	5.9	5.6	5.8	8.4	-	5.7	5.4	5.3	5.4	4.1	5.1	5.5	0.49	1.1
SAMM012	0.1	0.2	0	0	0.2	0.1	0.6	1.5	1.5	1.5	1.2	1.7	0.7	0.00	0.7
SAMM016	6.5	1.5	1.6	5.5	2.6	7.4	23.2	9.3	2.8	2.8	6.2	8	5.5	0.06	5.9
SAMM023	1.2	1	1.2	1.1	3	4.5	2.3	2.3	1.9	1.4	0	1.4	1.8	0.00	1.2
SAMM024	-	0.1	0.1	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.2	0.33	0.1
SAMM025	-	0	0	0.1	0.3	0.4	0.6	0.9	0.7	0.2	0	0	0.3	0.00	0.3
SAMM026	0.2	0.3	0.4	0.6	0.6	0.6	0.6	0.5	0.4	-	-	0.3	0.5	0.33	0.2
SAMM027	0.9	0.3	0.3	0.3	0.1	-	-	-	-	-	-	-	0.3	0.20	0.1
SAMM030	1.7	2.4	1.9	1.7	2.6	2	2.1	2.1	2.3	2	1.6	1.9	2	0.62	0.3
SAMM031	1.3	1.6	1.1	1.3	1.3	1.3	1.3	1.5	1.1	1.2	1	1.1	1.3	0.63	0.2
SAMM032	13.7	-	-	21.6	18.3	15.8	16	20.3	19.8	17.4	14.5	18.5	17.2	0.63	2.6
SAMM033	-	-	-	-	-	0.1	1.1	0.5	0.1	-	0.3	0.2	0.5	0.09	0.4
SAMM034	0.3	-	-	1.3	0.8	1.7	1	0.9	0.9	1	0.7	0.7	0.9	0.18	0.4
SAMM035	8.9	8.4	5.3	5.2	4.8	4.2	4.7	4.8	4.6	5	5.4	5.5	5.6	0.47	1.5
SAMM036	1.3	1.1	1.9	1.8	2	1.1	1.4	1.7	1.6	1.8	1.4	2.2	1.6	0.50	0.4
Total	2.7	1.5	1.4	1.7	2.6	2.6	2.7	3.1	2.6	2.6	2.4	2.7			
Mean	2.8	1.6	1.4	2.7	2.7	2.6	3.5	3.1	2.6	2.6	2.3	2.7			

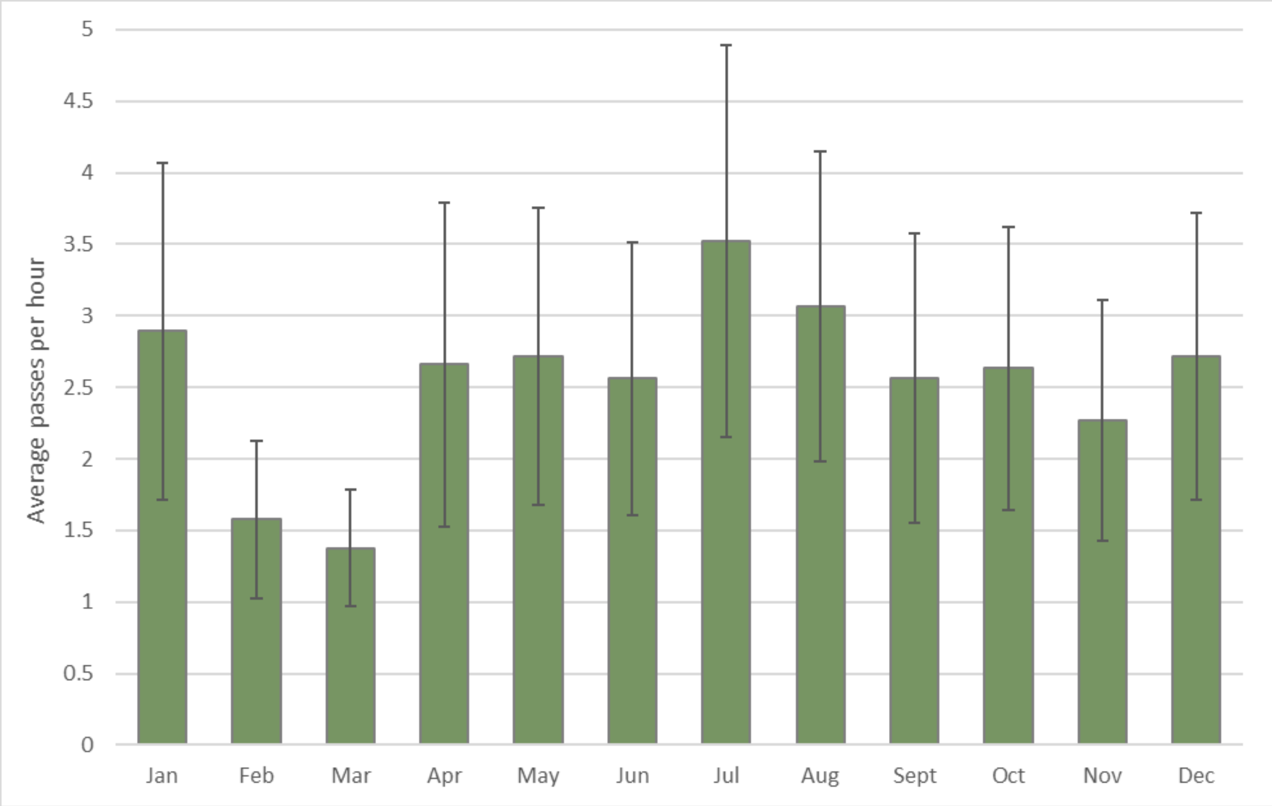


Figure 2: Mean passes per hour across all sensors. Error bars indicate the standard error values from the monthly averages for each sensor.

4.6 The hourly values were also examined, as shown in Table 9, which presents the hourly values for each sensor as a percentage of the total recorded across the day, thus allowing comparison between sensors. The red to green colouring shows the low to high values across the day and illustrates the single peak or twin peak distributions of busyness across the day for different locations.

4.7 The twin peak distributions are most clearly visible at SAMM010 and 025, but other sensors also show this pattern to varying degrees. A clear single peak appears at SAMM034, which also shows the single largest peak, with 23% of passes recorded between 15:00-16:00.

4.8 Within these values there will also be variation across types of day and more clearly across seasons, with the spread of values likely to be more truncated during reduced daylight hours. It was not surprising to see that very early morning values e.g. 7/8 am, with people walking before normal working hours. However, this pattern may have been lost within the whole dataset with different seasons and also different trends on weekend and weekdays.

Table 9: Hourly percentage of passes recorded for the different sensors, with cells coloured red to green for low to high values. Percentage calculation based on all recorded passes during the 24 hrs, but only values between 07:00 and 21:00 shown. Based on all data across the year, which may be variable for the different sensors.

	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
SAMM002	3	6	7	7	7	10	8	7	9	8	9	7	4	4	2
SAMM003	0	1	2	5	13	16	12	10	8	8	8	6	5	4	2
SAMM004	1	3	6	7	8	8	9	15	12	7	6	7	5	2	0
SAMM009	1	2	3	7	8	10	8	11	17	11	10	6	4	2	1
SAMM010	3	3	8	7	6	6	6	6	7	8	9	9	9	8	4
SAMM011	1	4	8	10	11	10	8	8	9	10	8	6	4	2	1
SAMM012	0	1	3	8	9	9	9	7	8	8	10	9	8	7	2
SAMM016	1	2	3	4	5	9	15	10	8	7	6	5	4	2	2
SAMM023	1	2	5	7	10	10	10	7	7	9	11	5	4	4	9
SAMM024	0	3	4	8	11	13	9	7	7	9	7	7	5	3	3
SAMM025	2	4	5	8	8	6	6	4	5	6	9	9	12	10	4
SAMM026	0	1	2	4	9	9	8	10	9	11	13	10	6	5	2
SAMM027	1	3	6	7	10	8	9	9	10	10	8	6	3	2	1
SAMM030	0	1	3	7	10	14	15	13	7	7	7	6	4	2	2
SAMM031	1	2	3	6	9	12	13	9	7	6	8	6	7	5	4
SAMM032	0	1	3	6	9	10	10	9	9	10	10	8	5	4	3
SAMM033	0	0	1	1	2	4	9	11	15	21	3	0	5	7	0
SAMM034	0	1	2	3	6	6	8	11	23	12	6	5	4	4	3
SAMM035	0	1	4	9	10	12	10	10	8	8	9	7	5	3	2
SAMM036	0	0	1	2	6	10	13	12	13	13	11	8	4	2	2

4.9 Table 10 is therefore presented which shows the differences in hourly values between the Sensitive and Non Sensitive periods. With increased day length in the Spring and Summer most sensors show the wider range of hours of visiting in the Sensitive Period. This is often more noticeable in the evenings for example at sensors; SAMM010 023, 031 and 033.

4.10 On average, approximately 6.6% of passes were recorded before 9 am and 8.0% after 7 pm during the Non-Sensitive period. In comparison, this increased to 10.0% before 9 am and 17.0% after 7 pm in the Sensitive period; therefore, just over one quarter of passes were outside of the period 9:00-19:00 during the Sensitive period.

Table 10: Hourly percentage of passes recorded for the different sensors, with cells coloured red to green for low to high values. For each sensor the values during the Sensitive period (1st Mar to 15th Sept) and Non-Sensitive period are shown as separate rows. Each row has a column for the percentage completeness of the data used, which has to be considering when examining the patterns shown.

Sensor	Non-Sensitive /Sensitive	Hour															Approximate percentage of period with data
		7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
SAMM002	NS	2	5	6	7	9	13	8	10	10	10	11	6	1	1	0	69
	S	4	7	7	6	6	7	7	6	8	7	8	8	6	6	3	89
SAMM003	NS	0	1	1	4	10	17	16	12	9	9	9	6	5	1	0	98
	S	0	1	2	7	16	15	9	7	7	6	7	7	5	6	4	65
SAMM004	NS	0	1	3	7	6	8	11	18	14	8	5	6	5	2	0	72
	S	1	4	8	8	9	7	6	11	11	7	7	8	5	2	1	99
SAMM009	NS	1	2	2	4	5	8	7	15	26	14	11	4	1	1	0	80
	S	1	2	3	10	11	13	9	7	8	8	8	7	5	3	1	99
SAMM010	NS	2	2	6	7	8	8	8	7	9	11	11	9	6	5	1	79
	S	3	3	9	6	5	5	5	5	7	7	8	9	9	9	5	99
SAMM011	NS	0	2	7	10	12	11	10	9	10	11	9	5	2	1	0	75
	S	2	5	9	10	10	8	7	7	8	9	8	7	5	3	2	70
SAMM012	NS	0	0	2	7	10	10	9	7	9	9	10	10	8	7	1	98
	S	0	1	5	10	9	7	9	6	5	8	9	7	7	7	5	99
SAMM016	NS	1	1	2	4	4	8	21	9	8	6	5	6	4	1	1	97
	S	1	2	3	5	5	10	12	10	8	8	6	4	5	3	2	88
SAMM023	NS	0	1	5	9	11	13	11	9	11	12	8	6	3	1	0	90
	S	1	2	4	6	9	8	9	6	6	9	12	5	5	4	12	99
SAMM024	NS	0	2	5	10	9	13	11	8	7	10	12	5	4	0	2	80
	S	0	3	3	8	12	13	9	7	8	8	6	8	5	4	3	99
SAMM025	NS	1	3	5	8	8	6	5	6	6	5	12	9	13	12	2	80
	S	3	4	6	8	7	7	6	4	5	6	8	8	12	10	4	99
SAMM026	NS	0	0	0	3	14	10	10	15	10	15	12	9	1	1	0	43
	S	0	1	2	4	8	9	8	9	9	10	13	10	7	6	2	98
SAMM027	NS	2	2	7	6	10	7	9	9	8	9	8	5	2	2	2	35
	S	0	5	4	7	10	9	9	9	13	11	8	7	4	2	0	33
SAMM030	NS	0	1	2	5	9	13	17	18	8	8	7	6	3	1	1	97
	S	0	2	3	8	10	14	15	9	6	7	6	6	5	4	2	99
SAMM031	NS	0	1	2	5	9	14	14	12	9	7	9	7	3	2	2	97
	S	2	2	4	6	9	11	12	7	5	5	7	6	10	8	6	99
SAMM032	NS	0	1	3	5	9	11	11	10	11	11	12	10	4	1	0	80
	S	0	2	4	6	10	10	9	8	8	8	8	7	6	6	4	70
SAMM033	NS	0	2	3	8	7	22	20	6	8	11	13	0	0	0	0	21

Sensor	Non-Sensitive /Sensitive	Hour															Approximate percentage of period with data
		7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
	S	1	0	0	0	1	2	8	11	16	22	2	1	6	8	0	47
SAMM034	NS	0	1	2	4	2	5	7	13	24	20	8	6	3	3	1	81
	S	0	2	2	3	8	6	8	10	22	8	6	4	4	4	4	70
SAMM035	NS	0	1	2	7	10	13	12	13	9	9	10	8	3	1	1	98
	S	1	2	6	11	10	11	8	7	7	7	8	6	6	5	3	99
SAMM036	NS	0	0	0	2	6	9	14	14	14	15	13	7	3	1	0	98
	S	0	1	1	3	6	10	12	11	12	11	10	8	5	4	3	99

4.11 Variation across the days of the week was strongly biased by towards weekends, particularly Sundays, across most sensors. This is illustrated in Table 11 which shows the average number of daily passes recorded on each day of the week for individual sensors. This data shows the distribution of passes across the week was 38% on average at weekends and 23% on Sundays. However, use could be as high as 57% on weekends and 49% on Sundays (at SAMM033). Although, at approximately four sensor locations the peak values were recorded on a weekday (SAMM004, 016, 023, 034). This daily information is shown graphically as proportions for each day in Map 6.

Table 11: The average number of passes for each day of the week. The percentage of all passes which occur of weekends and Sundays is also shown.

	Mon	Tues	Weds	Thurs	Fri	Sat	Sun	% of passes on weekends	% passes on Sundays
SAMM002	180.0	185.7	174.2	176.6	176	191.8	226.1	32	17
SAMM003	117.8	92.9	105.9	107.2	109.2	181.0	228.8	43	24
SAMM004	36.0	34.9	66.6	39.0	37.0	40.1	36.9	27	13
SAMM009	30.2	25.3	46.1	25.4	32.5	39.4	46.1	35	19
SAMM010	72.6	74.0	69.1	70.2	74.9	87.9	112.0	36	20
SAMM011	473.6	426.3	439.4	432.5	441.8	651.6	850.0	40	23
SAMM012	61.8	64.9	64.2	71.1	65.7	71.4	94.1	34	19
SAMM016	399.4	710.3	500.3	553.0	661.4	531.5	435.5	26	11

SAMM023	161.9	279.0	136.6	151.0	135.6	155.9	220.8	30	18
SAMM024	14.0	11.8	16.5	14.1	16.1	24.5	27.0	42	22
SAMM025	27.5	35.1	29.5	25.2	26.2	30.1	42.0	33	19
SAMM026	43.1	42.7	38.7	36.6	33.0	54.5	69.6	39	22
SAMM027	32.8	31.5	31.5	37.8	26.7	45.6	66.7	41	24
SAMM030	177.0	137.8	146.4	156.0	175.2	248.7	354.3	43	25
SAMM031	73.4	69.2	115.8	93.2	84.1	175.2	250	49	29
SAMM032	1558.9	1428.3	1441.2	1656.7	1484.7	1957	2295.9	36	19
SAMM033	12.3	19.4	55.5	47.6	8.6	26.2	161.1	57	49
SAMM034	98.2	88.4	96.2	107.6	68.1	64.3	93.5	26	15
SAMM035	487.7	546.1	485.2	502.9	442.9	515.3	827.6	35	22
SAMM036	120.8	95.3	80.5	101.8	94.1	194.2	409.3	55	37

Map 6: Proportion of passes recorded on different days of the week.

4.12 Variation across the year (see Table 8 and Figure 2) was most in interesting for its relevance to the Sensitive Period from 1st March to 15th September, during which the three SPA bird species are nesting. The data was therefore split the Sensitive and Non-Sensitive Periods (Table 12).

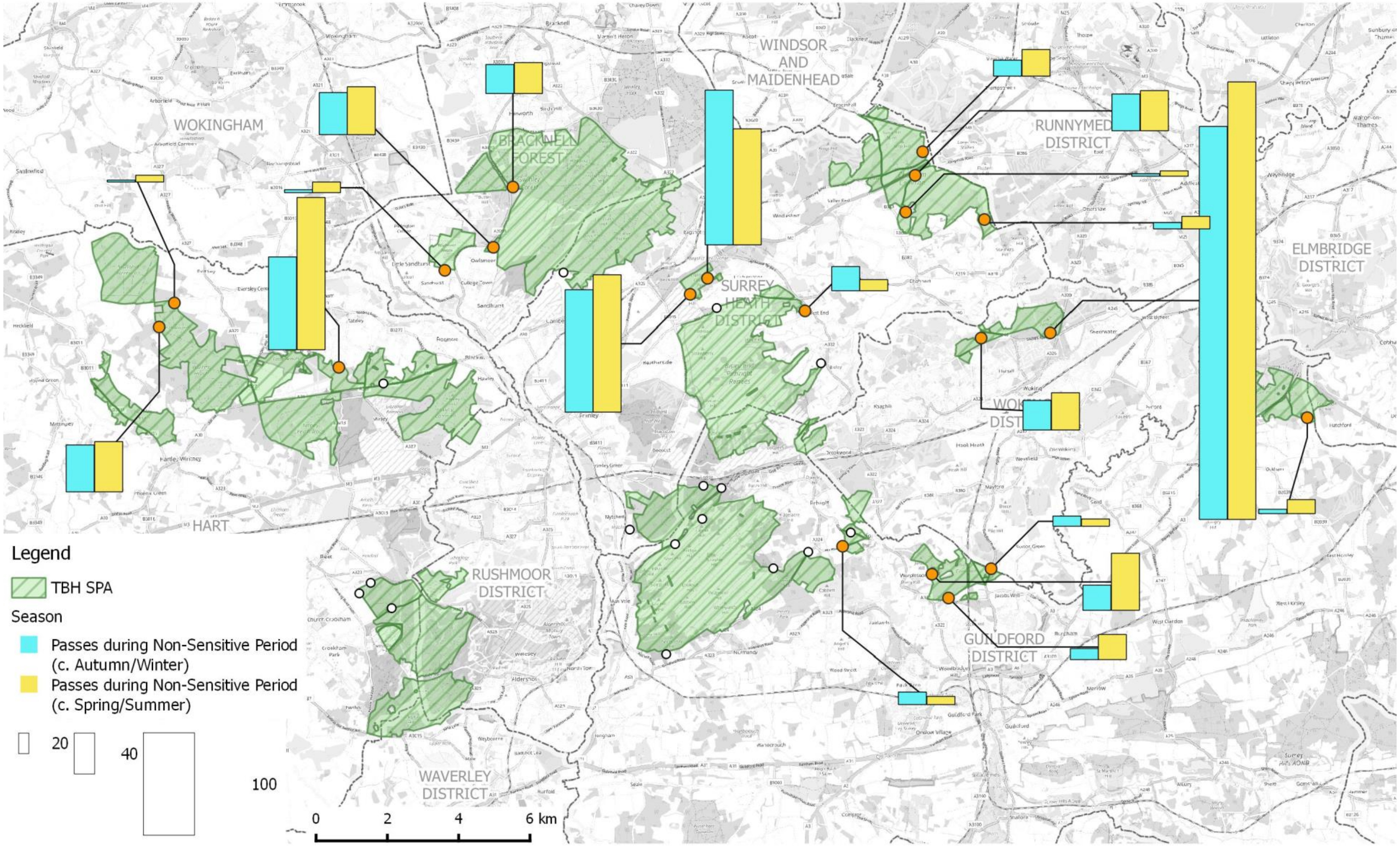
4.13 Overall it was considered that the typical passes per day was roughly equal between the Non-Sensitive Period (c. autumn/ winter) and Sensitive Period (c. spring/ summer). This would be surprising considering the summer peaks from the data discussed so far, with July/ August being the peak month (see Table 8). However, March and April were the lowest months and included in the Sensitive Period. Furthermore, the use of the sites in December and January (the Non-Sensitive Period) was relatively high.

4.14 The differences between the Sensitive and Non-Sensitive Periods are examined for each sensor and also presented in Map 7. At four locations, highlighted in Table 12, the mean number of passes per day in the Sensitive Period was greater than in the Non-Sensitive Period, these were; SAMM004, SAMM009, SAMM012, SAMM035.

Table 12: The average number of passes per day recorded for each sensor across the whole year and during the Sensitive period (1st Mar to 15th Sept) and Non-Sensitive periods. The final columns give the proportion of Non-Sensitive to Sensitive (col c/ sum(col c + col d) : col d/ sum(col c + col d)) and the ratio of Non-Sensitive passes to Sensitive (col b/d) - values greater than 1 (in bold) indicate greater use in the non-sensitive (winter/autumn) period.

Sensor	Location Name	Mean number passes per days			Proportion of Non-Sensitive to Sensitive Period	Ratio of Non-Sensitive
		Non-Sensitive Period (c. autumn/ winter)	Sensitive Period (c. spring/ summer)	Whole Year		
SAMM002	Broadmoor Bottom - Owlsmoor	41.3	47.1	44.8	47:53	0.9
SAMM003	Horsell Common - Horsell Common Rd	29	36.5	32.3	44:56	0.9
SAMM004	Bullswater Common - South Corral	12.7	8.3	10	**60:40**	**1.3**
SAMM009	Whitmoor - A320 Guildford Rd	10	7.3	8.4	**58:42**	**1.2**
SAMM010	Whitmoor Common - Salt Box Rd side	11.1	24.7	19.2	31:69	0.6
SAMM011	Lightwater Country Park - Viewpoint	119.5	134.2	127.2	47:53	0.9
SAMM012	Brentmoor Heath	23.8	11.2	16.9	**68:32**	**1.4**
SAMM016	Yateley Common - Vigo Lane	90.8	149	121	38:62	0.8
SAMM023	Whitmoor Common - Path to St. Mary's Church	24.7	56.2	42.5	31:69	0.6
SAMM024	Chobham Common - Clearmount	2.5	5.4	4.2	32:68	0.6
SAMM025	Wildmoor Heath - Thibet Rd	2.9	10.4	7.4	22:78	0.4
SAMM026	Chobham Common - Fishpool	6.2	12.7	11	33:67	0.6
SAMM027	Heath Warren Wood - St. Neots Road	2	6.7	2.8	23:77	0.7
SAMM030	Heath Warren Wood - Bramshill Depot	46.1	49.5	48	48:52	1.0
SAMM031	Crowthorne - Devils Hwy	28.4	30.6	29.6	48:52	1.0
SAMM032	Horsell Common - Near 6-ways car park	383.8	427.5	406	47:53	0.9
SAMM033	Ockham Common	4.4	13.9	11.3	24:76	0.4
SAMM034	Chobham Common - Burma Rd	15.7	26.3	21.1	37:63	0.7
SAMM035	Lightwater Country Park - Leisure Centre	151.3	113.5	130.6	**57:43**	**1.2**
SAMM036	Chobham Common - Staple Hill	36.1	39.3	37.8	48:52	1.0
Total		**57**	**57.1**	**57**	**50:50**	**1.0**

Map 7: Comparison of passes recorded during Sensitive Period (c. Spring/Summer) to Non- Sensitive Period (c. Autumn/Winter)



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5. Conclusion and Discussion

5.1 The results provide a fascinating overview of the access at the sensor locations, and over time it will be possible to look for changes across years. As such the counter network forms an important component in the long-term monitoring of access on the Thames Basin Heaths. The counter network is one component of the monitoring data, alongside the car-park counts (which provide an overview of use (by car-borne visitors) across the whole SPA; visitor interviews and other data collected by the partnership.

5.2 The counter data relate to very specific locations, i.e. single gateways or tracks. Looking across the locations, the sensor with highest level of daily passes (by some margin) was one at Horsell Common (SAMM032), around 50m down the track from the main car-park. This is a popular car-park and a busy part of the SPA. The counter is well placed to pick people up that are moving from and back to the car-park along the main track.

5.3 Other busy locations, in terms of daily passes, included Lightwater Country Park (SAMM011 and SAMM035). It is interesting here that the two counter locations (at opposite ends of the relatively small site) produced relatively similar numbers of daily passes. One counter is near the main car-park (on the SPA just to the west of the car-park) while the other is at the western end of the site at High Curley.

5.4 The variations between locations were marked and the numbers of daily passes at some locations appear low, in particular at Warren Heath (SAMM026, sensor on a track near the roadside parking in the north-east corner) and Chobham Common (SAMM024, at the south end of the site, near Clearmount). Both these counters were relatively close to other counters which recorded much higher levels of daily passes, indicating the local variation in use within sites.

5.5 Across all locations, results indicate the use is greatest around midday (e.g. SAMM016, Yateley Common), but that certain locations exhibit twin peak patterns with greater use late morning and again in late afternoon (e.g. SAMM025, Sandhurst to Owlsmoor Bogs & Heaths). Use was also typically greater at weekends, but this is location specific and a few sensors recorded higher values on weekdays.

5.6 While it would be expected that use is much greater in the Sensitive Period (March to mid-September), there was often a lull in use in February -April, which counters the greater use in peak summer. Furthermore, this was perhaps surprising given the car-park counts have shown some high levels of use coinciding with Easter.

5.7 This factor, combined with reasonably high access in December and January (likely influenced by Christmas/ New Year's holidays), resulted in an overall similar level of access between the Sensitive Period and Non- Sensitive Period.

Data quality

5.8 It is important to highlight that results give values for the number of passes recorded and that can be approximation for, but is not directly equivalent to, numbers of people. Sensors ideally require calibration, e.g. direct observation, to record how the passes recorded equate to the number of people and how different access is recorded. As such, while all results show the differences between sensors, these are not examined in great detail due to the unknown extent which these are values are a true reflection. There are however some clear magnitudes of difference between some sensors.

5.9 The overall reliability of the data is believed to be good, and while approximately 9% of data was discarded this was not considered unusual given the issues that can be encountered. The issues were often more apparent in winter, due to the general effects of winter weather (rain and frost damage the sensors), and in particular, pressure pads can be influenced by waterlogging of the ground, but all buried electrics are susceptible. The winter values need to be considered in light of this effect.

5.10 Vandalism is an issue, and this may be hard to avoid, and can occur at any time and wipe out all data which has been collected since the previous data download. Measures to minimise impacts on the data, such as regular checks and rapid replacement where issues occur are recommended.

5.11 While there may be some particular sensors which are more prone to vandalism, it seems unclear from this dataset whether this is the case, as yet. This is also true of the data quality from certain types of counter and from the current data it remains hard to conclude.

5.12 Networks of counters can provide very useful and detailed data but require considerable input to maintain, check and ensure the information is reliable and useable. The usefulness of the data comes from a consistent, well-maintained network running for a number of years, providing a long-term perspective of change and fluctuations. The data summarised here are the initial results and more data are required to conclude monthly patterns and allow change over time to be picked up. The data collected to date provides a reasonable sample of data at a daily and weekly level, but comparing monthly totals becomes more challenging, and the number of counters where this is possible is limited. The counter network needs to be carefully maintained, regularly checked and allowed to run for longer in order to allow more accurate and detailed comparisons between locations and over time. Calibration of each counter (as discussed later) is also required.

Recommendations

5.13 Key recommendations are to:

- Consider new sensors on the SPA to give greater geographic spread and types of access.
- Consider new sensors on SANGs sites to allow long term monitoring and paired comparisons.
- Detailed calibration of sensors to check how people are recorded as passes, and the entering/leaving ratio.
- Record in greater detail the types of access and types of locations (e.g. type of access point, number of parking spaces in associated access point) to allow us to categorise locations and consider changes in access in response to long term changes to access management (e.g. introduction of car parking charges)
- Continued phasing out of the practice of using different types of sensors, in favour of one or two types from a single company for more confident data comparison between sensors.
- Careful, regular checking with regular downloads and rapid replacement to minimise any data gaps

Sensors on SPA sites

5.14 There have been 36 deployed sensor locations used to date, and sensors are still being deployed. But we suggest that more could be done to ensure this provide a reasonable spread. Some sensors are clustered, e.g. relatively high numbers at the northern edge of Ash to Brookwood Heaths, while other parts of sites are poorly covered.

5.15 The current geographic distribution of sensors was examined relative to the car parking locations and number of vehicles recorded at these in the 2016 driving transect surveys. A comparison between these levels of access reported from the driving survey data and the sensor data is shown in Map 8.

5.16 An important further consideration is that sites towards the edge of the SPA and therefore closer to the edge of the SPA 5 km buffer, especially small ones with high potential for access, e.g. Hazeley and Wisley, could be argued to face the highest threat from increased recreation pressure (e.g. for Hazeley and Wisley from substantial housing growth in Basingstoke or Leatherhead and Elmbridge). From Map 8 we would suggest that locations which may be suitable for one or more sensors to improve geographic spread are:

- Southern half of Bourley & Long Valley – reasonable number of car parks and vehicles recorded (although some access restrictions).
- Northern edge of Broadmoor to Bagshot Woods & Heaths - reasonable number of car parks and some high access levels in places.
- Parts of Castle Bottom to Yateley and Hawley Commons – fragmented site with high variation in access points (overall sites with current low access have potential to increase greatly).

- North-west part of Bramshill.
- Hazeley Heath – relatively small site with low access and currently no sensors
- Wisley Common - currently has one access point with a sensor (SAMM033), on a small footpath to a relatively small number of houses. but with some reasonably busy car parks on other parts of the site.

5.17 The other consideration is for a spread across different types of locations, such as foot only access or car parking access points. Auditing the location type of current sensors, and more detailed information on the number of car parking spaces, parking charges etc. would help ensure coverage across types of locations.

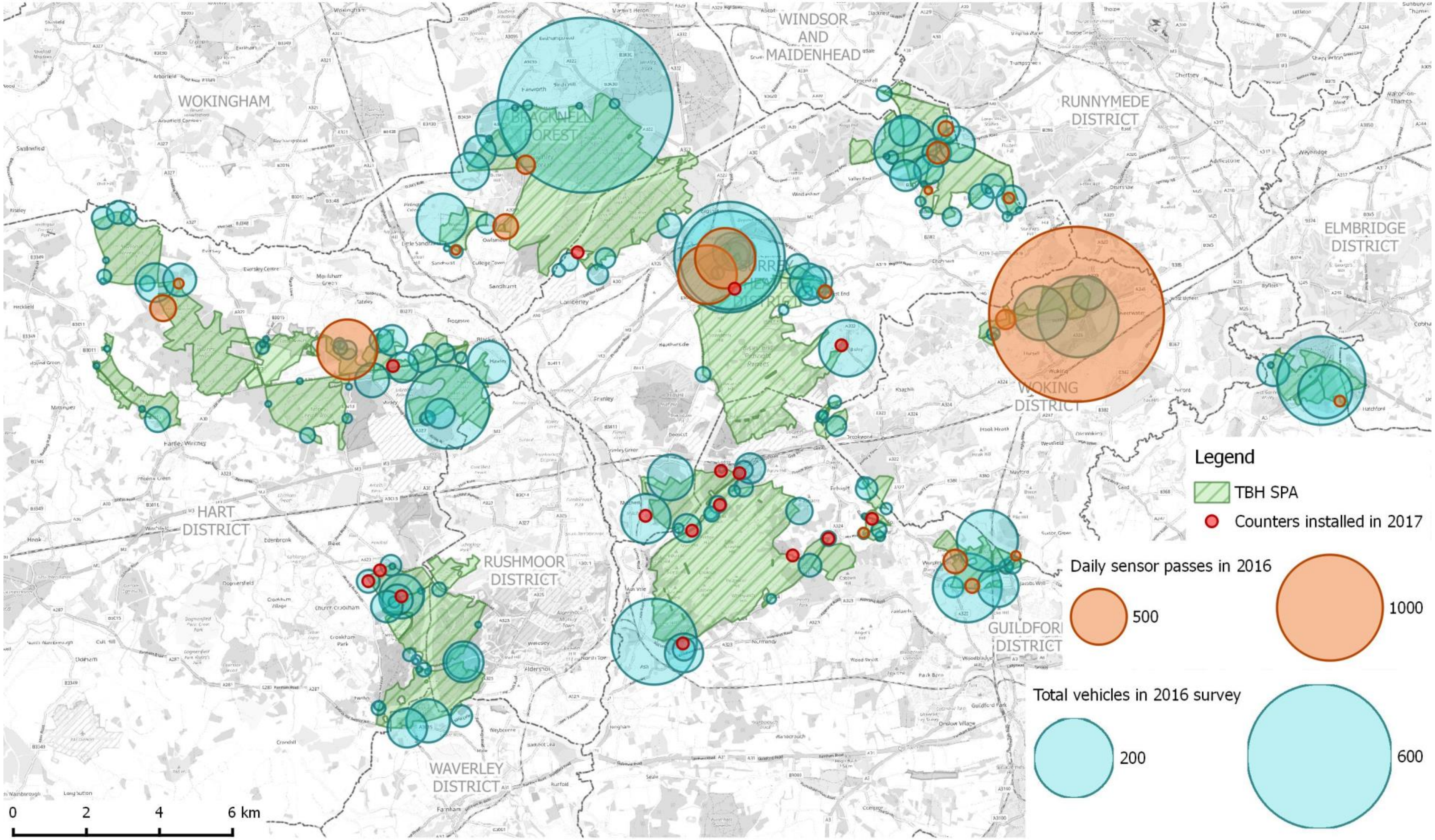
Sensors on SANG sites

5.18 Some SANGs already have automated counters, for example installed and managed by local authorities. It would be useful to view these alongside the SPA network and for the data to be explored with the SPA data to give a more strategic perspective. There may also be scope for additional counters to be placed at the many other SANGs that lack sensors

5.19 Sensors placed on SANGs would be best placed to match up with locations used in the visitor surveying, and this information paired together is a powerful tool. But we could also see merit in using sensors on sites where there is currently less known access, or entirely new sites, to examine uptake and how SAMM can encourage this.

5.20 SANGs could be chosen where access patterns are currently poorly understood and where there is scope for improvements. Sensor data can add extra information to inform management and help understand use of sites. Relevant sites may well be the larger and/or less busy ones. These are likely to be those where there is extra capacity and sensor data could help detect that potential.

Map 8: Comparison of daily average passes from 2016 sensor data to total number of vehicles from 2016 car park survey data. Sensors installed in 2017, but with no data, are also shown.



Calibration of sensors

5.21 While a simple calibration of sensors is usually undertaken on installation or data download, we recommend a detailed calibration and assessment. The raw averages shown depend on the number and composition of different types of locations, and types of sensor and types of visitors and their activities (e.g. passes recorded by dogs). All values would require stricter data cleaning and in addition calibration before values can be compared in this way with confidence. This would allow us to understand how the number of passes recorded by sensors relates to the actual number of people passing.

5.22 This will depend on a number of factors:

- Site infrastructure (e.g. fencelines, kissing gates), may result in people being recorded twice, or alternatively two people following closely being recorded as a single pass. People entering and leaving a site passing the point at the same time may be recorded differently at different locations.
- Visitor activity and group size e.g. multiple people close together may register differently; two individuals walking side-by-side, a person on a bike, with a buggy or with a dog may all register differently.
- Presence of a dog, as this may or may not be recorded depending on the placement and height of a sensor.
- Type of sensor e.g. a large slab may record two people following closely as one pass, while a pyro, as a single beam, may record this as two.
- Other possible factors are: season, sunlight, sensor sensitivity, double passes on circular routes.

5.23 We also need to understand the number of people entering, relative to the number of people exiting the site. This helps relate the numbers of passes recorded by the sensor to the number people entering. The relative number of people entering/exiting will depend on the position of the sensor and how circular walks are being conducted on the site.

5.24 Importantly, the visual count at each sensor will attempt to record a ‘pass’, as to how we believe the sensor should have recorded. However, the additional information and notes recorded will help to understand any differences between the visual count and the sensor.

5.25 Accurate observations will allow the raw values of the number of ‘passes’ recorded by the sensor, to be adjusted to more accurately reflect the number of people and the relative number entering/leaving.

Suggested calibration methodology

5.26 Counts should be carried out at times when the sites are likely to be at their busiest. These preferably should also be carried out within 2 weeks of a cube change to minimise the risk of damage to the cube data. The timing of each count must start on the hour and end on the hour (so it can be related to the number of passes recorded on the hour). Observations are advised to be conducted in summer and winter, with a minimum of three per season.

5.27 It is often unknown if the sensor was recording accurately or recording at all at the time of calibration and therefore the calibration results should be examined with the sensor data before the calibrations finalised and confirmed.

5.28 On a recording form, each row records an 'event'. Each event is an approximation of what the sensor will count as a pass; which is informed by the set delay on the individual sensor (usually c. 1 sec gap). If an individual is slow to pass over the sensor, then continue to duplicate the entry on the sheet for the entire duration, as the sensor would be duplicating this. For example, if an individual pauses on the sensor for five seconds, on a sensor with a 1 second delay, then record this as 5 event rows (and note this is a duplication). It is important to note anything which may cause the sensor to not accurately count the number of individuals.

5.29 The recorded 'groups' should refer to an approximate group of people who were visiting the site together (e.g. a family group or a single person). Such that using this information an average group size can be calculated.

5.30 On quiet sites where no people were recorded it is suggested that the surveyor should walk past the sensor several times to calibrate the sensor. Ideally this should be a random number of times, around 8-15 passes across the sensor. While these will influence the data, this is necessary to ensure accurate calibration.

Example datasheet – blue text shows the hypothetical data

<table>
<tr><td colspan="2">Date:</td><td colspan="2">01/01/2018</td><td colspan="3">Location:</td><td colspan="4">Brentmoor Heath</td><td colspan="2">Sensor ID:</td><td>SAMM016</td></tr>
<tr><td colspan="2">Sensor Type and delay:</td><td colspan="2">Slab, 1 sec</td><td colspan="3">Sensor location:</td><td colspan="4">in middle of kissing gate</td><td colspan="2">Recorder initials:</td><td>CP</td></tr>
<tr><td colspan="14">Start time - End time (recording must be on the hour): 10:00 -11:00</td></tr>
<tr><td colspan="14">Notes on sensor/path condition (anything likely to affect sensor recording): e.g. muddy in middle of gate. Sensor may be wet, and are people stepping around mud - may be missing the sensor. PIR in direct sunlight at time of visit.</td></tr>
<tr><td rowspan="2">Event no.(c. a sensor pass)</td><td rowspan="2">Group number</td><td colspan="3">No. of people/dog</td><td colspan="6">Activity/equipment</td><td colspan="2">Direction *</td><td>Other</td></tr>
<tr><td>adults</td><td>children</td><td>dogs</td><td>walking</td><td>Running/ jogging</td><td>biking</td><td>wheelchair</td><td>buggy</td><td>other</td><td>IN: east</td><td>OUT: west</td><td>Notes (e.g. "passed close to sensor, may not have registered"; "small dog, likely to have been missed by sensor"; "person paused over sensor")</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td></td><td></td><td>1</td><td></td><td></td><td></td><td></td><td></td><td>✓</td><td></td><td>Stepped over mud, may have missed sensor</td></tr>
<tr><td>2</td><td>1</td><td>1</td><td>1</td><td></td><td>1</td><td></td><td></td><td></td><td>1</td><td></td><td>✓</td><td></td><td></td></tr>
<tr><td>3</td><td>2</td><td>1</td><td></td><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td>✓</td><td></td><td>Dog and owner</td></tr>
</table>

4	*3*			*1*								✓	*Small dog well ahead of owner (may have been too small to set sensor)*
5	*3*			*1*							✓		*Dog ran back to owner past sensor*
6	*3*			*1*								✓	*Dog ran back past sensor again*
7	*3*	*1*										✓	*Dog's owner*
8	*4*	*2*			*2*							✓	*Couple walking very close, likely registered as single event.*
9	*5*	*1*		*1*	*1*						✓		
10	*5*		*1*				*1*				✓		*Bike long time over sensor*
11	*5*		*1*				*1*				✓		*Bike long time over sensor*
12	*5*		*1*				*1*				✓		*Bike long time over sensor*
*recode as north - south, east - west													

5.31 Hypothetical groups observed:(Group number. Event description)

- A group of two adults with a child in a buggy, walking into the site. This is recorded as two rows for two events, as these are two discrete 'passes'. The group was walking together, however the first adult past across the sensor first, some 2 seconds ahead of the adult with buggy. The second adult followed separately because this is a wide kissing gate. The sensor will likely record the first adult as one pass, refresh, and then start to record the second pass. The adult with a buggy would likely record as just one. However, if there was a long time spent over the sensor, while negotiating a kissing gate with a buggy, this may record as two (or longer depending on the duration of time over the sensor).
- A single adult with a dog; the dog is on a short lead, both pass over the sensor as a single event. This is likely a count of one.
- This is followed by the dog walker returning some time later, now the dog is off-lead. This is a single group but the dog is some distance ahead of the walker. It should be noted this would depend on whether the dog is large enough to set off the sensor/ the sensor type. The dog runs back past the sensor and finally forward again past the sensor. If large/heavy enough to registered by the sensor, each pass over the senor would count as an event
- A couple walking very close together. Likely to register on a sensor only as one.
- Last group, an adult (on foot) with a dog and a child on a bike. Likely count of two - the adult with dog on a short lead, and child are together in a single group, but the kissing gate means there is a long time between the adult with dog and then the child on bike negotiating the gate. If the child is a long time with over sensor, this may cause duplicated counts.

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